Exploring the Relationship Between Teamwork Skills and Team Members' Centrality

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Exploring the relationship between teamwork skills and team members’ centrality

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Abstract

The present paper describes an exploratory study of small teams working on a four-month project as part of a graduate engineering program. The research had two primary goals. The first was to utilize the log files from shared repositories used for team collaboration to describe the network structure of the teams. The second was to determine whether the network centrality of any individual team member is associated with their teamwork skills and attitudes towards the collaboration platform. The relationship between teamwork skills, attitudes towards the collaboration technology, and the centrality index was explored using Pearson correlations. A total of 35 students in 10 teams were included in the analysis. Findings showed a moderate and significant relationship between teamwork skills and the relative degree of centrality. The relative degree of centrality had no relation to any dimension of technology acceptance. Findings from this study indicated that the level of teamwork skills of an individual is related to that individual’s position within the network. Additionally, this study provides an innovative example utilizing user activity logs from shared workspaces to uncover patterns of collaboration and knowledge sharing in teams.

Keywords
Teamwork, collaboration, network analysis, teamwork skills, technology acceptance

1. Introduction

The study of the patterns of interaction and collaboration taking place within teams has received considerable research attention. Existing technologies supporting online collaboration provide a platform to study team processes and team dynamics. Cloud-based applications are being widely used to facilitate remote collaboration in work teams as well as student teams [1]. These technologies facilitate access to information about interactions within the team that can be utilized to conduct network analysis. These applications or tools typically contain shared workspaces that can provide rich information about collaboration activities and the underlying social networks in teams. Previous studies have applied network analysis to uncover patterns of interactions based on user online activities [2, 3]. However, more research is needed to investigate the relationship between network characteristics and teamwork processes so that we can gain a better understanding of the structural features of teams that are more conductive to successful collaboration. This study uses activity logs from shared team repositories to extract meaningful information about the network structures in teams and their knowledge sharing patterns. This paper particularly explores the relationships between teamwork skills, the attitudes towards the collaboration platform, and the structural characteristics of the team collaboration network. It was expected that individuals’ teamwork capacities and their perceived usability of the collaboration tool were related to their centrality in the team network.

2. Methods

This paper describes an exploratory study in the context of small student teams working on a semester project as part of a university course. Participants used a cloud-based collaboration tool to facilitate collaborative work. The tool was tested and validated through a prior study [4]. Please, refer to Pazos et al. [5] for a detailed description of the collaboration platform. The goals of this study were (1) to uncover the network structure of the teams reflecting their interaction throughout the project, and (2) to determine whether the network centrality of any team member was
associated to their teamwork skills and attitudes towards the collaboration platform. Thirty five students participated in the study as part of 10 small teams of sizes ranging from 3 to 4.

2.1. Variables
For this study, data was collected to assess the following variables: teamwork skills, attitudes towards the collaboration platform, and network centrality. Surveys were used to collect data on teamwork skills and attitudes towards the technology. User activity logs reflecting students’ interactions through project documents were used to create team networks and calculate network centrality indexes. The variables are described in the following sections.

2.1.1. Teamwork Knowledge, Skills, and Abilities (KSA)
Teamwork skills’ data was collected through the Teamwork KSA instrument developed by Stevens and Campion [6]. The KSA measures two categories of teamwork competencies: Interpersonal KSAs and Self-management KSAs. Each category contains certain sub dimensions of Teamwork KSAs, as shown in Table 1.

<table>
<thead>
<tr>
<th>Category of KSAs</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpersonal KSAs</td>
<td>Conflict resolution</td>
</tr>
<tr>
<td></td>
<td>Collaborative problem solving</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
</tr>
<tr>
<td>Self-management KSAs</td>
<td>Goal Setting and Performance Management</td>
</tr>
<tr>
<td></td>
<td>Planning and Coordination</td>
</tr>
</tbody>
</table>

The Teamwork-KSA test has 35 situational items describing hypothetical teamwork scenarios. Each item contains four multiple-choice responses, but only one is defined as the subject matter expert answer based on empirical evidence [6]. Each item can be coded as correct (1) or incorrect (0) to calculate the overall test score, which can vary from 0 to 35. This research considered the overall Teamwork-KSA test score for the analysis as recommended by O’Neill, Goffin and Gellatly [7].

2.1.2. Attitudes towards technology
The attitudes towards the collaboration platform was measured using two dimensions of the Technology Acceptance Model (TAM) [8]. TAM has been used to predict individual behavioral intention to use new technology based on two determinants: perceived usefulness and perceived ease of use [9]. Perceived usefulness refers to the personal belief that using the collaboration platform would enhance the team’s performance, while perceived ease of use refers to the personal belief that using the collaboration platform requires minimal effort [8]. This theoretical model is relevant to this study since the teams were provided a collaboration platform to support project completion. For this research, a set of six-item scale on a seven-point Likert scale from “strongly disagree” to “strongly agree” was used to measure (1) Perceived usefulness of the collaboration platform, and (2) Perceived ease of use of the collaboration platform. An example item is “I believe the collaboration site was useful in supporting goal accomplishment for the team.”

2.1.3. Degree of centrality
Centrality is a metric from graph theory that reflects how well connected is a node in the network [10]. The degree of centrality is often used to measure the power, influence, popularity, and prestige of individuals in a group [11]. The degree of centrality allows identifying active components in a network by counting the number of direct ties a node has to the rest of nodes in the network [12]. For this study, an individual centrality index is composed of two elements: the weighted in-degree of centrality, calculated as the number of ties from other nodes to the node; and the weighted out-degree of centrality, measured as the number of direct ties from the node to the other nodes. As a result, the weighted degree of centrality not only shows the presence or absence of ties but the strength of those relations [13].
From the social network perspective, nodes may represent individuals, organizations, websites, or any entity that can relate to other objects [14]. Ties, on the other hand, may represent different types of linkages among nodes including formal or informal relations (i.e., social interactions, workflows, transfers of materials) [11, 15]. In this research, nodes represent team members, and ties represent instances of collaboration through shared objects (i.e., documents, images). The degree of centrality was obtained through two types of user activity logs extracted from the collaboration tool: sharing an object and editing an object. Log files were assumed to reflect patterns of interaction among team members. Thus, sharing an object and editing others’ objects contributes to the weighted out-degree of centrality, while receiving others’ objects and getting editions from others on a shared document contributes to the weighted in-degree of centrality. See Figure 1 for an example of in and out direct ties among nodes.

Figure 1: Sample figure showing direct ties among a three-node network (A, B, and C). Weighted out-degree of centrality of node A = 3 (sharing one document to node B + editing two times a document shared by node C). Weighted in-degree of centrality of node A = 4 (three editions from node B to a document shared by node A + one document shared by node C). Weighted degree of centrality of node A = 7.

The Relative Degree of Centrality (RDC) index was incorporated due to the different team sizes. The relative estimators of centrality are useful to compare centrality indexes of nodes that belong to networks with a different number of members. RDC is calculated by dividing the degree of centrality by the number of nodes in the network minus one [16]. See Equation (1) below:

$$RDC_i = \frac{WDC_i}{N-1}$$

Where $RDC_i$ = Relative Degree of Centrality of node $i$; $WDC_i$ = Weighted Degree of Centrality of the node $i$; $N$ = number of nodes in the network.

Table 2 summarizes the variables included in the analysis.

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teamwork KSA</td>
<td>35 multiple-choice situational items</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>Three items in a seven-point Likert scale</td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>Three items in a seven-point Likert scale</td>
</tr>
<tr>
<td>Relative Degree of Centrality</td>
<td>See Equation (1)</td>
</tr>
</tbody>
</table>
3. Data analysis and results

A total of 35 students in 10 teams were considered in the study. The sample was composed as follows: males (66%), females (34%); White or Caucasian (66%), Black or African American (17%), Hispanic or Latino (11%), Asian (6%). Throughout the semester, students used the collaboration tool to share and edit project-related documents. The first stage of the data analysis was the development of graphic representations of the network structures of each team based on the activity logs. Gephi 0.9.2 [17] was used to develop the graphs. **Figure 2** depicts the graphic representations of four student teams with different network structures. In the graphs, nodes represent team members and narrows between them illustrate the collaboration linkages as a result of sharing and editing objects.

![Figure 2](image)

**Figure 2**: Graphic representation of four student teams working on the semester project using the collaboration tool. The lines are weighted, so the darkest lines represent more frequent interaction between nodes.

The sociograms show some individuals held more active roles within the networks. For example, from-network 1, node C was significantly active interacting with the rest of the team. Team 2 shows that node CB collaborated with all the other students and served as a bridge between node SW and the rest of the team. The collaboration activity of each node was reflected in the Relative Degree of Centrality (RDC). **Figure 3** shows the distribution of RDCs among all the students in the sample. We can see two outliers representing members of two different teams that displayed very large frequencies of interactions with others and contributions to the overall project.

![Figure 3](image)

**Figure 3**: Box plot showing the distribution of RDCs. Mean=9.69, Min.=1, Max.=41, SD=8.30.
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The second part of the data analysis included a quantitative exploration of the relationship between the variables of interest. Table 3 includes descriptive statistics (mean and standard deviation) for the variables included in the study.

Table 3: Descriptive statistics of the variables

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teamwork KSA</td>
<td>20.65</td>
<td>4.55</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>5.63</td>
<td>1.44</td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>5.37</td>
<td>1.23</td>
</tr>
<tr>
<td>User intention to use</td>
<td>5.48</td>
<td>1.51</td>
</tr>
<tr>
<td>Relative Degree of Centrality</td>
<td>9.69</td>
<td>8.30</td>
</tr>
</tbody>
</table>

It was hypothesized that the node position in the network is related to teamwork skills and attitudes towards the collaboration platform. A bivariate correlation analysis was conducted to test this hypothesis. The correlation analysis was conducted using Pearson correlation. Table 4 shows the resulting correlation matrix.

Table 4: Correlation matrix

<table>
<thead>
<tr>
<th>Gender</th>
<th>RDC</th>
<th>Teamwork KSA</th>
<th>P. Usefulness</th>
<th>P. Ease of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>1</td>
<td>-0.390*</td>
<td>0.103</td>
<td>-0.163</td>
</tr>
<tr>
<td>RDC</td>
<td>1</td>
<td>0.372*</td>
<td>-0.056</td>
<td>0.127</td>
</tr>
<tr>
<td>Teamwork KSA</td>
<td>1</td>
<td>0.067</td>
<td>0.258</td>
<td></td>
</tr>
<tr>
<td>P. Usefulness</td>
<td>1</td>
<td>0.736**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. Ease of use</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results showed a moderate and significant correlation between teamwork KSA and the relative degree of centrality. Meanwhile, the relative degree of centrality was not related to the individual’s attitude towards the collaboration platform. Additionally, the correlation matrix reveals that gender had a significant relationship with the RDC and teamwork KSA.

4. Conclusions

The goal of this study was to explore the network structures of virtual teams and to determine whether the Relative Degree of Centrality of an individual in a network is associated to teamwork skills and attitudes towards the technology. This study found a positive and moderate association between the Relative Degree of Centrality and teamwork competencies. This finding indicates that individuals with higher levels of teamwork skills, tend to play a more central role in a team network. That is, team members with higher levels of teamwork skills, tended to be more active in contributing critical project related documents to the team repository, and they were also more likely to make edits and comments to other documents that were contributed by other teammates. Meanwhile, the non-significant relationship between the two dimensions of the technology acceptance model and the Relative Degree of Centrality suggests that the likelihood of editing and sharing objects with other members through the collaboration tool is not associated to that individual’s attitudes towards the technology (perceived usefulness and ease of use). Although the relationship of gender and the RDC was not a primary goal of the study, the significant correlation between the variables is considered a relevant finding. Results suggests that females tend to play more active roles than males in the network. Similarly, the correlation matrix shows that females tend to attain higher levels of teamwork KSA. The
role of gender on the degree of centrality and teamwork KSA provided an important insight for future research in the study of collaboration patterns for teamwork-based systems. This study showed that user activity logs from shared workspaces could be used to discover patterns of collaboration throughout a project’s lifecycle. It is suggested that technologies used by virtual teams to facilitate collaboration and to store and manage project documentation can be used to help managers and team members to understand the underlying patterns of interaction within the teams and to monitor and evaluate collaboration over time. Limitations of this study were related to the types of user activity collected, and the sample size. Activity logs included two types of activities, new document uploads and edits to existing documents. The logs excluded activities such as reading and downloading documents. Likewise, the logs excluded other activities that might have been completed outside of the collaboration platform such as project updates or notifications. However, since all the teams used the project repository in the collaboration platform to store and interact with all project documents, we believe that the calculated network structures still provide an accurate portrayal of the information sharing that took place in the teams throughout the project. The available sample size limited the use of more advanced statistical methods to develop predictive and more sophisticated models. Additional data is being collected to address these limitations. This exploratory study will serve as an antecedent for future research on network analysis in team settings. Network analysis techniques proved useful in describing the group structure and determining the structural position of individuals within a group with regards to teamwork abilities.

References