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Innovations through networks: understanding the role of social relations for educational innovations

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Abstract Scholars of diverse disciplines have begun to observe the growing importance of social networks for educational innovations. However, there is still a lack of studies that analyze the implementation of educational innovations by drawing on empirical techniques of Social Network Analysis (SNA). SNA research is critical to help us understand both how normative and complex social innovations are realized and what the possibilities of innovative ideas in educational contexts are. This article addresses the research gap and seeks to better understand the role of social networks in the implementation of educational innovations. It presents results of theoretically based empirical studies that implement SNA in five different German municipalities. It shows, for example, that the innovation networks are characterized by both dense cliques and central actors that foster the formation of shared values and trust, on the one hand, and brokerage positions that support the diffusion of innovations, on the other hand. Altogether, results point to the value of SNA methodology in understanding implementation of educational innovations.

Keywords Social network analysis · Egocentric social network analysis · Educational innovations · Educational landscapes · Education for sustainable development

Innovation durch Netzwerke – Zur Bedeutung sozialer Beziehungen für Bildungsinnovationen

Zusammenfassung Seit einigen Jahren wird in verschiedenen wissenschaftlichen Disziplinen die wachsende Relevanz sozialer Netzwerke für Innovationen im Bil-

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dungsbereich beobachtet. Gleichwohl mangelt es an Studien über die Etablierung von Bildungsinnovationen, die auf empirische Techniken der Sozialen Netzwerkanalyse zurückgreifen. Soziale Netzwerkanalysen helfen dabei zu verstehen, wie normative und komplexe Konzepte realisiert werden sowie was die Möglichkeiten innovativer Ideen im erziehungswissenschaftlichen Kontext sind. Der vorliegende Beitrag adressiert den Forschungsmangel und wendet sich der Bedeutung sozialer Netzwerke im Kontext der Etablierung von Bildungsinnovationen zu. Präsentiert werden Ergebnisse theoretisch geleiteter Sozialer Netzwerkanalysen, die in fünf unterschiedlichen Kommunen durchgeführt wurden. Es wird gezeigt, dass die Innovationsnetzwerke auf der einen Seite gekennzeichnet sind durch dichte Cliquenstrukturen und zentrale Akteure, die die Herausbildung gemeinsamer Werte und Vertrauen fördern. Auf der anderen Seite unterstützen Akteure mit Brokerfunktionen die Diffusion von Innovationen. Insgesamt weisen die Ergebnisse auf den Nutzen der Sozialen Netzwerkanalyse in Bezug auf ein besseres Verständnis der Implementation von Innovationen im Bildungswesen hin.

Schlüsselwörter Soziale Netzwerkanalyse · Egozentrierte Netzwerkanalyse · Bildungsinnovationen · Bildungslandschaften · Bildung für nachhaltige Entwicklung

1 Introduction

The world is faced with pressing challenges that require a massive global transition. Educational and political systems around the world are confronted with considerable problems, such as growing social disparity, environmental pollution, demographic change, and other negative societal and ecological developments. The dominant idea of economic growth is losing support with the public and decision-makers due to severe problems originating from the logic of uncontrolled systems themselves. Simultaneously, new societal visions are being developed by scholars and practitioners. Educational innovations, such as Education for Sustainable Development (ESD), are gaining international significance. Social networks have the potential to influence how educational innovations are implemented, and diffused. Educational innovations are accepted in processes of interaction, and they are established and diffused through social relations. Even so, little research has been done that examines the role of social networks in the field of educational innovations.

This contribution addresses the research gap by seeking to better understand the role of social networks in innovation diffusion processes in the field of education.[1] It uses a methodological approach that draws on techniques of egocentric and complete Social Network Analysis (SNA) to analyze social networks in five municipalities. Data were collected on social networks that are actively engaged in implementing the social innovation of Education for Sustainable Development (ESD) in order to

[1]The article is based on results of a research projects that has been conducted between 2010 and 2013 at the Freie Universität Berlin and has been supported by the German Ministry of Education and Research (project number: NB108A).

better understand the role of social networks in the implementation of educational innovations.

In recent years, the term "social network" has attracted a lot of interest. Network approaches are becoming increasingly important in several scientific disciplines. Particularly since Germany's disappointing PISA scores, the power of social networks has been regarded as increasingly important for educational researchers looking at implementation of educational reforms. To give an example, the social background and the social relations of individual pupil are regarded as among the most important factors that influence school achievement (Baumert et al. 2000; Sun 1999). Social networks influence processes of learning (Morgan and Sørensen 1999), socialization (Henning and Stegbauer 2012), and innovation (Valente 2005).

Despite the clear impact of social networks in educational contexts (Jütte 2002), SNA has not yet been used to look at the social networks responsible for implementing educational innovations (Rehrl and Gruber 2007). This article wants to contribute to this research gap. It is divided into six sections. After this introduction, the next section provides necessary theoretical background that defines core concepts and clarifies assumptions. The third section presents the research design, the data collection procedures, and particularly the use of Social Network Analysis (SNA). The fourth section compares the five cases and highlights structural weaknesses in two municipal networks. Fifthly, the role of social networks and their structural properties in promoting innovation processes are discussed. The last section summarizes major arguments and outlines prospects for future research.

2 Theoretical background and concepts

The scientific literature includes several different understandings of social networks. Frequently, SNA is used metaphorically to describe social phenomena (Hwang and Moon 2009, p. 7), such as how cultures influence behavior in bounded groups (Wellmann 1988). However, relying on metaphors as the foundation for development strategies and policy advice can be harmful and lead to unintended results (Ostrom 2010, p. 23). This article draws on Wasserman and Faust's definition of social networks, which is broad enough that it can be combined with different theoretical approaches. Hence, a social network "consists of a finite set or sets of actors and the relation or relations defined on them. The presence of relational information is a critical and defining feature of a social network" (Wasserman and Faust 2009, p. 20). At the same time, this contribution specifies social networks as collective actors that emerge from common interests, topics and problems. Thus, social networks, and their members and boundaries, are defined according to their specific contents, and topics. Network boundaries are fluid, the result of ongoing negotiations and content-related, substantial interactions. Exchange and deliberation facilitated by social networks gives them the potential to generate new knowledge and promote ideological and structural change in local systems.

The term "actor", in turn, is conceptualized as a social-acting individual. While the scientific literature mostly distinguishes between individual and supra-individual actors, this study operationalizes only individuals as actors. On that note, formal edu-

cation actors are those who work in schools, whereas non-formal education actors are individuals who belong to educational organizations, such as community colleges. In contrast to formal and non-formal learning, informal learning does not result in graduation, degrees, or certificates.

In order to better understand how social or educational innovations are implemented in social networks, this article focuses on Education for Sustainable Development (ESD). The term *social innovation* refers to processes of implementing and diffusing new social concepts across different sectors of society. While "innovation" implies a kind of renewal, "social" connotes interaction of actors. Social innovations are directly related to the search for solutions to social problems and challenges. *Educational innovations* are social innovations in educational contexts, such as new forms of educational cooperation or novel learning concepts. It is assumed that the structural properties of social networks have an impact on how social and educational innovations are implemented and diffused. Empirical studies show that the behavior of contact persons correlates highly with individual's adoption behavior (Rogers 1995). Implementation and diffusion of innovations are social processes; innovations are accepted and established in social networks and diffused by social relations that are based on these networks. Likewise, education is seen to be a key to implementing innovations, such as sustainable development or *Education for Sustainable Development (ESD)*. ESD is defined here as education that empowers people to foresee, try to understand, and solve the problems that threaten life on our planet. In order to promote behavior changes to shape a more sustainable future, ESD integrates principles of sustainable development into all aspects of education and learning (de Haan et al. 2008).

The concept of *sustainable educational landscapes* refers to the German term "Bildungslandschaft" and is regarded as an integration of both educational landscapes and sustainability. In current educational debates topics around regional, municipal, or local educational landscapes are increasingly discussed (Luthe 2009; Berse 2009), not least because sustainable educational landscapes seem to provide solutions for societal, educational, ecological, political, and economic problems. In addition, sustainable educational landscapes seek to integrate the three dimensions (social, economic, and ecologic) of sustainable development (Kolleck et al. 2012).

3 Implementing Social Network Analysis in innovation processes

This article presents results of a larger study of sustainable educational landscapes, which examines networks interested in fostering the social innovation of Education for Sustainable Development in five German municipalities. While the research design of the study combines quantitative and qualitative techniques, this article mainly focuses on the quantitative part, which is based on techniques of egocentric and complete SNA.[2] These networks represent five different German municipalities–Alheim, Erfurt, Frankfurt am Main, Gelsenkirchen, and Minden–each of which has been commended by the United Nations Decade of Education for Sustainable Devel-

[2] Some of the qualitative results are discussed in the article of Kolleck and Bormann in this issue.

opment (UNDESD). The municipalities are actively engaged in the field of ESD and are thus equipped with diverse networks, initiatives, and actors who seek to establish and diffuse ESD. The five cases differ in terms of geographic size, total population, location, sustainability performance, and municipal profile. Individuals engaged in the field of ESD stem from different sectors in formal, informal, and non-formal education.

With respect to the research design of this contribution, a combination of egocentric SNA and complete SNA was pursued. Egocentric network designs assemble data by selecting a node, including all actors that are connected to that node. In contrast, in complete SNA a group of actors is decided on. Network boundaries are predefined and all network ties are measured. The study of this contribution mainly used egocentric SNA to collect data, disclose network members, and define network boundaries. A snowball approach was employed (Scott 2007), using the data base of the UNDESD as a starting point. Based on the name generators according to Fischer (1982) and Burt (1982) interviewees were asked for their contact persons in the field of ESD. However, while Burt does only apply name interpreters for five of the mentioned alters, the study included name interpreters for every contact person. Alters were also interviewed with the same questionnaire. "In other words, the alters mentioned in the name generator are also used as a basis for further recruitment" (Kowald and Axhausen, p. 1087). In this way, and by applying a great number of iterations, almost all network members in the field of the social innovation within the five municipalities could be identified and network boundaries were defined. Subsequently, data was aggregated in order to allow for further analyses with complete SNA. Measures of complete SNA were only applied for persons who completely filled in the questionnaire.

Empirical data was collected from across different municipalities, initiatives, institutions, and thematic groups between 2011 and 2012. Prior to the application of SNA, relevant actors in each municipality were systematically identified. As the research project had a direct connection to the national committee of the UNDESD, it had access to a database that includes contact details of all projects, initiatives, and municipalities that have been distinguished by the UN Decade (currently around 2,000 projects and 21 municipalities). Additional contact details were gathered by project researchers prior to the creation of the questionnaire that formed the basis of the quantitative SNA.

A 12-page online questionnaire with name generators and interpreters was created in order to analyze the ESD networks in the municipalities. Name generators, that is to say questions to elicit lists of names, aim at identifying relevant actors. In this way, it was possible to detect network members and to reveal network boundaries. Name interpreters can be regarded as follow-up questions about the network members, their attributes, types of ties, and relationships between pairs of contact. Thus, name interpreters were incorporated in the questionnaire to get more information about the characteristics of the persons within the networks and the qualities of the relations between the actors involved (Kolleck 2012, pp. 257–260). The questionnaire was sent to individuals, not to organizational contacts. Thus, in some organizations, many individuals were contacted, whereas in others only few persons were actively engaged in the field of ESD. By this means, different roles and positions within the

same organizations as well as the constraints and opportunities that arise from how individuals are embedded in networks could be captured empirically. Furthermore, the conceptualization of actors as individuals enabled to interpret the reach of the educational innovation and the network boundaries.

The questionnaire first asked respondents to mark people in their ESD network, defined by efforts to contact, cooperation, collaboration, problem-solving, and idea exchange. Respondents were also asked to assess the quality and contact frequency for each relation mentioned and to name those persons with whom the interviewee cooperated especially closely or had established high levels of trust. They were then requested to score their named connections' impact and the relevance with respect to the diffusion of information and the implementation of ESD. Finally, the questionnaire included questions on future prospects, desires, and developmental possibilities.

In order to optimize the questionnaire, 30 pre-tests were performed in the municipalities. The survey itself was primarily sent via email; non-respondents and actors without an e-mail address were sent paper questionnaires and reminded by telephone to respond. After the first data collection period, persons named by respondents but not yet been included in the analysis (alters) were also given the questionnaire. Altogether, a survey respondent named an average of 11.6 alters. A fundamental part of SNA is distinguishing between insiders and outsiders; that is, defining network boundaries. Network boundaries are necessarily fuzzy. Every researcher conducting SNA must decide how to define network boundaries. This study only sent a questionnaire to actors named more than once, which led to the survey being sent out multiple times as contacts were generated. Data collected by egocentric SNA was aggregated in order to allow for calculations with complete SNA. Measures of complete SNA were only applied for persons who completely filled in the questionnaire.

The dataset was cleaned up by deleting all actors who did not complete the questionnaire, whose identity could not be confirmed, and who could not be related to one of the municipalities. The final network for all five municipalities consists of 1,306 persons (see Table 1) and 2,195 edges.

After having collected the data, actors within the ESD networks were clustered according to their areas of activity. This was intricate because the specific area of activity is not evident in all cases. In the end, seven different clusters used to sort members: administration/government, NGOs, non-formal education, business, formal education, media, and church. Every network member was assigned to one of these fields. If someone was working in two of these fields, the field of her/his main

Table 1 Number of network members, revised dataset

Municipality	Number of actors	Percentage of total
Gelsenkirchen	413	31.6
Erfurt	309	23.7
Frankfurt am Main	267	20.4
Alheim	162	12.4
Minden	155	11.9
Total	**1,306**	**100**

occupation was chosen. In the event that no evident field of activity could be identified for an actor, the category "other" was chosen as an eighths cluster.

SNA is based on the assumption that opportunities and constraints arise from how actors are embedded in social structures and how interactions among involved actors take place. This duality and interactive relation between structure and individual is addressed by basic concepts and methodological applications of SNA. The examination of the results of this study, as covered below, starts with some of the basic properties of the regional networks as well as the whole trans-regional network.

The longest shortest path between any two nodes in the network is called the diameter. It indicates how many steps are necessary to get from one side of the network to the other. The diameter of the trans-regional network is 11, which means it will take at most 11 steps to reach any node in the network from any other. In order to average the minimum distance between network actors, the geodesic distance is commonly used. The average geodesic distance (the average of all shortest paths in the network) of the trans-regional network is 4.15. This means that any two nodes are on average 4.15 steps away from each other. Hence, new information diffuses relatively slowly through the network.

The network density indicates how closely network actors are interconnected. It is defined as the total number of observed edges in a network divided by the total number of possible edges between all pairs of nodes and ranges from 0 to 1. Hence, a perfectly connected network, also called a clique, has a density of 1. The density of the whole network of all municipalities studied here is 0.0013, meaning 1.3 % of all possible ties exist. This relatively low density may also be traced back to the high number of network members. Figure 1 compares the density of the five municipalities. It shows that the density of a network is inversely related to the number of persons within the network: the larger the network, the less dense it tends to be.

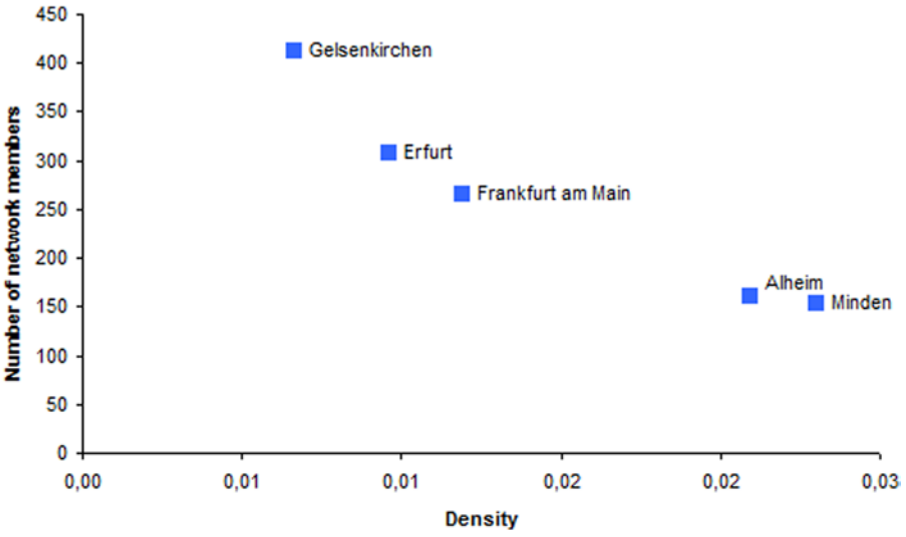

Fig. 1 Municipal networks based on network density and number of network members

A larger network may imply more potential partners and possibilities for cooperation, innovation, and diffusion. At the same time, it becomes increasingly difficult to maintain and to foster strong and trusting relations. While ESD networks are characterized by dense structures within the municipalities, the density of the trans-regional network is especially low. However, an additional reason for the low density of the whole, trans-regional network is structural holes, which are defined as a lack of connection between two nodes. Structural holes become evident when the network is visualized. For example, the lack of ties between Minden and Gelsenkirchen indicates a structural hole.

In order to visualize the network of all municipalities (see Fig. 2), directional relations between network members were put into UCINET and visualized with Netdraw. The iterative method of "spring embedding" was chosen for the graph-theoretic layout, because it supports neat illustrations of large data sets. Thus, the lengths of the ties do not have information content. The nodes in Fig. 2 represent persons that are engaged in implementing ESD in their municipalities.

As Fig. 2 illustrates, the networks form five coherent regions. Although there are close working groups within the municipalities, there are only a few broker positions that bridge structural holes (Burt 1992) between local networks. The concepts "brokerage" and "structural hole" refer to structural embeddings of actors. Brokers, who maintain connections with people who themselves do not become interconnected,

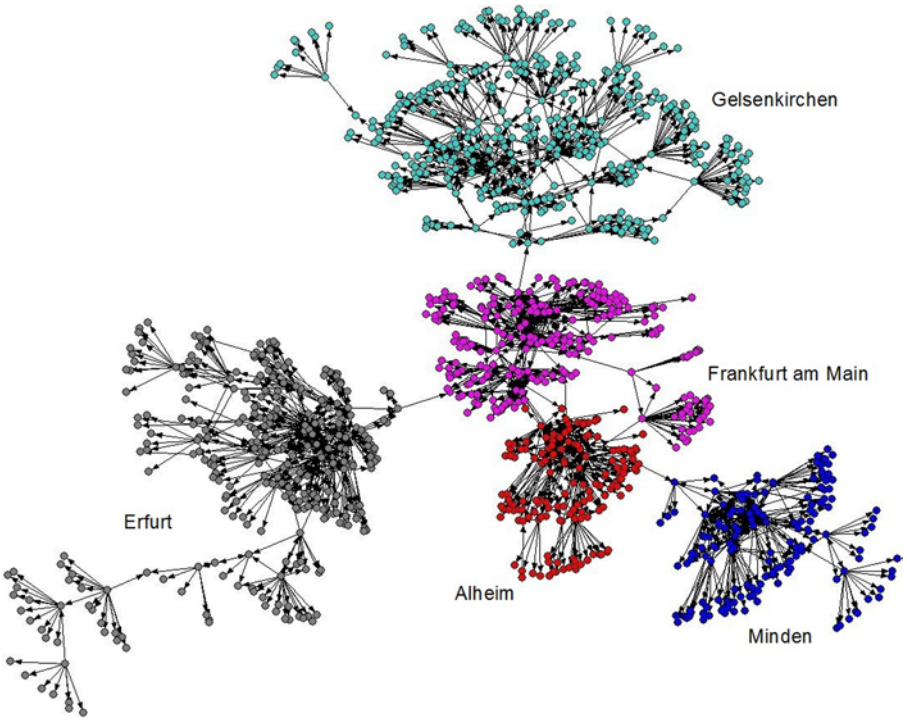

Fig. 2 Whole network of five municipalities

benefit from the ability to mediate between these contacts (Podolny and Baron 1997). When brokers connect two individuals or groups, they benefit from serving as intermediaries between the others. Through such intermediation, brokers can potentially negotiate the stream of information and bring together ideas that emerge within the network. Structural holes, by contrast, are often defined as gaps between individuals or groups with complementary resources or information (Burt 1992). While many organizations tend to focus their activities inside their own groups, brokers that bridge structural holes provide access to new information and control benefits. In Fig. 2 you can find many structural holes between the municipalities. Furthermore, within some municipalities such as Erfurt, more structural holes can be identified than in others. According to Burt (1992), this trans-regional network can be regarded as a best case with a "model structure", because it provides access to many different cliques and clusters, and benefits from additive information that are given through many structural holes. However, in the following sections, some weaknesses will become evident.

The relative high density within the municipal networks and the high number of structural holes across municipalities are also surprising because the UNDESD supports regular trans-regional working groups, roundtables, and other opportunities for cooperation. In addition, the UNDESD assumes that ESD is realized primarily beyond institutional borders. Just like with sustainable educational landscapes, ESD is intended to overcome institutional borders, foster cooperation between formal, non-formal, and informal education, and diffuse ESD through collaborations between different areas of activity. Reality shows, however, that the implementation of ESD is mainly due to actors from NGOs, non-formal education, and policy sectors, with sectors such as formal education underrepresented. Altogether only 7.5 % of the network members work in schools. Furthermore, formal education actors exhibit the lowest centrality as well as few and weak relations. Figure 3 points out that school still takes a back seat in the process of implementing ESD in the five municipalities.

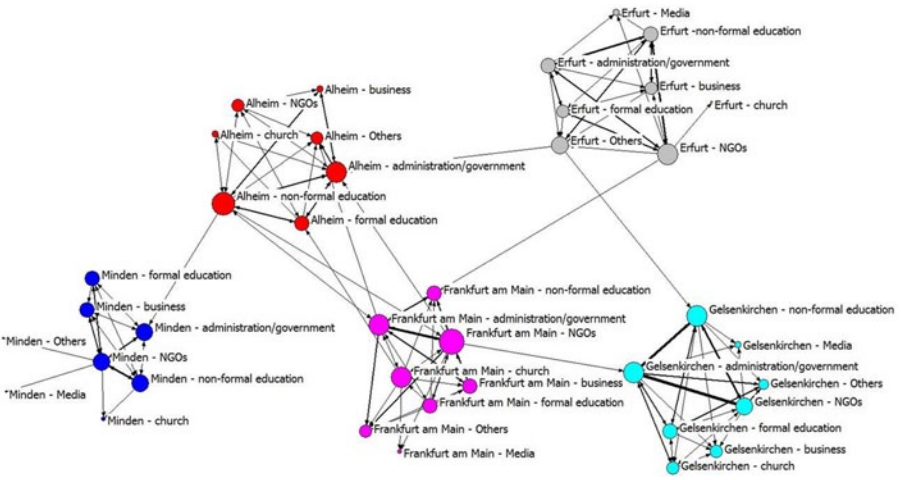

Fig. 3 Membership network

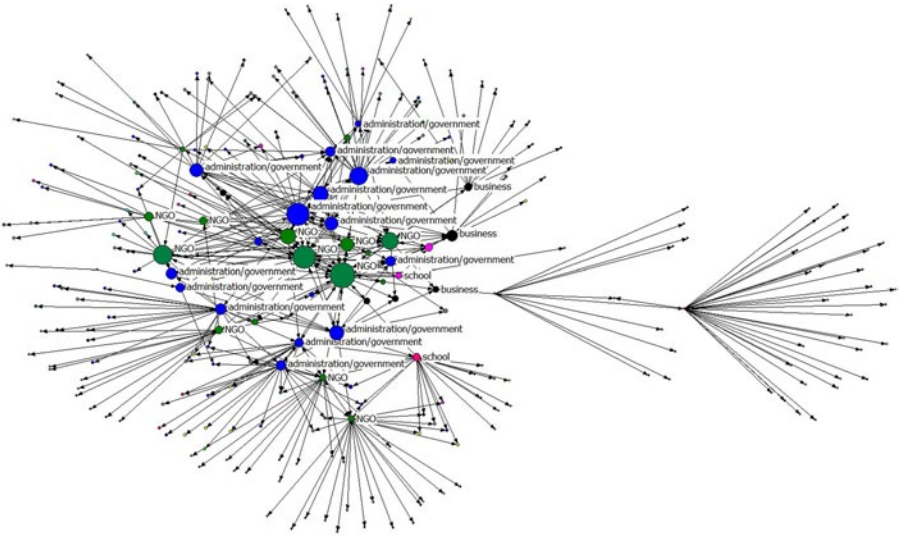

Fig. 4 Eigenvector centrality Frankfurt am Main. Nodes represent actors according to their area of activity

In order to visualize the membership network, persons who are engaged in ESD in the same sector (e.g., non-formal education) were combined; they are represented in one node. The larger the node in the figure, the higher is the sum of the in-degree[3] centrality of the persons involved. (The arithmetic mean of all degrees in the network is 3.4). Furthermore, the lines between the nodes are defined by the sum of the degree; their thickness indicates the number of links between nodes. Hence, groups with the highest activity and the strongest relations become clearly recognizable.

It becomes evident, however, that the sectors administration/government, NGOs, and non-formal education exhibit the highest centrality. Furthermore, persons from these areas of activity boast the strongest relations (as defined by their degrees). At the same time, persons from formal education, business, media, church, and others are less integrated into the network. In terms of sustainable educational landscapes, the low centralization of formal education actors can be regarded as especially problematic. It is only possible to achieve the goals of education for sustainable development by integrating schools and synthesizing areas of formal, informal, and non-formal education. Beyond the weak representation of formal education within the networks, relations with formal education actors are relatively low in trust, reciprocity, and strong ties. However, although schools seem to have weaker ties to other network actors, intra-school relations are particularly strong (Kolleck forthcoming).

Although other centrality indexes have the same result with respect to school actors, they bring about dissimilar results in other issues. Thus, an actor's centrality within a network depends on which centrality concept is applied. To give an example, Fig. 4 presents the eigenvector centrality in Frankfurt am Main by sector. Frankfurt am Main was chosen because its ESD network boasts the highest number of central

[3] The *in-* or *out-degree* of a node is defined as the number of links that lead into or out of the node. The *degree* is the sum of the in- and the out-degree.

actors with different affiliations. Eigenvector centrality is especially suitable in larger and complex networks, because it identifies the importance of each node in a graph. A node's centrality is based on the sum of the centrality values of the nodes that it is connected to. Actors with many connections to other central or popular actors are considered to be more central. Hence, eigenvector centrality is based on the social principle "you are as important as the people you know" and is often regarded to be a more precise indicator for popularity than in-degree centrality.

With respect to the eigenvector centrality, central actors in Frankfurt belong to the areas of administration/government and NGOs. Furthermore, these actors were often named by others and are thus situated in the centre of the figure. In contrast, betweenness centrality discloses many actors at the periphery as central actors. Betweenness centrality is a measure that is equal to the number of shortest paths from all vertices to others that pass through that node. Hence, betweenness centrality is useful to identify actors who lie on the path between others. This centrality index is especially suitable for assessing the importance of nodes in diffusion processes and the exchange of information. Actors who lie on the path between others are instrumental in determining whether innovations are implemented and disseminated. According to the betweenness centrality, in Frankfurt the affiliations of central actors differ. Thus, most central actors belong to other areas of activity, such as church and business. The question of who is a central actor depends heavily on the definition of centrality and the measure that is applied. School actors, however, are underrepresented and low in centrality. This also holds true in the other four municipalities. For network members it is important to know that it is not just the number of connections that counts. The implementation of ESD also depends on actors with a mediator, gatekeeper, or brokerage role. Only these roles enable links with other regions, efficient cooperation, and the diffusion of innovations. On the one hand, networks with a great number of common "friends" and high density have more chances to strengthen trust, common opinions, norms, and stability. On the other hand, roles that bridge structural holes are very important in terms of diffusing innovations (cf. Kolleck and Bormann in this issue).

The results discussed so far highlight the density within the ESD networks. The next section analyzes how ESD is implemented in the municipal networks and the contribution of network relations in this process. In order to analyze whether implementation of ESD takes place in exclusive groups of people who associate closely, an index was built based on the mean of the four dimensions (strength of cooperation, problem-solving, development of ideas, and information exchange in the field of ESD).[4] However, QAP (Quadratic Assignment Procedure) correlations obtained with UCINET show that the correlations between entries in the matrices are significant. The QAP is a technique that has been developed in SNA (Mantel 1967) and is used for statistical significance testing. In contrast to parametric statistical

[4] Survey respondents were asked to evaluate relations between the persons named with respect to their cooperation, problem-solving, development of ideas, and information exchange in the field of ESD. On a scale of 1 to 4, interviewees could assess each relation according to the contact frequency: 1. never/ less than once every three months, 2. approximately every two to three months, 3. about once a month, or 4. more often than once a month. In cases where the strength of the relationship differed between two people, the higher value was used for analysis.

techniques observations being analyzed are not independent of one another. In social network analysis observations are usually highly dependent of one another. The QAP approach "provides a specific type of permutation test which keeps intact the dyadic data structure under the permutations. The principle of this test can be applied to many kinds of models" (Decker et al. 2007). In this study QAP correlations show, for example, that persons who are frequently contacted for problem-solving tend to also be approached to develop new ideas. Network members who are influential in terms of implementing ESD also tend to be important in disseminating ideas. Furthermore, there is a strong correlation between good cooperation and trusting relations. Herewith theoretical perspectives on trust prove successful according to which, for example, trusting relations are associated with particularly frequent cooperation (Kolleck forthcoming).

While previous results have highlighted the strong density within the municipal networks compared to the low density in the trans-regional network, further analyses show weaknesses with respect to the quality, the strength, and the trust of the relations within the municipalities. Figure 5 depicts the strengths of the ties in Erfurt. Erfurt was selected here because it shows the greatest number of structural holes and the lowest number of strong and trusting relations of all five municipal networks. The strength of the relations in Fig. 5 correlates with the thickness of the arrows: stronger connections are indicated by thicker arrows.

Figure 5 shows that strong ties in the field of ESD in Erfurt are not concentrated with a small, tight-knit working group. Instead, there are strong ties between different groups. At the same time, groups with strong ties are separated by structural holes. Whereas the visualizations of the other four municipalities with respect to the strength of the ties reveal structural holes, they are more prevalent in Erfurt than the other municipalities studied.

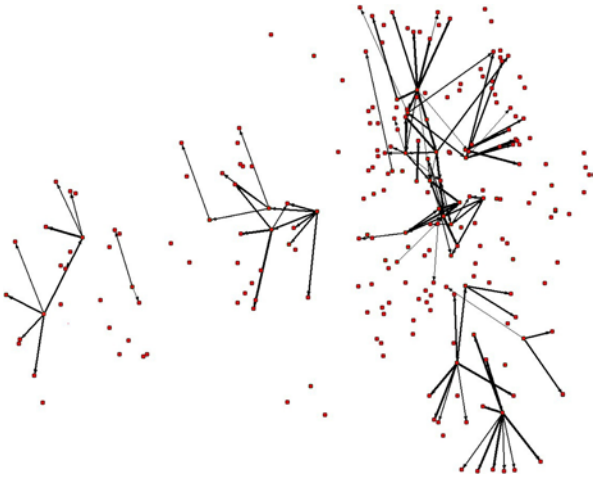

Fig. 5 Strength of the ties in Erfurt, Index (contacts rated as made at least once a month are defined as strong ties)

4 Comparing social networks

Although the municipal networks are similar in many ways, such as with respect to the lack of school actors or the existence of several central actors, there are also structural differences. Some of these differences can be related to the size of the network. The density of the five municipal networks, as already mentioned, correlates inversely with size. In addition, the number of network members also has an influence on the clustering values. The clustering value indicates the average number of common "friends" in every regional network. If person A names two other actors B and C, and B and C in turn are connected to each other, this indicates a triangular relationship.

Figure 6 presents the regional networks according to their number of members and their clustering values, where clustering is defined by the number of triangle relations. While the networks in Minden and Alheim are about the same size, there is more clustering in Minden. At the same time, the network in Minden has a higher degree of centralization, as assessed by the Gini coefficient (measured by the indegree). Hence, Minden exhibits a higher Gini coefficient than Alheim. Here, the higher value of the Gini coefficient indicates a smaller number of actors who exert greater control over the network. One reason for Minden's high clustering value and Gini coefficient is that the realization of ESD is mainly concentrated among central actors from civil society organizations. In Alheim, by contrast, actors from different sectors have a central role in the field of ESD. Also, cooperation between state and non-state actors in ESD is very high in Alheim. In turn, cooperation beyond NGOs is very low in Minden. Actors from other sectors do not play a central role in implementing ESD in this municipality. At the same time, a higher percentage of the relations are considered to be trusting in Alheim than in Minden (55.4 to 47.6%). The imbalance

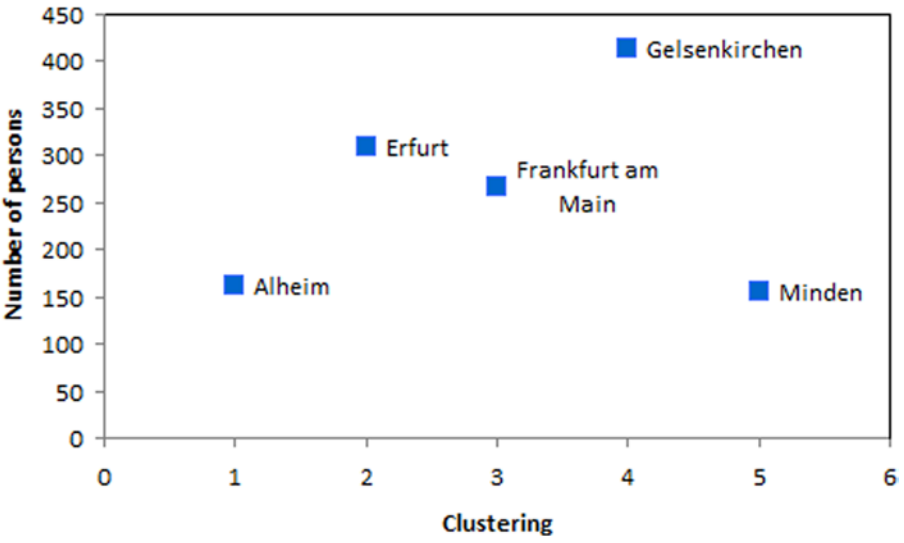

Fig. 6 Clustering values

and the high centralization related to the implementation of ESD in Minden have disadvantages. Not least, actors from important areas of activity, such as government, business, or schools, are at the periphery. If they get the impression that ESD is just a matter for NGOs or non-formal education, in which other actors do not have a role to play, efficient implementation and diffusion of ESD gets more difficult.

Cooperation problems can also be identified in Erfurt. Although many authors argue that voluntary networks reduce cleavages and distrust by providing opportunities for interaction between different actors (Putnam 2000), the promotion of networking in Erfurt has resulted in aggravation of conflicts between different segments of the municipality. Different large-scale development and research projects in Germany, such as "LernenvorOrt", "Lernende Regionen", or the UNDESD could not overcome conflicts that range from how to define ESD and networks to how sustainable educational landscapes should be realized and what the regional emphasis should be. This is also reflected in the low level of trust: At 35.3 %, Erfurt's ESD network exhibits the lowest proportion of trusting relationships of the five municipal networks studied.

5 The role of SNA in promoting innovation processes

Social Network Analysis has the potential to reveal weaknesses in implementation of innovations. The chance of an innovation getting adopted increases significantly if it is represented not only by singular individuals, but by interconnected actors (Valente 2005). Social networks may foster learning processes and promote synergy, bring together resources and technological know-how, and promote diffusion of innovative ideas. However, social networks are not an end unto themselves. If social relations have positive impacts on innovation processes in some cases, they may also hinder others. The success of social networks also depends on structural issues.

This article has argued that the role a social network plays in the course of establishing innovations depends on characteristics of the networks themselves. For example, the trans-regional ESD network is characterized by structural holes, brokerage positions, and a low density. On the one hand, these characteristics are important for diffusion processes, efficiency, diversity, and low coordination costs. On the other hand, networks with structural holes lack stability, resilience, trust, and common norms. At the same time, there are strong relations and a high density within the municipal networks. These factors simplify the development of strong social networks with a widely accepted identity. While this tendency may be true for most municipal networks, the trans-regional ESD network is shaped by structural holes and few weak ties that bridge municipal borders. However, the low trans-regional cooperation can also be traced back to competition between municipalities in the field of ESD. Municipalities integrate educational innovations in order to compete with other municipalities and be seen as leaders in their respective fields. But this explanation is incomplete: even within municipalities, ESD networks are characterized by structural holes and weak relations. This is especially true in Erfurt, where the strength of the ties, information exchange, and trust are mainly concentrated in cliques, each representing a different group of actors pursuing different interests and

ideas under the umbrella of ESD. For implementation and diffusion processes such conflicts are dangerous. If social networks don't succeed in overcoming conflicts and establishing cliques with strong and trusting relations in order to positively adopt new ideas, those ideas will be hardly implemented and diffused widely.

Although conflicts and weaknesses may persist in some municipalities, others have been very effective in implementing and diffusing ESD. In general, networks that possess strong relations between state and non-state actors seem to be stronger and more successful. In Gelsenkirchen, for example, networks in the field of ESD have claimed that the innovation of ESD became a fundamental part of the municipal profile. The implementation of ESD in Alheim benefits from strong relations between the mayor and non-state network members. There, it was possible to develop and realize aims in the area of political accountability in a short space of time. Hence, strong network structure resulted in the elaboration of an educational plan, composed according to the principles of ESD.

Another important impact on the diffusion of educational innovations can be seen in the extent of clustering, defined by the number of triangle relations. Against the background of promoting the implementation and diffusion of social innovations, a high clustering value can reveal serious impediments. In the case of Minden, empirical results indicate that ESD implementation is mainly concentrated in influential circles. Actors from NGOs and non-formal education possess the highest centrality. These closed networks perpetuate biases against other sectors. At the same time, actors from other domains would like to be more integrated in processes of realizing innovative concepts, such as ESD.

With respect to Minden, a future strategy that fosters greater participation of stakeholders from other areas of activity may be helpful in promoting implementation of ESD. Businesses and teachers, in particular, complain about not being sufficiently integrated into ESD networks and that the same people always take control and create turf battles. Furthermore, a lack of transparency and information exchange on existing ESD projects is observed. Business actors are often confronted with assertions that they ignore the ecological and social dimensions of sustainability. In Minden, for example, ESD is mainly concentrated on environmental topics and many ESD actors express reservations against business aims.

6 Outlook

This article has argued that structural characteristics of social networks have an impact on the implementation and the diffusion of social or educational innovations. Techniques of SNA can help to interpret existing networks, analyze their structural properties, and gain insights into the opportunities and limitations of existing networks. The success of educational innovations depends on the structure of the social networks in place. In order to better understand the role of social networks on educational innovations, the implementation of ESD was analyzed by using Social Network Analysis in five municipalities. This demonstrated that the implementation of educational innovations depends on structural issues, such as network size, network density, and the integration of different sectors. This leads us to the general questions

of what sorts of ties are most important in innovation implementation and diffusion. With respect to the case studies of this article, three dimensions can be distinguished: density, centrality, and trust between actors from different sectors.

On the one hand, ESD networks are characterized by dense cliques, triangle relations, and central actors that foster the formation of shared values and trust. On the other hand, the trans-regional network shows many structural holes, weak ties, and brokerage positions that support the diffusion of innovations. While the number of network members, for example, correlates with the network density, it is more difficult in large networks than in small networks to have a relation to every network member. The combination of dense municipal cliques and several weak ties and brokers seems to be a perfect condition for diffusion and implementation processes. While strong, trusting relations foster the adoption of new social concepts, weak ties support the spread of innovations. However, SNA could also disclose structural weaknesses within the municipal networks. For example, most central actors are representatives of NGOs or non-formal education. Actors from other important sectors, such as school, business, and in some municipalities even government, are less integrated. Actors from these sectors complain about not having the opportunity to be a main part of the innovation network. Improving coordination between sectors and integrating actors from diverse areas of activity would be an important task to improve implementation of the social innovation.

While this article has introduced some insights with respect to the role of networks in processes of implementation and diffusion of innovations, a typology on the sorts of ties that are most important in innovation implementation and diffusion is still missing. This indicates the need for greater empirical attention to structural issues of social networks. Future research in SNA is needed to further analyze and assess the role of social networks for innovation processes in terms of educational research. Many questions remain unanswered. What kind of social innovation networks can be identified? How do these networks change over time? What role do norms, ideas, perceptions, and network structures play in these changes? Comparative analyses at the global level could be interesting and fruitful. In terms of the cases in this article, it would be useful to analyze how ESD is implemented in other United Nations member states. The role of regional social networks in developing countries and in emerging nations could be especially illuminating. The basic conditions for Education for Sustainable Development differ considerably around the world. The same goes for educational approaches. Sustainability in a so-called developing country may mean something different from what it would in an industrialized country. While a typology of the role of social networks in educational innovation processes is still missing, further comparative empirical analyses in this area are needed. This article has shown that SNA can begin to answer questions related to implementation and diffusion of educational innovations. I hope it will open up new possibilities for further use of SNA in this exciting field.

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