SOCIAL NETWORK ANALYSIS FOR ASSESSING SOCIAL CAPITAL IN BIOSECURITY ECOLITERACY

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Abstract: Social Network Analysis for Assessing Social Capital in Biosecurity Ecoliteracy. Biosecurity ecoliteracy (BEL) is a view of literacy that applies ecological concepts to promote in-depth understanding, critical reflection, creative thinking, self consciousness, communication and social skills, in analyzing and managing issues around plant health/living, animal health/living and the risks that are associated with the environment. We used social network analysis (SNA) to evaluate two distinct forms of social capital of BEL: social cohesion and network structure. This study was executed by employing cooperative learning in BEL toward 30 undergraduate teacher training students. Data then was analyzed using UCINET software. We found the tendency of social cohesion to increase after students participated in BEL. This was supported by several SNA measures (density, closeness and degree) and these values at the end were statistically different than at the beginning of BEL. The social structure map (sociogram) after BEL visualized that students were much more likely to cluster in groups compared with the sociogram before BEL. Thus BEL, through cooperative learning, was able to promote social capital. In addition SNA proved a useful tool for evaluating the achievement levels of social capital of BEL in the form of network cohesion and network structure.

Abstrak: Analisis Jaringan Sosial untuk Menilai Ekoliterasi Ketahanan Hayati. Ekoliterasi ketahanan hayati (EKH) adalah literasi yang mengaplikasikan berbagai konsep ekologi untuk mempromosikan pemahaman yang mendalam, refleksi kritis, kesadaran diri, keterampilan sosial dan berkomunikasi, dalam menganalisis, dan mengelola isu yang terkait dengan kesehatan/kehidupan tanaman, kesehatan/kehidupan binatang, dan risiko yang terkait dengan lingkungan. Analisis jaringan kerja sosial (AJS) telah digunakan untuk mengevaluasi dua bentuk model sosial EKH: kohesi sosial dan struktur jaringan kerja. Untuk itu, dilakukan penelitian EKH dengan menggunakan pendekatan pembelajaran kooperatif, dan melibatkan 30 orang mahasiswa (S_1) calon guru. Mereka mengikuti 14 kali pertemuan tatap muka di dalam kelas, dua kali kunjungan lapang, baik pada ruang tertutup maupun terbuka (*indoor* dan outdoor). Setiap mahasiswa (sebelum, dan setelah EKH) diminta menominasi nama lima mahasiswa lain yang dianggap memiliki hubungan paling erat dengan mereka. Data dianalisis dengan bantuan piranti lunak UCINET. Hasil penelitian menunjukkan adanya kecenderungan peningkatan kohesi sosial mahasiswa setelah mereka mengikuti EKH. Hal tersebut didukung berbagai ukuran AJS (kepadatan, keterdekatan, dan derajat), yang menunjukkan kohesi sosial mahasiswa berbeda nyata, antara sebelum dan setelah EKH. Peta struktur sosial (sosiogram) setelah EKH juga menggambarkan mahasiswa lebih berkelompok sesuai dengan grup, dibandingkan dengan sebelum EKH. Hal tersebut menunjukkan bahwa EKH melalui pembelajaran kooperatif mampu meningkatkan modal sosial mahasiswa. Di samping itu, AJS terbukti sebagai instrumen yang efektif untuk menilai modal sosial EKH dalam bentuk kohesi sosial dan struktur jaringan sosial.

Key words: biosecurity ecoliteracy, cooperative learning, social structure, social cohesion, network structure

Social network analysis [SNA] is a method based on graph theory and statistics for systematically understanding, identifying, mapping and measuring connections among actors (Janssen et al., 2005; Krebs, 2006). An actor is defined as each participant in the collaboration and it can be persons, organizations, or groups (Aviv et al., 2003:4). The concept of a social network primarily emphasizes the fact that actors are related to each other and how actors are embedded within the overall network (Hanneman 2001; Daniel & Beng-

Chong, 2007). Its mention on flows (links or edge) among actors (node or vertices) other than the attributions and characteristics of autonomous individual units (Wasserman & Faust, 1994; Cassi, 2003; Krebs, 2006). Consequently, actors are usually not sampled independently, like most typical surveys do (Hanneman, 2001). Network studies generally include all of the actors who exist/live within a certain (usually naturally occurring) boundary. Hanneman interestingly describes "…when we study patterns of interaction among students in a classroom, we include all of the children in a classroom…" (Hanneman, 2001:4). Thus SNA focuses on an entity consisting of a collection of individuals and the linkages among them, such as two actors and their ties, subgroups of individuals, or entire networks (Wasserman & Faust, 1994). It assumes that community thrives not only on its resources, but also on the relationships among members (Cheaks et al., 2006).

The Biosecurity ecoliteracy (BEL) is a kind of transformative learning which employs basic concepts of ecology to promote in-depth understanding, creative thinking, critical reflection, social skills, and self consciousness in managing plant living/health, animal (including human) living/health and issues associated with the environment (Surata et al, 2009). The successful application of BEL to students depends on how far we are able to facilitate the teaching-learning process as social learning. Its involves interactions for the exchange of ideas, experiences, views and beliefs in the hope that such interaction will mutually influence the actors involved, which in turn transfers knowledge about science that can occur among all actors, thus leading to a creative, interactive and reflective knowledge transfer about science (Prell et al., 2006; Surata, 2010). The reason why we are testing the usefulness of BEL as a positive form of social learning is because biosecurity management, as an engagement of multiple and cross-sectoral stakeholders in government, organisations and communities, is truly interdisciplinary: the definition and interpretation of risk and adverse effects are socially constructed and contextually dependent (Galbraith & Clendon, 2009; Surata, 2010). Moreover, community participation is a key ingredient in the management of biosecurity, particularly as awareness and early reporting are important strategies in reducing the time taken to identify an incursion and minimize its impacts (Aus-Indo BIOCOM, 2009). Thus BEL, through social learning for teacher training students, could have strong capability both to educate the adult teacher and influence leaders of the future, not only "about" but "to be" aware, in-depth, creative, critical and interactive in facilitating social learning of biosecurity management. It is expected that social capital is included in this process, because social learning is about relationship, reciprocity and networks. Social capital refers to "social organization, and connections among individuals forming the social networks and the norms of reciprocity and trustworthiness that arise from them" (Putnam et al., 1993:167,170; Putnam, 2000:19). BEL is actually a mechanism to build social capital among trainees by empowering them to develop the main components of social capital such as trust, norms of reciprocity and engagement in networks (Van Schaik, 2002).

This paper presents a case study of how SNA was applied as a tool for assessing quantitatively the achievement level of social capital in biosecurity ecoliteracy (BEL) through a cooperative learning approach with undergraduate teacher-training students. SNA was used because it has been used in very diverse scientific and technological disciplines, such as psychology, health, business, organizations, communications, leadership and learning networks (Cross et al., 2002; Aviv et al., 2003; Lopez-Fernandez et al., 2004; Prell et al., 2006; Daniel & Beng-Chong, 2007; Tilton, 2008; Serrat, 2009). SNA was effective, accurate and successful tool for understanding, identifying, measuring and mapping social networks. Cross et al (2002:6) showed SNA could be a very effective tool for promoting collaboration and information sharing within expert consulting groups. Tilton (2008) found a model for attempting to use online social networks in the prediction of elections of a connected social group (the university). Meanwhile SNA was also implemented in learning research, such as in evaluating cohesion, role and power of network structures in asynchronous learning networks (Aviv et al., 2003); combining SNA with qualitative evaluation for study of classroom social interactions (Martinez et al., 2007); designing participatory activities and evaluating social learning (Prell et al., 2006).

These references support our own curiosity as how to learn more about how accurately SNA as tool identifies social capital in transformative learning of BEL. The questions for this research are how can data on personal interactions help to explain the generation social capital? How these interactions are spatially distributed? Are there significant differences in SNA measurements, between before and after ecoliteracy of biosecurity?

METHODS

The general focus of this research is on the social dimension of cooperative learning using the egocentric network approach. It done by utilizing tradi-

tional surveys, asking each respondent to whom they have interacted with, as well as the relationships within those interactions. While information on social network can be obtained pragmatically through surveys. A very informative social network diagram can be generated from a 10-15 minutes survey assessing information or knowledge flow among members of a group (Cross et al., 2002). Ego network analysis involves assessing the network qualities of a person (size, diversity, average income, etc.) or relation between their attribution of ego with the attribution of their alters (homophily). This is usefull for understanding how network affect individuals, and it will also give (incomplete) a picture on the general texture of the whole network (Hanneman, 2001:9). Ego network analysis is extremely convenient since it can be used in conjunction with random sampling, enabling classical statistical techniques for hypothesis testing.

By assuming the social cohesion of cooperative learning as an emerging spatial network of a person, 30 participants (12 males and 18 females) from undergraduate teacher training students were employed to become subject of biosecurity ecoliteracy. They were 3th semester students of the Biology Education Department at Mahasaraswati University Denpasar. The following steps were taken: (1) Identifying group members. We divided students into 6 groups, each consisted of small member (5-6 students). Pre-lecture then was conducted to ensure that the group were diverse in gender, race, ability levels and position in class network (Fig 2a); (2). Asking each student twice (before and after learning) to choose 5 of their classmates with close relationship with them; (3). Lecturing student with biosecurity ecoliteracy. This was conducted by using cooperative-learning structure based on artistic-product approaches (such as concept map, advertorial, flow chart, ecoART, illustration, oral report, concept note and Power Point). The lecture content was divided to 10 topics, which consisted of 14 time classroom courses as well as indoor and outdoor site visits (each twice). The syllabus, handouts, materials and rubric of evaluation were distributed to students a week before each lecture. We employed 3 groups of reviewer (i.e lecturers, senior-peer, and self reviewer) to evaluate the achievement levels of cooperative learning (Surata et al., 2009). 5). Analysing data with UCINET sofware (Borgatti et al., 2002) for measuring several measurements and visualizing data in the form of social-network map (sociogram). We then measured the density for overall network index (Table 1). The three indices, Betweenness Centrality, Closeness Centrality and Degree centrality (Table 1), were measured for understanding the extension of classes which are organized around particular focal points, as well as to identify which nodes are in the 'center' of the network (Moody, 2004).

At the end, we constructed a sociogram, where actors are represented as nodes and the links among them as lines in the graph (Martinez et al., 2003:7). It works as an understanding of new ways in presenting and managing data, while effectively convert the data into meaningful information.

RESULTS AND DISCUSSION

Result

The index of density (0.169) and the number of ties (147) after treatment (POS) was a bit higher than before treatment (PRA) (i.e. 0.160 density index and 139 ties). But all together both density of relationships were relatively low, only 16.0 to 16.9 percent of all ties were present.

Table 1. Some Social Network Analysis Measures and their Meanings

Measure	Meaning	Relation with social capital
Between ness centrality	The number of times ego needs to reach the other via the shortest path between the other two actors (Daniel & Beng-Chong, 2007).	**Positive:** actors with high between ness has great influence, whereas link together actors who are otherwise unconnected, creating opportunities for exploitation of information and control benefits (Borgatti et al. 1999; Krebs, 2006). They can either act as brokers (facilitators of information exchange), or as gatekeepers (i.e. they selectively prevent the passage of information) (Hanson et al., 2009).
Density	The proportion of all ties that could be presenting what actually are (Hanneman, 2001).	**Positive**: the higher the density the more connected department are within the network (Daniel & Beng-Chong, 2007)
Degree centrality	The number of direct connection or ties the actor has (Hanneman, 2001; Krebs, 2006).	**Positive:** more people we have in relationships, the greater the chance that one of them has the resource we need (Borgatti et al., 1999). The actor with the most ties is the most important (Moody, 2004).
Closeness centrality	The sum of the shortest path (geodesic) between an actor (ego) and other actors within the network (Hanson et al., 2009).	**Positive:** class with high closeness has the shortest path to the others – they are close to everyone else (Krebs, 2006). An actor is considered important if he/she is relatively close to the other actors (Moody, 2004).

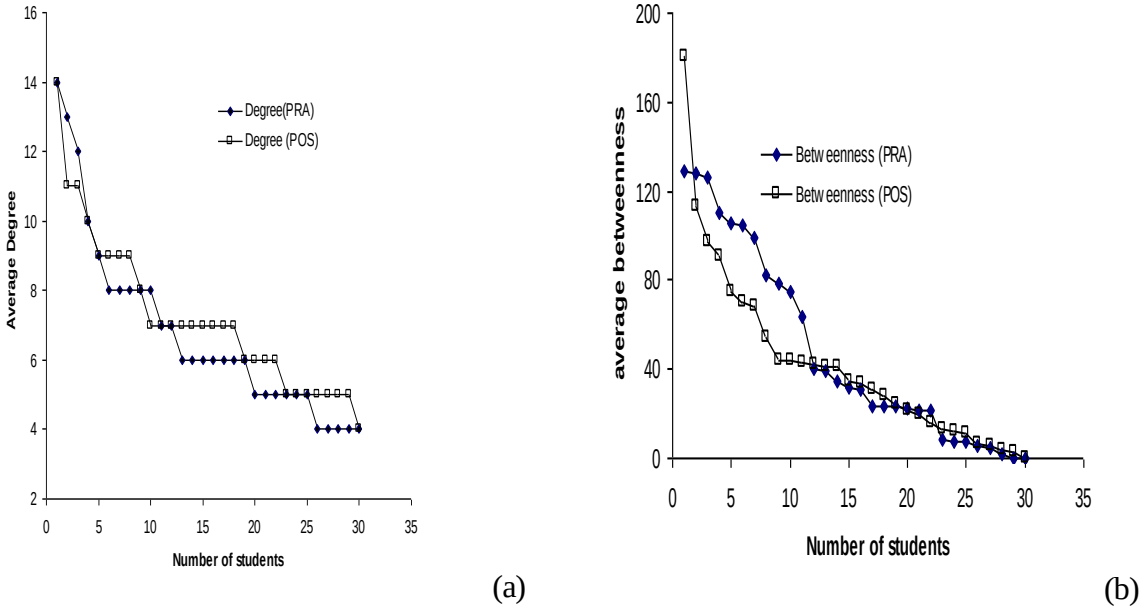
The average degree of centrality for the POS (7.20±2.250) was higher than the PRA (6.8±2.644). This difference was statistically significant ($t_{2:29}$= *2.845; p=0.008*). On the other hand, the variance of the POS (3.486) was lower than the PRA (3.930). These mean that the conditions of students in class after treatment are more homogenous than before treatment. Figure 1A shows that the majority of the students have higher degree of centrality at POS rather than PRA. It was also found that 3 to 4 students have strong degree of centrality position (Figure 1a).

Suprisingly, betweenness centrality for the POS (42.167±39.267) was a bit lower than the PRA (48.367±43.609), but it was not significantly different ($t_{2:29}$*=1.868; P=0.072*). Perhaps, this was because the majority of the students who scored below 40 points at PRA tended to increase their score after they participated in biosecurity ecoliteracy. On the contrary, students who scored higher than 40 points at PRA tended to decrease their score. It wasalso found that after treatment one of the students has a higher betweeness centrality (Figure 1b).

Table 2 shows four types of closeness centrality that were measured. Both mean and variance of Farness for POS were lower than PRA. On the other hand, closeness mean and variance after treatment were higher than before treatment. There are statistical differences for outFarness (t2,29=19.010; P=000), inCloseness (t 2,29=5,418; p=000) and outCloseness (t2,29=16.570; p=000). These indicate positive relation with social cohesion; because the sum length of geodesic distance of students tended to shorten, the other way the number of links that the class took to get to everyone else tended to increase.

Farness is the sum of length of the geodesic to everyactors. In Closeness the total number of links for other actors to get to the target actor; outCloseness the number of links of an actor to get to other actors; inFarness is the the sum of length of the geodesic for other actors to get to the target actor; outFarness is the sum of length of the geodesic for target actor to get to the other actors.

The average degree of centrality for POS was higher than PRA. It had a positive correlation with social capital, because the direct connection of students after treatment was higher than before treatment. In contrast, the standard deviation and variance before treatment are higher than after treatment. These mean that the condition of class after treatment was homogeny than before treatment, or else more people has increase their degree of centrality than before treatment (Table 3).



(a) (b)

Figure 1. The Degree Centrality and Betweenness Centrality between Before (a) and After (b) Biosecurity Ecoliteracy

Table 2. The Closeness Centrality Between Before and After Biosecurity Ecoliteracy for Undegraduate Teacher Training Students

Values	inFarness		outFarness		inCloseness		outCloseness	
	Pra	Post	Pra	Post	Pra	Post	Pra	Post
Mean	114.27	99.20	114.27	99.20	39.15	41.51	28.14	29.55
Std. Dev.	167.90	144.69	7.68	9.54	11.98	12.41	2.05	3.34
Variance	28189.47	20920.50	58.93	90.89	143.52	153.89	4.19	11.14
Minimum	50.00	44.00	89.00	67.00	3.53	3.33	25.20	24.79
Maximum	1056.00	870.00	127.00	117.00	64.00	65.91	35.96	43.28

Table 3. The Comparison of Degree Centrality between Before and After Biosecurity Ecoliteracy

Values	Degree		NrmDegree	
	Pre	Post	Pre	Post
Mean	6.80	7.20	23.45	28.83
Std Dev	2.60	2.21	8.97	7.63
variance	6.76	4.89	80.39	58.19
Minimum	4.00	4.00	13.79	13.79
Maximum	14.00	14.00	48.28	48.28

Degree (the number of direct connection student has); Nrm (normalizes) the value in matrix, mean is normalizes to be zero this achieved by substracting from every rows, columns, or matrix and multiplying by 100, standard deviation is normalizes to be one. It is by dividing the rows, columns or matrix by the current standard deviation.

The average number of relationships maintained by network members (average degree) increased, while the average distance (average Farness and Closeness) for separating actors reduced after treatment. Similarly, the centralization index (from 0.103 to 0.176) as well as network centralization index (from 0.313 into 0.334) increased. The BEL did have influence on social structure of network, and members of the network were much more likely to be clustered in groups (Figure 2). By comparing social structure between PRA (Figure 2a) and POS (Figure 2b), it can be identified that five to six groups of students had formed strong cliques after participating in ecoliteracy of biosecurity, while the members of the other group were still separated in several positions.

Discussion

The results from several SNA measurements (except betweenness of centrality) and social mapping, support our hypothesis that our model of biosecurity ecoliteracy through cooperative learning can effectively promote social capital of learners. It was also found that SNA is a usefull tool to evaluate social capital achievement levels of BEL in terms of network cohesion and network structure. Thereby, our finding supports previous researchers that SNA can be used as a usefull tool for revealing network structure of cooperative learning groups (Aviv et al., 2003). SNA has a lot of advantages in helping us to understand students' position in the network and indentifying which group is a clique (Daniel & Beng-Chong, 2007). Our quantitative analysis of the pre and post-course questionnaires reflects an improvement in students' perception on their academic understanding of BEL (Praptiningsih, 2010). While from rubric of observations, these studies yield an increasing social skill and cooperative process (Ekayanti, 2010), as well as team skill partnership in power point presentation (Gunawan, 2010).

However, SNA by itself is not enough for achieving a full understanding of the problems, and needs to be complemented with other methods, like qualitative data analysis (Martinez et al., 2003:2). In consequence we need to use mixed methods in which quantitative data can be used as an account for the occurrence of an action or event, and relate them with the qualitative catagories, while qualitative data such as those obtained througth observations, questionnaires, interviews are used to capture the perceptions of the participants (Martinez et al., 2003:3). Actually we have collected data by observation, questionnaires and focus group discussion (it will be reported in other article), but mostly are still limited for quantitave analysis (such as questionnaires with closed-ended questions and observation with forms of rubric). Therefore, some directions for future research that come to mind are the following: (1) *ethnographic approach* for qualitative analysis mainly through open-ended questionnaires, in-depth interviews and focus group discussions; (2) *bridging network* among groups. We will look to see how each group makes connection with other groups and also with other groups behind the linking ties. Such bridging ties are important to make decision in facilitating community action; (3) *network Dynamics*:

One fascinating direction is an inquiry into the time development of network structures. When do cliques develop? Are they stable? What are the network structures that determine this behavior? (Aviv et al., 2003).

CONCLUSION

Personal data obtained through egocentric network approach can describe the development of social capital, in the form of social cohesion and social structure. This is based on valuation by using several SNA instruments. Both density and centrality degree indices were higher after than before ecoliteracy of biosecurity. These indicated when learning has been done, there are more connections among learners, and they therefore have more chances to work together. While closeness centrality is lower after ecoliteracy means that the sum length of the geodesic distance of students tended to shorten, as well as the number of links the class took to get to everyone else tended to increase. The sociogram showed that, the spatial distribution of learners after learning were much more clustered in groups. Thus, in addition to the fact that the cooperative learning that we have implemented in our models of biosecurity ecoliteracy was able to promote social capital of the learners, SNA was found to be an effective, accurate and powerful tool to evaluate social capital in terms of network cohesion and network structure.

The results in this paper have highlighted a number of areas needing further research. Three in particular are worth noting, i.e ethnographic approach, bridging network and social dynamics. Understanding these areas are crucial if we wish to achieve a comprehensive perspective that can to show why and how social network analysis works in assessing social capital.

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