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Team structure and team performance in IS development: a social network perspective

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Abstract

Teamwork during IS development (ISD) is an important issue. This paper discusses the relationship between team structure and ISD team performance using a social network approach. Based on empirical evidence collected from 25 teams in a system analysis and design course, we found that:

(1) Group cohesion was positively related to overall performance.
(2) Group conflict indexes were not significantly correlated with overall performance.
(3) Group characteristics, e.g., cohesion and conflict, fluctuated in different phases, but in later stages, much less cohesion occurred and the advice network seemed to be very important.
(4) Group structures seemed to be a critical factor for good performance.

Further in-depth studies were conducted on teams exhibiting the highest and lowest performance to determine their differences from a sociogram analysis perspective.

Keywords: Information system development; Social network analysis; Teamwork

1. Introduction

Information system development (ISD) is very important. Software development is considered to be one of the top 10 critical IS issues in the world [49]. The personnel involved in developing an IS include users, system analysts, programmers, and project managers; hence, it is usually the outcome of ISD team member interactions. However, the deep and dynamic nature of team structure has not been appropriately addressed in IS studies and thus it is valuable to conduct research into the social processes among teammates in order to understand the key predictors of IS performance [22,23]. The objective of this study was to explore group structure and ISD team performance from the viewpoint of social network analysis, a powerful tool that can be used to uncover the inner structure of a group.

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2. Literature review

There is a relatively large body of literature on the effects of teamwork in various disciplines, such as organizational behavior, industrial psychology, and management [11,42,46]. In a classic study, Gladstein [16] proposed and empirically tested a model for group behavior. In this, he included independent variables at the group level (group composition and structure) and organizational variables (resources available and organizational structures). His dependent variables included process and group effectiveness, while the moderator variable was the group task. In a review paper, Paris et al. [39] identified at least eight theoretical approaches to the teamwork concept. Langfred and Shanley [28] gave a clear picture of past research and discussed the trend toward small group research. Several studies have been conducted to gain insight into team member interaction factors and organizational productivity [5,19,24]. It is quite clear that teamwork is not only an interdisciplinary research topic, but also of practical concern to managers and employees.

In recent years some scholars noticed that social structure could play an important role in teamwork. Thus, concepts from social network analysis, such as centrality, centralization, and network density, were added to the study of work satisfaction, performance, and power. Network factors have been found to be associated with job-related perceptions and performance [21,29], academic performance and learning attitudes [1], intergroup conflict [27], and individual performance [45]. If the social structural properties were a dominant factor of individual and group performance, it is likely that the social structures of an ISD team could influence its outcomes. With social network analysis, it is possible to describe the underlying relationships among ISD teammates and probably gain a better understanding of its processes.

In the IS field there has been an effort to find success factors for team performance. Some researchers have examined the personalities of team members, the characteristics of team structure, and communication modes on ISD team productivity [4,8,40,50]. Others have examined the relationship between IS developers and users; this includes the concept of user participation and user involvement [3,9,34]. In addition, the underlying ISD coordination processes have been investigated [12,25,35,36,41,47].

Another two streams of research, computer-supported cooperative work (CSCW) and business process re-engineering (BPR), are also concerned with the ISD teamwork. CSCW deals with the use of computers can be used to support work in distributed places [30], and it has been extended to the complex tasks of ISD, for example conceptual modeling [17], editing, debugging and messaging tasks [2], design methodologies [10], the whole software development life cycle [26] and online collaboration [7]. One focus of CSCW research is to design new tools and methods to overcome distributed ISD problems, with the goal of enhancing ISD team productivity.

Although previous research results were fruitful, the deep and dynamic nature of team structure has not been appropriately addressed in IS studies. Furthermore, little is known about the dynamic relationship between ISD team processes and team performance. Therefore, the objectives of this study are threefold: (1) to explore the variations in team structure during different phases of projects; (2) to identify the relationship between team structure and ISD team performance; and (3) to explore the relationship of a social relational map (sociogram) and ISD performance. Although there are many variables affecting ISD team performance, only three important structural variables, cohesion, conflict and centrality, were included in our study.

3. Social network analysis

3.1. Sociometric analysis

Social network analysis is usually known as *sociometry* in social psychology, psychodrama, and education. It is a method developed by Moreno [31] for estimating the interpersonal relationships within a group. In an article ‘‘Ontology of Sociometric Theory’’, he argued that the ‘‘internal, material structure of the group is only in rare instances visible on the surface of social interaction; and if it is so, no one knows for certain that the surface structure is the duplicate of the depth structure’’. It offers us a good chance to describe and delve into the ‘‘deep structure’’ of human relationships. Several disciplines mingled and gave birth to a theory of the modern social network, which is a frequently used term in the literature. The social network perspective encompasses theories,

models, and applications that are expressed in terms of relational concepts or processes. That is, relations defined by linkages among units are a fundamental component of network theory.

3.2. Key concepts

Some group characteristics, e.g. cohesion, conflict, and leadership, have been widely studied and associated with team performance. However, seldom is research designed to understand the dynamics of team structure and performance. Social network analysis provides an excellent tool to capture the underlying interaction processes within teams.

Centrality is one of the most important concepts to have been developed. The idea is that if a person is central in his or her group, he or she is the most popular and gets the most attention. In the early sociometry literature, centrality was termed social status [48] and the sociometric concept of ''star'' refers to the same idea. Intuitively, a point is central if it is at the center of a number of connections and the simplest and most straightforward way to measure ''*point centrality*'' is by its degree-of-connectivity in the graph. A degree-of-connectivity measurement of point centrality reflects only the intuitive notion of how ''well'' a point is connected within its local environment; therefore, it is also termed ''*local centrality*''. In a directed graph, local centrality can be classified into in- and out-centrality. The measurement of local centrality has a major limitation: comparisons of centrality score can only be meaningfully made among the members of the same graph or between graphs of the same size. Freeman [15] proposed a relative measure of local centrality in which the actual number of connections is related to the maximum number that it could sustain. This gives a more general approach to the measurement of local centrality.

There are several group characteristics, and the most important are cohesion and conflict. Their definitions in social network analysis were different from common sense definitions, since the group indexes here just measure the structural properties numerically.

Cohesiveness is defined as ''the forces holding the individuals within the groupings in which they are''. Although a few scholars do not agree with this definition [51], we take it for comparing our research results to previous ones.

Sociograms were designed to illustrate the structure of informal relations within the workgroup in the Hawthorne studies [43]. They were constructed to show each of a number of aspects of group behavior: involvement in games, job trading, helping, and friendship, and antagonisms. In sociograms, a circle represents a person and arrows represent relationships between them; positive and negative relations exist. The lines in a graph can be given signs (+ or −) to indicate whether they refer to 'positive' or 'negative' relations, and they can be given arrowheads to indicate their 'direction', which is attached to a line is a way of distinguishing person A's orientation relative to person B from B's orientation relative to A.

3.3. Operational definitions of group structural variables in the study

Group cohesion index is the ratio of positive mutual relationships to all possible ones. The rationale is that if many positive relations exist in a group, the group is more cohesive. Of course, any member could form more than one positive relation in a group. The key point is to compute the ''reciprocal'' positive relations, no matter how many choices a teammate may make. That is, the group cohesion index in a group is calculated by

$$G_{\mathrm{g}} = \frac{\sum_{i=1}^{N}\left(\sum_{j=1}^{N} A_{ij}^{+}\right)}{(1/2)N \times (N-1)}$$

where A_{ij}^{+} is the number of positive reciprocal communications in the group, and N the group size. Multiplying G_{g} by 100 gives a density percentage of positive group reciprocity in relation to a possible 100%.

On the other hand, the group conflict index is the ratio of negative mutual relationships to all theoretically possible relationships. The rationale is that if many mutual negative relations exist in a group, the group is more in conflict.

In-degree centrality is used to measure how many choices an individual receives from other group members. Out-degree centrality index is used to measure how many choices an individual sends to other members. The in-degree centrality index is the ratio of the number of received to the theoretically maximum number received. The maximum centrality index is used to measure the extent to which a central person exists in the situation.

4. Research method

4.1. Measures of social network analysis

A teammate interaction questionnaire (TIQ) was designed to measure the interaction between team members. An original questionnaire with four positive and four negative questions was designed and pre-tested in two ISD groups at another school. The typical question was "during software development, with which teammate would you most like to discuss using the phone or e-mail?" (see Appendix A for details). However, some students hesitated to answer the negative questions or were unwilling to answer honestly. Therefore, a TIQ was devised to ask positive questions only, and the respondents were told to "rank" her or his teammates by 1, 2, 3, 4, etc. The "negative" relationship could be computed from the "lowest" ranking.

Interactions within an ISD team can include task-related and social-related support. Task-related support might form an information or advice network, and social-related support might strengthen emotional support or the sense of belonging. For the TIQ we adopted Forsyth's [14] classification of social support in teamwork, four dimensions of teammate relationships: advice, leadership, obligation, and social network.

Since different tasks were encountered in each ISD phase, a universal form of the TIQ might not be appropriate. So, three forms of the TIQ were prepared, one for the beginning, middle and end of the semester. (We refer to these as the beginning-term, mid-term, and end-term TIQs. Please see Appendix A for details) The items in the TIQ were sampled from Hoffer et al. [20,37].

Advice networks consisted of relations through which individuals share resources, such as information, assistance, and guidance, that related to the completion of their work. During ISD, various tasks could be achieved through the exchange of resources. Therefore, an advice network seems vital to success. All work-related items in our questionnaire implied advice networks, for example, "if paper work is needed, who is the most suitable for this task?" The beginning-term of the TIQ consisted of one item of this kind; the mid-term TIQ had four, and the ending-term of the TIQ had 10 items.

Leadership is considered to be one of the most important factors in organizational effectiveness [13]. Therefore, it is reasonable to regard it as a vital factor in the ISD group dynamics. We measured leadership in terms of human resource allocation, resolving conflicts, conviction in a belief, ease of being understood, and persuasiveness. The beginning-term of TIQ consisted of one item; mid-term had two, and the end-term had five.

Though seldom mentioned in the literature, obligation or sense of responsibility is believed to be a key factor in ISD, as judged from one of the author's past teaching experiences. Obligation was measured by asking, "Who in your team cares the most about the project's outcome?" or by "Who shows up earliest for each meeting?" or "Who takes up unwanted tasks", etc. The beginning-term of the TIQ consists of one item of this kind, the mid-term had three, and end-term had four.

Social or affective dimension is a kind of interpersonal relationship important to work satisfaction and performance. Social dimension was measured by asking, "Who is the one you would most like to express feelings to?" or "Who is the most capable of dealing with interpersonal relationships?" The beginning-term and mid-term of the TIQ consisted of one item of this kind, while the end-term had two items.

Table 1 shows the four interpersonal relationships in our study and the corresponding items in the three TIQ forms.

Reliability considerations for TIQ: The reliability of sociometric measures has long been addressed and reviewed [32]. Even though its reliability coefficient was not estimated in this study, the question items of TIQ were similar to those used in previous research.

Validity considerations for TIQ: In past studies on the relationship between group sociometric scores and group performance, the criterion validity was established by showing that external criteria were highly consistent with sociometric scores [33]. In our study, all the test items were discussed with an IS expert and all were related to ISD tasks. Therefore, content validity was considered.

4.2. Data collection

Two SA&D classes with 124 undergraduate and 20 graduate students formed 30 groups: 25 consisted of five members, 4 of four members, and 1 of three.

The first TIQ was administered on the day that all groups turned in the first part of their documents (their

Table 1
Interpersonal relationship dimensions of team interaction questionnaire

Dimension	Phase			
	Number of items in the beginning-term	Number of items in the mid-term	Number of items in the end-term	Item number in the final-term questionnaire (refer to Appendix A)
Advice	1	4	10	1, 3, 4, 5, 13, 14, 16, 18, 20, 21
Leadership	1	2	5	2, 8, 15, 17, 19
Obligation	1	4	4	6, 7, 9, 11
Social	1	1	2	10, 12
Total of items	4	11	21	

live case background descriptions), the second part was administered during the mid-term examination and the third during the final exam. Open-ended questions were also provided in the final-term TIQ in order to collect some qualitative data. All students turned in the three questionnaires.

4.3. Sociometric software

There are numerous sociometric packages already available. UCINET, GRADAP, and KrackPlot are some common packages. We took SociometryPlus 2.0β which was purchased on the Web.[2] The reason of using this was its ease of use and suitability. It can be used to provide individual indexes, group indexes, and sociograms.

4.4. Project tasks and grading procedures

ISD project assignments were announced on the first week (February 19) of the spring semester. All students were required to form a project team of size three to five before 12 March. They then visited organizations to develop live case information systems. The project score accounted for one third of the final grade. To simulate some scheduling pressures, if the project were submitted one week ahead of the deadline (8 June), a 5% bonus was added to the project score. On the other hand, a delay would be seriously punished. If a project were delayed, 5% would be deducted on a daily basis.

The firms in the live cases varied from banking (e.g., Bank of America, Taipei) to a local cosmic store. At the end of the semester, teaching assistants (TAs) telephoned every target firm to make sure that it had a live case and had filled out a software quality questionnaire that collected users' judgments.

All four graduate group projects were distributed to a Ph.D. TA and the remaining projects were assigned randomly to the two TAs. To make the grading as objective as possible, a scoring guideline (Appendix B) was formed ahead of time and the five groups submitted early were graded by both TAs.[3] After discussing the discrepancies among the five groups, they decided to grade all the DFDs and structure charts for the remaining groups at the same time. Thus, the sub-scores for DFDs and structure charts of all groups were obtained by averaging two TAs judgments.

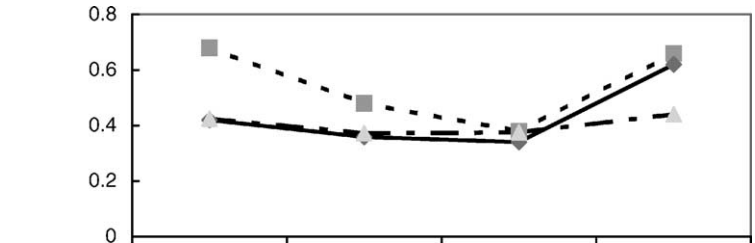
5. Results

5.1. Profile of respondents

Interaction between four members could not be analyzed with SociometryPlus 2.0. Therefore, only 25 groups (125 students) were included in the analysis. All students had taken a prerequisite basic computing course. Thirty-two percent of the sample students were female. Eight groups consisted of all male members, and two consisted of all female members. Four groups consisted of all MIS graduate students and one consisted of all non-MIS major undergraduates. The average age of undergraduates was 20, and graduate students, 28.

[2] Available at http://www.thesociometry.com/.

[3] No group project was submitted after deadline.



	ADVICE	LEADER	OBLIGATION	SOCIAL
Initial	0.68	0.48	0.38	0.66
Mid	0.42	0.36	0.34	0.62
Final	0.42	0.37	0.38	0.44

Fig. 1. The average cohesion index variation among different ISD phases.

5.2. Analysis of cohesion

Cohesion index refers to the ratio of the number of existing positive relationships to the theoretically maximum number of positive relationships in a group under a certain criterion. Therefore, each group has a cohesion index at each criterion. The average cohesion indexes (across all groups and one dimension) in all three ISD phases are shown in Figs. 1 and 2.

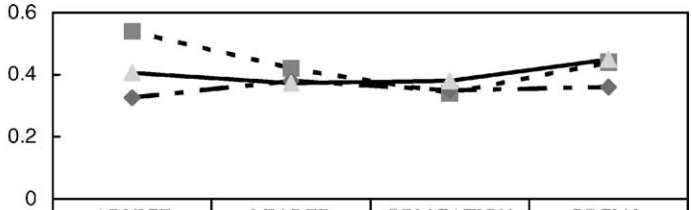
It is quite obvious that the cohesion index fluctuated between different ISD phases. At the start-up, the cohesion of the advice network was high, but as the project progressed, much lower cohesion resulted. In the mid-term and end-term, there was no difference in cohesion of the advice networks. This can be interpreted as follows.

Each group was self-selected: probably each person sought out others with whom he or she preferred to work. Thus, during the beginning phase, most team members were satisfied with their team. However, during the execution of the ISD tasks, each team member became more acquainted with other team members. If someone could not give other members sufficient information, or could not meet deadlines or other work constraints, the index of cohesion was likely to decrease.

With leadership, the same pattern occurred. Initially, several groups had positive relationships among members, possibly because team members formed a team with a potential leader. However, as the project progressed, they might become a little disappointed with their potential leader.

With regard to obligation, there was no noticeable difference in different phases. Probably a sense of responsibility is a stable personal trait.

For the social or affective dimension, the pattern is a little different. Cohesion in the social dimension was



	ADVICE	LEADER	OBLIGATION	SOCIAL
Begin	0.54	0.42	0.34	0.44
Mid	0.33	0.38	0.35	0.36
End	0.41	0.37	0.38	0.45

Fig. 2. The average conflict index variation among different ISD phases.

almost the same in the first two phases but lower in the final one. The most reasonable explanation is that only one item (''Who is the one you would most like to express feelings to?'') of social dimension had been provided on the first two phases. And the additional item ''Who is most capable of dealing with interpersonal relationships'' in the end-term questionnaire would measure capability other than popularity. Excluding this item, it seems that social relationships were also stable in different phases.

In summary, cohesion varied under different conditions. It seems that the advice network changed the most during the different phases. No distinctive change happened with regard to obligation and social networks.

5.3. Analysis of conflict

Hindrance exchange relations usually have been described in terms of such behavior as interference, threats, sabotage, and rejection as well as relations to affective responses to such behaviors, including annoyance, emotional upset, and anger [38]. The conflict Index measures the percentage of the number of actual negative relationships divided by the theoretically maximum number of negative relationships in a group under a given criterion. Since it is difficult to measure valid data about negative relationships, researchers measure negative exchanges such as avoidance or adversarial relationships. In our study, the ''least positive relationship'' was used to stand for the negative relationships in four dimensions of inter-teammate relationships. It seemed better to describe the resulting network as adversarial, since we did not measure the conflicts in a group directly. Therefore, the following results must be interpreted with caution.

With respect to the adversarial advice network, some variations existed in different phases. At the beginning of the project, a high conflict index occurred (on average, more than one pair in a team least liked to work with another). However, during the SA&D phase or implementation (IMP) phase, teammates probably worked closely and became acquainted better. As a result, the initial negative impressions modified a little and the conflict index decreased. At the completion of project, the adversarial advice network returned to some degree.

With regard to the adversarial leadership or obligation network, there was no noticeable difference among phases. Leadership and sense of obligation are stable personal traits, even when measured in terms of least positive relationships.

For the adversarial social network, there was little difference between the initial and final phase. However, the conflict index was slightly lower during the middle phase. During the SA&D phase, there were fewer negative social relationships, although relatively little. Probably the lower adversarial relationship during this phase was better for the project.

5.4. Analysis of centrality

Centrality is a key concept in social network analysis. As far back as Moreno, researchers attempted to quantify the notions of sociometric ''stars'' and ''isolates''. An actor in a network is prominent if he or she ties to others to make the actor particularly visible to the other actors in the network. Thus, at the individual level, centrality is an index of prestige or social status. If an actor is central, she or he can access resources, such as task-specific knowledge and important information about work-related issues.

To compare the ''centrality'' between groups, we need some group-level measures. Freeman gave a convenient, mathematical definition for a group-level index of centralization and it became widely used in the literature. Unfortunately, the ''relationships'' in our study were directional and no existing appropriate group-level measures were applicable. The maximum centrality of an actor in a group was adopted here. We hope that it will prove to be a useful measure of the extent to which there is a pivotal person under a certain criterion. The higher the maximum centrality index, the more the actor can influence a certain criterion or task.

Only significant Pearson product correlations are shown in Table 2. The most striking result is that centrality of item 6 (sense of responsibility), item 14 (user requirements) and item 20 (organizational goal) correlated positively with the total project performance. When there was a team member who cared strongly about the success of the project, even though he or she was not necessarily the formal leader, there was a tendency for that person to take the responsibility of fulfilling the requirements. If there was a person on the team in charge of eliciting user

Table 2
Correlations between maximum group centrality index and project outcomes[a]

	I1	I2	I4	I5	I6	I7	I10	I11	I12	I14	I20	TA	SA	SD
I9	–	0.49*	–	–	–	–								
I11	–	–	–	–	0.40*	–	–							
I12	–	–	0.40*	–	–	–	–	–						
I14	0.43*	–	–	–	–	–	–	0.53**	–					
I16	–	−0.46*	–	0.41*	–	–	–	–	−0.51**	–				
I18	–	–	0.44*	–	–	–	–	–	–	–				
I20	0.50*	–	–	–	0.41*	–	–	0.49*	–	0.61**				
I22	0.45*	–	–	–	–	0.46*	0.44*	–	–	–	0.41*			
TA	–	–	–	–	0.43*	–	–	–	–	0.45*	0.53**			
SA	–	–	–	–	–	–	–	–	–	0.48*	0.52**	0.90**		
SD	–	–	–	–	–	–	–	–	–	–	0.41*	0.92**	0.68**	
IMP	–	–	–	–	–	0.41*	–	–	–	–	0.40*	0.61**	–	0.56**

[a] TA stands for total project score; SA is the sub-score for system analysis; SD for system design; IMP for implementation.
* $P < 0.05$.
** $P < 0.01$.

requirements and acquiring necessary domain knowledge, even though the ISD projects were just course exercises (not in the field organizations), then there was a better chance of guiding the ISD life cycle to success.

As for the other relationships, three groups of significant correlations were observed: (1) items 4 (document preparation) and 18 (clear expressions in documents), (2) items 5 (programming) and 16 (efficient coding translation), and (3) items 14 (user requirements) and 20 (domain knowledge). Document preparation, coding, and system analysis are three different types of task. While investigating the raw data in the study, it was found that the central person in the document preparation or the same as the central person who could do the job best. Thus, the three groups of correlations reflect three types of tasks that could be taken by different team members.

While investigating the SA, SD, and IMP subscores, some other interesting trends were observed. If a person shows up early for the meeting, there is a tendency for the team to perform better in the IMP phase. This suggests that some tasks during the IMP phase can be better handled by pro-active teammates. Also, where there was a key person responsible for domain knowledge (item 20), there was better performance in all ISD phases. Domain knowledge seems to play a very important role in guiding ISD directions.

Item 22 offered a chance for teammates to choose team members in a possible future setting. Item 22 was correlated positively with item 1 (most preferred member for discussions), item 7 (showing up earlier), item 10 (expressing feelings) and item 20 (domain knowledge). It seems that the more a person was apt to take the initiative, to care about other's feelings, to gain better domain knowledge, and to be popular in the workplace, the more likely other team members would prefer to work with him or her.

There are two negative correlations in Table 2, item 2 (project rescheduling) with item 16 (coding translation), and item 12 (interpersonal relationship) with item 16 (coding translation). Maybe when there was a coding expert in the team (coding might occupy a high proportion of resources in students' projects), it was less important to adjust project schedules. Similarly when there was a project scheduling expert, it was less important to rely on a coding expert. By the same argument, if there was a team member who could handle interpersonal relations very well (implying that resources could be allotted easily and efficiently), it was less important to have a coding expert.

5.5. Relationship between cohesion index, conflict index and performance

The basic statistics of project scores are given in Table 3. The two-sided Pearson correlations were computed for cohesion index and performance. Only significant results are shown in Table 4.

Table 3
Basic statistics of performance scores[a]

Performance	TA	SA	SD	IMP
Maximum	2625	1134	924	630
Minimum	1745	675	500	530
Mean	2289	940	770	580
Standard deviation	208	104	106	28

[a] TA represents total score, and SA the sub-score for system analysis, SD for system design and IMP for implementation.

The cohesion of items 1 (like to work most) and 20 (domain knowledge) was correlated positively with total project scores. While scrutinizing the sub-scores, the impact of work relations and domain knowledge relations were different. Cohesion on work relations played a critical role in every ISD phase, although IMP influence was less. The cohesion of domain knowledge seemed to exert an influence on SA scores, and partially influenced SD scores.

While items 6 (the one who cares most about the project) and 12 (interpersonal relations) were correlated positively with IMP sub-scores, it was quite surprising to find that the cohesion of item 4 (suitable for documents preparation) was correlated negatively with IMP sub-scores. A number of tasks had to be integrated during the IMP phase. Document preparation was just one such task. It was usually done by one or two persons. It seems that if the cohesion on document preparation were high, the more positive mutual pairs would exist in a team. In such a case, probably more than one person was responsible for the documentation task, and thus more coordination and time was needed to keep the whole document consistent and reliable. However, it was just a term project and students often made their greatest effort very close to the deadline. Therefore, most teams did not have enough time to coordinate and refine their final documents.

Table 4
Correlations between cohesion index and performance outcomes[a]

Item	TA	SA	SD	IMP
I1	0.50*	0.48*	0.44*	0.28
I4	−0.11	−0.23	0.13	−0.45*
I6	0.27	0.18	0.23	0.41*
I12	0.29	0.18	0.28	0.48*
I20	0.42*	0.52**	0.31	0.06

[a] TA represents total score, and SA the sub-score for system analysis, SD for system design and IMP for implementation.
* $P < 0.05$.
** $P < 0.01$.

Interestingly, the only significant correlation between conflict index and performance was the pairing of item 9 (who is more likely to take unwanted jobs) and IMP sub-score, which had a correlation of -0.51 and $P < 0.01$.[4] The negative relationship between IMP performance and conflict index in item 9 implies that the greater the number of mutual negative pairings regarding taking the unwanted jobs (denial of responsibilities), the poorer the quality of the IMP of projects would be. Actually, all scores were related negatively to item 9 on conflict index, but the only significant sub-score was IMP, implying the relative impact is different on all phases. We do not suggest that conflict resolution and management is unimportant, but assert that the effect of utilization of all human resources in a small project is limited.

5.6. Sociogram analysis

Here we present an analysis of the best performing team and the poorest performing team. The choice of best and poorest is based on their final project scores. Certainly, there are many variables affecting team performance. However, we did not intend to cover all factors, but just emphasized the ''internal structure'' of teams and assumed that it could provide some information explaining the final outcomes.

Demographics of these two teams were equivalent: all team members were sophomores with an MIS major and had similar abilities and computing experience. However, as shown in Fig. 3, there was a noticeable structural difference between the poorest and best performing team. Note that the dashed lines represent adversarial relationships between actors and the solid lines represent positive ones. Each node with a capital letter stands for an actor on a team. Generally speaking, the best performing team exhibited a better team structure. In particular, there were two positive pairs, {I and L} and {U and E}. The more positive pairs that existed in a group, the more cohesive was the team.

[4] Since only one coefficient was significant, the table ''correlations between conflict index and performance outcomes'' was omitted.

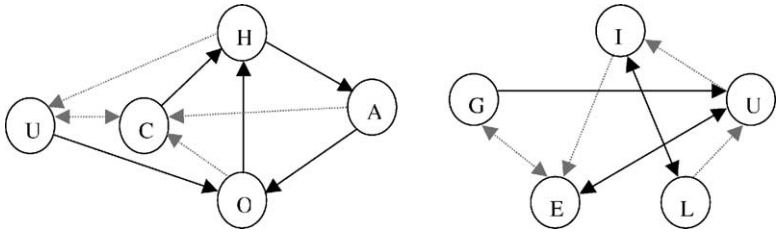


Fig. 3. General sociogram of a low performance team (left) vs. a high performance team (right).

However, no positive pair existed in the poorest performing team. With respect to adversarial relationships, there was not much difference between the two teams. But, in the poorest team, actors C and U were almost ''isolated''. This relationship implied that C and U were not popular in their team and could be the most difficult people to work with, talk to, or relate to in tasks. In a follow-up review with the team leader, it was learned that C and U took less of a role in the project during the last phase. However, in the best team, actor E also had many negative relations, but the adversarial ones were more diverse. This implied that general negative relations of the best team could be alleviated, resulting in everyone having some function. On the whole, the high-performing team was more cohesive and had less conflict.

Note that a triangle formed between H, O and A in the low-performing team. In a digraph like this, the relationships were not balanced. For example, if A liked to work with O, and O liked to work with H, the balanced situation should be that A liked to work with H. Such a balance was found in early sociometric studies, and Heider [6,18] proposed that every person has a tendency toward balance. He explained ''the tendency toward balance is a tendency of the parts of the cognitive field not to quarrel with each other, to be accommodating, and to make up a harmonious family. Parts that are connected in some way should fit each other, should be concordant, and so it is very plausible that parts that are connected as cause and effect will also be seen as fitting each other''.

If there is an imbalanced situation in an advice network, it is not easy to reach a consensus in a task. For example, if A regards B as the most suitable person for a certain task, B considers C as better, and C thinks A better, then it is easy for them to deny their own responsibilities since they think other team member(s) should take charge.

The follow-up interview with the leader of the poorest performing team leader revealed the meaning of Fig. 3. According to the leader, during the first phase, U took the database design job. Since U did poorly on his mid-term exam, U shrugged off much of his responsibilities and A assumed these duties later. Then, A worked as a coordinator between the team and the target organization, whose CEO was actually A's relative. During the last phase, O, the nominal leader in this team, did the programming and much remaining work. Therefore, the triangle in Fig. 3 expresses the time lag between ''main project tasks'' and reflects diffusion of responsibilities to a certain extent. H completed almost all the paper work on his own and C contributed the least, since he lived far from the other members (who were in the same dorm room). Although most members of this team responded to an open question that they encountered no big obstacles and they rated their performance in this project not bad (average 80 on a 100 scale), the coordination problem was clearly reflected in their sociogram.

Since the domain knowledge (item 20) was found to be a dominant factor contributing to the final outcomes (no matter whether the measurement was centrality or cohesiveness), it seemed insightful to investigate the sociograms of this item in Fig. 4. Again, the best performing team exhibited a central actor I. However, the poorest had no key person on this issue. The H–O–A triangle pattern also appeared in this diagram, but there was some difference, since there was a positive pair between A and U. The structure of this low performing team in this partial sociogram was more balanced than that in the overall sociogram. Also, for the adversarial relationships there was not much difference. But, the high performing team seemed better,

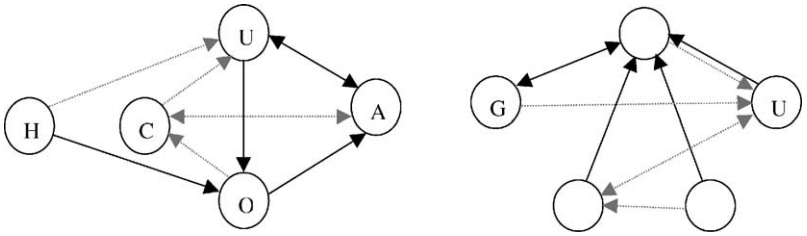


Fig. 4. Partial sociogram (on item 20) of a low performance team (left) vs. a high performance team (right).

since the teammates with the least domain knowledge were U and E. In the low performing team, even the potential key person A was challenged by his team members. Follow-up interviews with O help us understand that O relied on A for some domain knowledge since O believed A to be a domain expert (his relative was in charge of the target organization). On the other hand, A considered U as more knowledgeable on domain issues, because A could not design databases without appropriate industry knowledge. Since O did all the programming, U thought A should understand the business rules and operations (otherwise he could not handle this job properly). The partial sociogram in Fig. 4 did demonstrate some relationships that are difficult to find by other methods.

6. Discussions and conclusion

Few studies attempt to understand the structural variations among different ISD phases. Our study demonstrates that structural properties of work group fluctuate in different phases. Cohesion in an advice network and social network fluctuates more; however, cohesion in a leadership and obligation network was stable in different phases. Likewise, conflict in an advice network and social network changed more drastically among different phases, but conflict in a leadership and obligation network was more stable. This implies that leadership and a sense of obligation should be stable personality traits, but cohesion and conflict on an advice and social network fluctuate more during different ISD phases.

As for the relationship between teamwork and software development performance, cohesion and centrality seem to be better predictors; conflict indexes were not related to final performance. However, the impact of cohesion and centrality on performance varied under different conditions. The striking finding was that the centrality of domain knowledge was a dominant factor contributing to ISD performance. Therefore, it seems that a key person with rich domain knowledge might be a prerequisite for guiding the smooth progress of ISD.

Our finding is not consistent with previous results [44]. Shaw concluded that central positions in groups are related positively to individual performances; however, centralization at the group level was positively related to group performance only for simple tasks. System analysis in our study is certainly not a simple task. Shaw also predicted that no correlation exists between centralization and group performance on complex tasks. No proper index for centralization was given in our study since all the relations were directional. The maximum centrality index was adopted as the group index, which just reflects whether there is a central person in a given condition. Also if there is a central person with rich domain knowledge, the tasks related to domain knowledge might become simple. Actually, tasks should be analyzed in all ISD phases in order to understand all the required knowledge and tasks.

Though our analysis on sociograms was preliminary, the difference between best performing and poorest performing teams was structurally obvious.

6.1. Contributions

The contributions of this study are: (1) It reminds the IS community of a social research method to tackle the ''group processes'' factor. (2) Some important factors were found to be related to ISD team performance; a further systematic investigation of these factors might contribute to the work design for ISD teams. (3) Sociograms might be used as a managerial

tool and enriching our understanding of ISD processes.

6.2. Limitations

There are several limitations in this study.

Firstly, the sample was university students. Therefore, the results should be cautiously generalized to actual work environments since some organizational variables, for example, authority and incentives are different from those in universities.

Secondly, the number of groups was not large; therefore, generalizations of results are uncertain.

Thirdly, there are no appropriate measurement performance tools for ISD, and the course instructor subjectively assigns the weight for each sub-score. The validity of ISD performance measurement was not addressed carefully here.

Although social network analysis is regarded as a powerful tool for diagnosis, analysis and study of group dynamics in many fields, it has not received much attention in the IS domain. It is hoped that our research will serve as a building block for IS team building.

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Appendix A. TIQ (end-term edition)

1. During software development, who is the teammate that you most like to discuss matters with using the phone or e-mail?
2. If project is behind schedule, who is the most capable person in your team to re-adjust human resources?
3. While conducting system analysis and encountering some difficulties in industrial domain knowledge, who is the person most able to deal with this problem?
4. If paper work is needed, who is the most suitable for this task?
5. If a new programming language is needed for this project, who is most capable of learning it?
6. According to your judgment, who in your team cares the most about project's outcome?
7. Who is the earliest to show up for a project meeting?
8. When conflict arises, who is the most capable of resolving it?
9. If there is something that no one is willing to do or take responsibility for, who is the most likely to take up?
10. When you encounter obstacles in your project and feel depressed, who is the one you would most like to express your feelings to?
11. Up to now, who is the one who has devoted the most effort and time to your project?
12. Who is the most capable of dealing with interpersonal relationships?
13. Who can pose the most appropriate questions in order to get needed information?
14. If a user's requirements are unclear, who will ask the user to make clarifications?
15. Who is most committed to an action or belief, even though the action or belief is unpopular?
16. Who is most capable of transforming system specifications into efficient and effective programming?
17. During group meetings, who can express his opinion most clearly and most understandably to others?
18. In writing system documents, who can express his/her (written) opinion in a way that is easily understood by readers?
19. Who is the most persuasive person in your group?
20. In regard to the target corporation or organization unit in your project, who best understands the organizational goals and operations?
21. Who is most capable of transforming user requirements into system specification?
22. If you have a chance to form a new group, who is the one in this current group that you would most like to choose?

Note 1. The TIQ mid-term form consists of questions identical to questions 1–11; beginning-term consists of four questions similar to items 1, 2, 9 and 10, which ask about advice, leadership, obligation, and social relationship, respectively.

Appendix B. ISD project grading schema

The grading schema was devised to measure the learning effectiveness for SA&D course project and the weight for each ISD deliverables was described below:

Item	ISD task	Sub-score	Percentage	Phase in SDLC
1	Corporate introduction	150	5	SA
2	Making the business case	400	13	SA
	System service request	60	2	SA
	Baseline project plan report	100	3	SA
	Statement of project scope	60	2	SA
	Gantt Chart and PERT	120	4	SA
	Walkthrough review form and walkthrough action list	60	2	SA
3	System analysis	700	23	SA
	Interview documents	100	3	SA
	Context diagram	50	2	SA
	DFD of new logical system with CASE tools	350	12	SA
	Data repository and structured English	200	7	SA
4	System design	90	3	SD
5	Form and report design	150	5	SD
6	Dialogue and interface design	150	5	SD
7	Software design (structure chart and pseudocode)	400	13	SD
8	Consistency between DFD and structure chart	150	5	SD
9	Consistency between structure chart and program listing	150	5	SD
10	User manual	100	3	IMP
11	Program (executable)	100	3	IMP
12	Diskette or CD (with all documents)	100	3	IMP
13	User questionnaire	60	2	IMP
14	Software quality questionnaire (by TA)	250	8	IMP
15	Documents in general	50	2	IMP
Total score		3000	100	

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