Measuring Students' Class-level Sense of Belonging: A Social-network-based Approach

Dr. Dong Zhao, Michigan State University

Dong Zhao is an Assistant Professor of Construction Management and an Assistant Professor of Civil Engineering at Michigan State University. He is a LEED AP certified by US Green Building Council. Prior to joining MSU, he was a Postdoctoral Fellow at Virginia Tech where he earned his PhD. His research focuses on the computational integration of human information into construction work and training systems. He has authored more than 50 peer-reviewed papers and serves as a member of several national committees and an editor or reviewer for many international journals and conferences. Some of his honors include receiving the Best Journal Paper Award from the American Society of Civil Engineers (ASCE).

Dr. Denise Rutledge Simmons P.E., University of Florida

Denise R. Simmons, Ph.D., PE, LEED-AP, is an associate professor in the Department of Civil and Coastal Engineering in the Herbert Wertheim College of Engineering at the University of Florida. She holds a B.S., M.S., and Ph.D. in civil engineering and a graduate certificate in engineering education – all from Clemson University. She has over ten years of construction and civil engineering experience working for energy companies and as a project management consultant.

Dr. Simmons has extensive experience leading and conducting multi-institutional, workforce-related research and outreach. She is a leader in research investigating the competencies professionals need to compete in and sustain the construction workforce. She oversees the Simmons Research Lab (SRL), which is home to a dynamic, interdisciplinary mix of graduate researchers who work together to explore human, technological and societal interactions to transform civil engineering practice with an emphasis on understanding hazard recognition, competencies, satisfaction, personal resilience, organizational culture, training and social considerations.

As a researcher, Dr. Simmons passionately pursues workforce research characterizing, expanding, sustaining, measuring and training the technical and professional construction workforce in the US. The broader impact of this work lies in achieving and sustaining safe, productive, diverse, and inclusive project organizations composed of engaged, competent and diverse people.

Meltem Duva, Michigan State University

Meltem Duva is a PhD student and graduate research assistant in the Construction Management Program in the School of Planning Design and Construction at the Michigan State University. She holds a B.S. degree in architecture and M.S. degree in construction management. She has worked for several companies and projects prior to starting PhD. Meltem Duva pursues her PhD on the social network interventions on the Architectural, Engineering and Construction (AEC) projects. Her research is focused on the social network analysis to evaluate and improve the sustainability performance of the AEC projects.

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Abstract:
Social interaction with peers has long been recognized as one of the critical factors for facilitating the learning process. Extant studies have investigated the impact of social ties and structural network position on academic performance and find that social ties are positively associated with academic performance. Social ties are important to construction engineering which highlights interpersonal collaborations in construction projects. However, little to no research has shed light on the impact of social ties on students' sense of belonging at the class level. The objective of this paper is to develop a social-network-analysis (SNA) based measurement that can be used to assess a student's class-level belonging. In reaching such a goal, the authors distribute a survey to multiple construction classes across multiple institutions in the United States. Data (N=70) are collected to verify the performance of the measurement in assessing class-level sense of belonging. Results show that the measurement is highly reliable and consistent across demographic attributes including gender, race, ethnicity, and academic grade through cross-validation while being sensitive to different classes. Results reveal that white students often have a higher sense of class belonging than their African American classmates. Results also identify a significant relationship between a student's class-level belonging and his/her group-level network centrality. The findings imply that a student who has a more central position in a study group may not have a higher sense of class belonging. Further, the findings suggest that SNA-based measurement is able to assess a student's sense of class belonging.

Keywords:
Construction engineering, social networks, social engagement, engineering education.

1 Introduction

Social interactions with peers have long been recognized as one of the critical factors for facilitating the learning process. Such social and interpersonal skills are ranked by employers as the highest expectation for construction engineering and management students to possess upon entry into the workplace. The interaction is critical for construction engineering students for building their collaborative skills and abilities of common goals, communication, coordination, and cooperation (4Cs). The collaborative process to solve practical engineering problems becomes key to students when entering the industry [1, 2]. Therefore, extant studies have investigated the impact of social ties and structural network position on academic performance and find that social ties are positively associated with academic performance.

The classroom environment is viewed as social ecology and learning in classroom is viewed as a socially organized process. Students who lack a sense of belonging are at greater risk of underachieving and of suspending their studies. A large body of research has linked active classroom environments to the development of student social engagement, with studies investigating the relationship in both directions. For example, active learning develops social engagement and vice versa. Active classroom activities have also been shown to be related to and effective in increasing the development of social networks, student interpersonal interaction, perception of social support, liking among students, friendship and social learning relations [3-5].

However, instruments and measurement tools have not been developed for a student's engagement with a particular course. Social engagement is operationalized as value, reciprocity, and conduit of belonging[6]. Of the three, the sense of belonging represents the psychological sense of community, which is an important component to measure social engagement in engineering education [7]. Therefore, there is a critical need for measures that assess student's belonging with a particular course to provide meaningful feedback to instructors for adapting instructional strategies to match or correspond to student needs. Such measures could also fill the need for meaningful evaluation measures for instructors, departments, and/or universities [8].

The objective of this study is to demonstrate a social-network-analysis (SNA) based tool that can measure the network and social connection aspect of student-student interactions and student-teacher to represent in- and out-of-class individual student social belonging. The tool particularly allows for measuring post-secondary engineering students' network-based social engagement in classroom activities. The resulting outcomes from the implantation of this tool can be used (1) to describe the way in which engineering faculty engage in the practice of measuring and assessing their classroom practices, in order to improve the instructional practice; (2) to relate student social engagement in classroom to their learning outcomes, and study the impact of social ties gained from classroom activities. In short, the SNA tool will contribute to the development and understanding of how classroom activities support and foster student social engagement which supports learning gains and an inclusive environment.

2 Background

2.1 Social Engagement

Student engagement with a college course can come in many forms and occur inside and outside of the classroom. The classroom experience can range from entirely composed of lectures to those having only interactive activities. Students may additionally attend laboratory, recitation, or comparable sessions. Students may engage in a multitude of ways with class material outside of the classroom to include working in groups, alone, with a tutor, or with an instructor during office hours on class assignments and studying for quizzes and exams. Substantial reform in science, technology, engineering, and mathematics course content and teaching practices has occurred over the past several decades impacting both in- and out-of-class experiences. Some innovators have made substantial modifications to their courses.

Astonishingly, however, in the presence of such a broad investment of time and money, no reliable instruments exist to measure the frequency and quality of students' social engagement inside and outside of the classroom in relation to the activities associated with a specific course. The interactive classroom activities have been shown to be most effective in increasing knowledge attainment and the development of social networks. Several studies have established the effectiveness of active learning in improving student interpersonal interaction, perception of social support, liking among students, friendship and social learning relations, which are the components of social network [3]. Social capital is valuable for student for a variety of outcomes, including learning and retention [9]

2.2 Social Network Position

Developing a social network through which resources can be exchanged is an important outcome of classroom teaching as well as an antecedent of student academic success, so it is important to have a valid social network instrument to measure the effectiveness of teaching practices. However, after reviewing studies on social capital attained through social engagement in a classroom and classroom social network, we found there is no widely accepted instrument on it. In previous studies, the measurement of classroom social network and social capital focused on the different aspects of classroom relationships. Some studies focused on peer relationships such as friendship and social learning network among students, whereas some focused on the student-teacher relationship such as teacher support [4]. Some studies focused on the functions of social network, for example, information sharing, discussing, solving doubt and creating a product in common; some focused on the structures of relationships such as local of positions in the classroom network [10, 11]. Some research measured classroom social capital in terms of student perception of cooperation and trust in the classroom, while some measures it through objective report of the frequency of interaction between students [9, 12]. Therefore, there is a need to develop a valid instrument to measure classroom social network.

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3 Data and Methods

3.1 Data collection

The survey was administered online via Qualtrics to 368 undergraduate engineering students across three institutions. Because the survey was administered in the context of studying students' social connections in their social network, we embedded a register of classmates into the survey using a name generator to enable students to provide a response to the survey for up to five classmates as members of their social network. Because students could identify up to five classmates in their network, some students had multiple responses to capture each of their friends. Of all invited to complete the survey, 70 valid student responses are received, yielding a 19% response rate. Males represented 90%, females 8% and other 1% of the study participants. Most of the study respondents self-identified as White (88%). The analysis was based on the 2.2 unique responses per participants, and the total responses for all participants (184 responses).

3.2 Measures of the sense of class belonging

Recent quantitative research suggests that a student's sense of belonging is related to a student's perception of her/his ability, possibly more so than to actual performance [13]. The qualitative

analysis further suggests that feelings of belonging can influence students' attitudes toward the mutability of ability. Supporting a student's sense of belonging both to the discipline and their supportive communities can improve the academic resilience of engineering students, thus improving retention [14]. From these studies, we know social belonging is an important outcome of classroom teaching as well as an antecedent of student academic success, so it is important to have a valid instrument to measure teaching practices and social engagement.

Social engagement, given our recent results, is now being operationalized as trust, individual connectedness and class belonging which was adapted from the belongingness and psychological sense of community scale [6, 7].

Our measurement of the sense of class belonging contains five items, as follows:

- I feel comfortable in the class. (M1)
- I feel like a part of the class. (M2)
- I feel supported by my classmates. (M3)
- I feel committed to the individuals in class. (M4)
- I often feel like an outsider in my class. (M5)

3.3 Measure of social network position

The social network analysis (SNA) is based on three domains of social network characteristics as measures of social engagement: (1) function measures, which reflect the content of network ties, and the provided network resources or information by the active learning in classroom that individuals use to advance their purposes; (2) structure measures, which reflect the strength of ties, and describe how individuals in the network of active learning in the classroom are connected to one another; and (3) location or positional measures, which reflect an individual's location in a network, to examine how certain network location and actor position diffuse influence and other resources via active learning in classroom to other network actors.

Centrality is a measure of individuals and defines the most important or central node in a network. There are different centrality measures proposed depending on the definition of importance. Particularly, we used the closeness centrality degree to measure each student's position in his or her network. The centrality emphasizes the distance of a node to all other nodes in a network. It can be calculated as the sum of the length of the shortest paths between the node and all other nodes in a sociogram. A high closeness centrality means that there is a large average distance to other nodes in the network. That is, the more central a node is, the lower its total distance to all other nodes. The centrality is calculated using the following equation:

$$c_i^c = 1/\sum_{j:j\neq i} d_{i,j} = 1/[(n-1)\bar{d}_i]$$

where $d_{i,j}$ is the minimal distance (i.e., path length) from the *i*th node to the *j*th node.

4 Results

4.1 Reliability of the measurement

We analyzed the reliability of our measurement of the Sense of Class Belonging through confirmatory factor analysis. The Cronbach's Alpha value for the instrument with five items (M1-

M5) is 0.73 which is considerably good reliability. Table 1 lists the correlations among the five items. The results indicate the pairwise correlations among M1 to M4 are statistically significant. The finding also suggests that M5 does not measure well the sense of class belonging. The statement of M5 is "I often feel like an outsider in my class". M5 is a reverse statement and it does not align well with other items. M5 turns to be an outlier item in instrument. When removing M5, the instrument's Cronbach's Alpha value increases to 0.88 which shows very consistent reliability. Therefore, we will remove M5 in the rest of data analysis.

Table 1. Correlations of Items M1-5

Item	by Item	Correlation	Lower 95%	Upper 95%	Sig.
M2	M1	0.8367	0.7490	0.8956	<.0001*
M3	M1	0.8024	0.6992	0.8728	<.0001*
M3	M2	0.7612	0.6408	0.8450	<.0001*
M4	M1	0.5022	0.3030	0.6594	<.0001*
M4	M2	0.4899	0.2881	0.6500	<.0001*
M4	M3	0.5610	0.3755	0.7033	<.0001*
M5	M1	0.1429	-0.0953	0.3656	0.2379
M5	M2	0.1262	-0.1121	0.3507	0.2980
M5	M3	0.0501	-0.1871	0.2818	0.6803
M5	M4	-0.1670	-0.3868	0.0707	0.1669

* denotes 99% confidence.

4.2 Class-level sense of belonging

Figure 1 displays the distribution of our data. The figure indicates a good fit of normal distribution. The mean of the sense of class belonging from students is 3.45 (Std. Err=0.12) in a scale of 5 points. The median of the sense of class belonging is 3.61 (2.91–4.75 for quantile 25%–75%). Therefore, the averages suggest an overall positive sense of belonging at classroom.

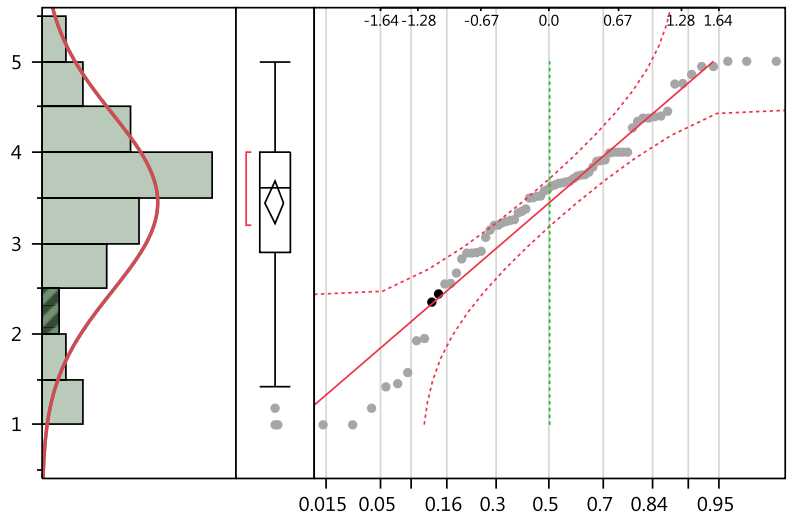

Figure1. Distribution of the measure of class belonging

We used the cross-validation approach to testing the validity of our measurement of the sense of belonging at class level. Specifically, we used *t*-tests and ANOVA to examine the difference by gender, race, ethnicity, grade, and class. Figure 2 displays results of the comparisons. Overall, the statistical analyses indicate no significant differences among the comparisons. Regarding gender, the mean of the class belonging for male students is 3.46; and the one for female students is 3.32. Such difference is not significant (t=0.35, p=0.73). Regarding race, the mean of the sense of class belonging for black students seems relatively lowest at 2.24 but this is not significant at 0.95 (F=1.65, p=0.19). Regarding ethnicity, the mean of the sense of class belonging for Hispanic students is 3.49 and the one for non-Hispanic students is 3.45, which is not significant (t=0.05, p=0.96). Regarding grade, the sense of class belonging for freshman to senior ranges from 3.1 to 3.9, indicating no significant difference (F=1.82, p=0.14). It is noteworthy that the sense of class belonging for various classes is significantly different at 0.95 level (F=5.40, p=0.02), suggesting a very good sensitivity of this measurement.

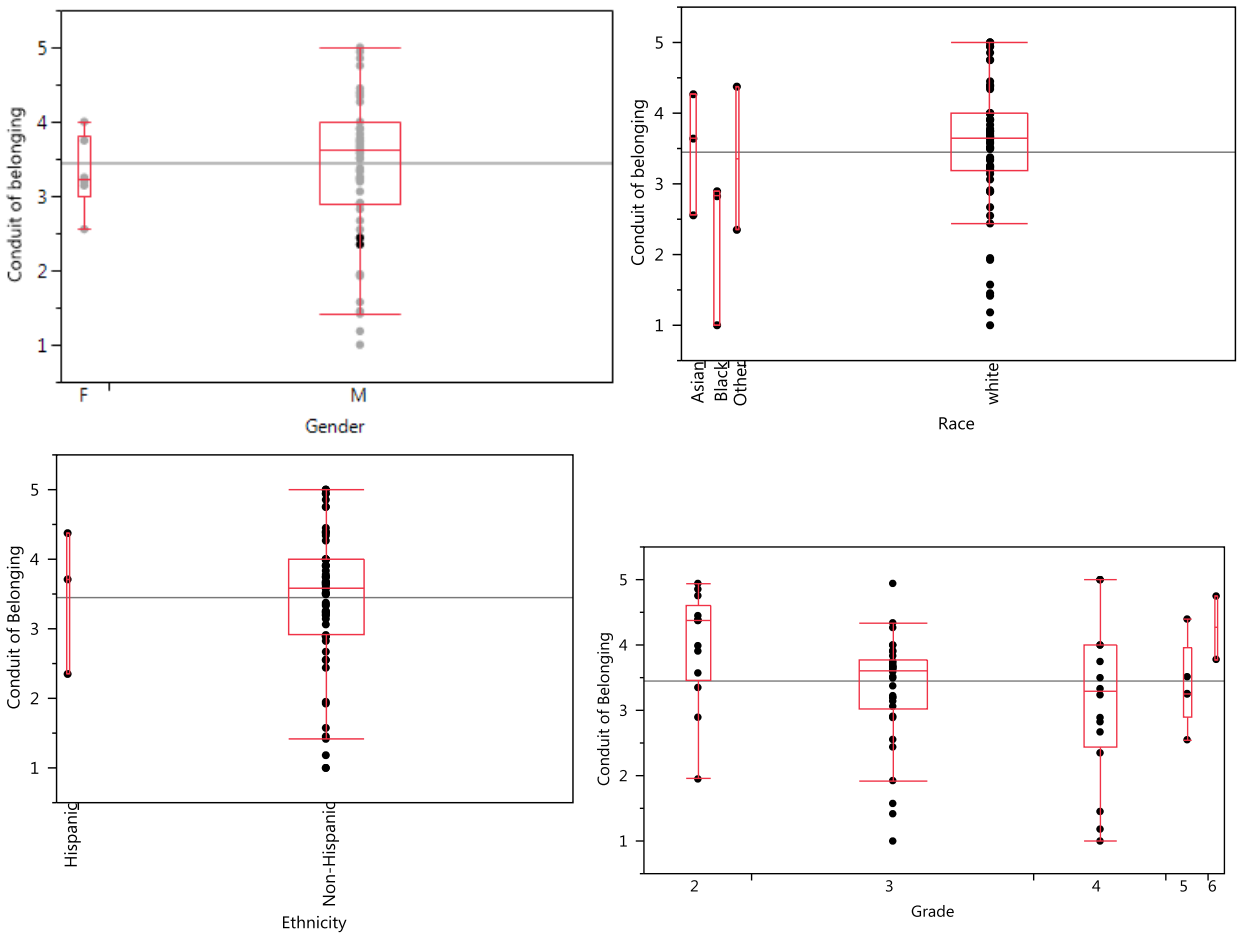

Figure 2. Comparisons of the sense of class belonging by gender, race, ethnicity, and grade.

We further compared the pairwise difference of the sense of class belonging for students by race. Although the variance of belonging across all races is not significantly different, this comparison enables to identify the difference between two specific race groups. Table 2 lists the results of such comparison. The results indicate the White students have a significantly higher sense of class

belonging than Black students at a 0.95 level (p=0.03). The results do not suggest any other significant difference between any other pairs of race groups, though.

Table 2. Ordered Difference of the Sense of class belonging by Race

Level	- Level	Diff.	Std Err	Lower	Upper	Sig.
White	Black	1.267	0.570	0.129	2.406	0.03*
Asian	Black	1.248	0.787	-0.325	2.820	0.12
Other	Black	1.123	0.880	-0.635	2.880	0.21
White	Other	0.145	0.693	-1.239	1.528	0.84
Asian	Other	0.125	0.880	-1.633	1.883	0.89
White	Asian	0.020	0.570	-1.119	1.158	0.97

4.3 Social network analysis

Figure 3 illustrates the distribution of the communication between a student and his/her close classmate. The communication includes both in-class and out-of-class based on student responses. Results show that most students communicate twice (36%) and 3 times (22%) for a class with a total of 58%. Results also show that communication often lasts for less than half of an hour, mostly for15-30 minutes (42%) or even less (28%). Coupling results suggest that student communication is not frequent and does not last for long. This implies that they may communicate once after a class, assuming they have two classes per week for a course.

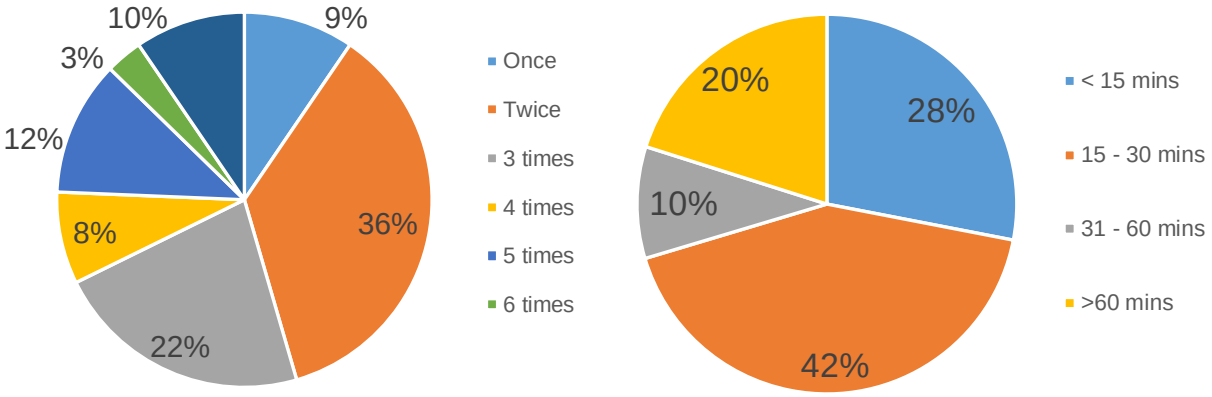

Figure 3. Frequency and duration of student communication for a class

We performed the SNA to produce sociogram and subgroups. First, we organized the input data by discarding the rows with missing information. Since every person in the network needs an ID for the analysis, we assigned each student a unique number as ID, starting from 1. Second, we calculated the strength value of communication between each pair of nodes by multiplying the frequency and duration. To prevent a zero value (no connection), we then normalized the strength values according to the highest possible value of this multiplication and rounded up in order. In this calculation, the maximum value of the multiplication corresponds to the strength of 9 as the strength value is supposed to be between 0 and 9 using the software KliqueFinder.

Figure 4 is the sociogram showing relationships between nodes with strength values. 14 subgroups are identified in the figure, which is illustrated by color. A subgroup represents a small studying group with close classmates who often communicate. The connections between nodes within a subgroup are shown with black ink whereas the links between nodes from different subgroups are in gray. The thickness of the links shows the strength of the ties as thicker is stronger.

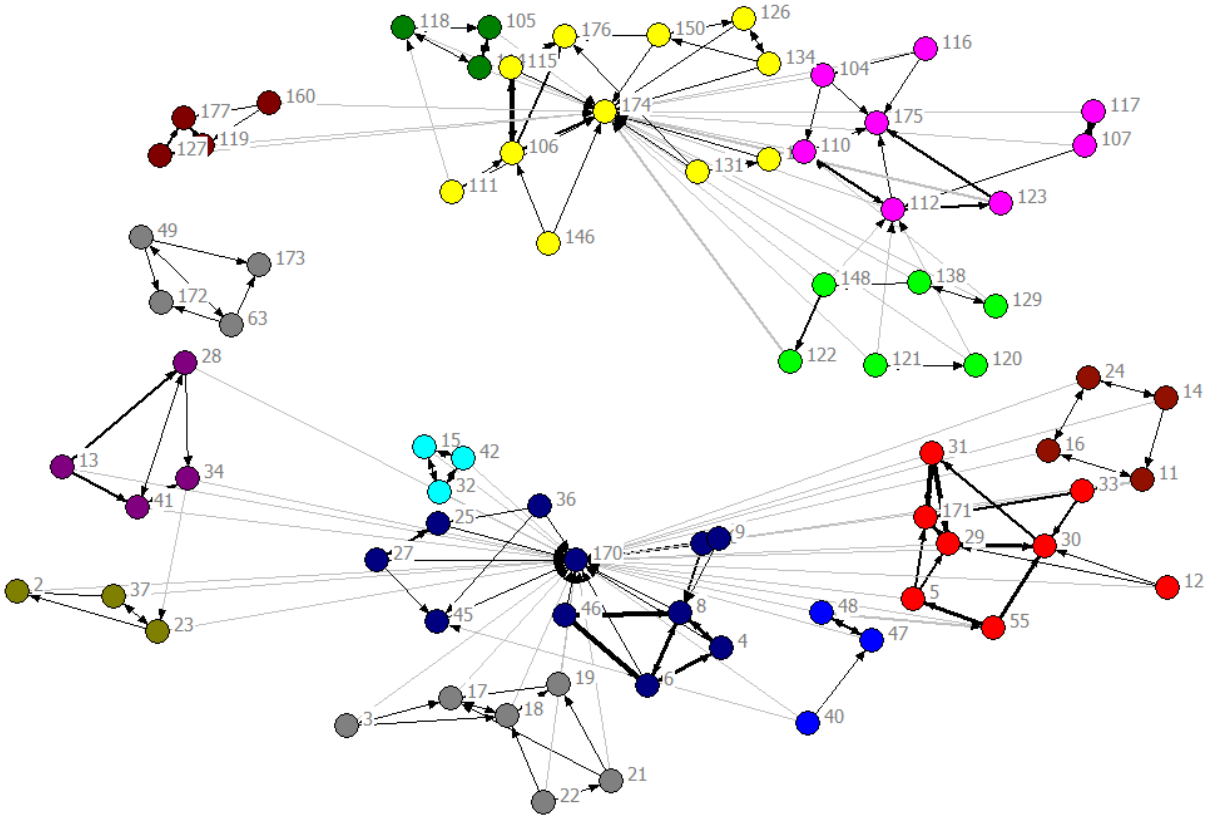

Figure 4 Sociogram of student communication

We then used multivariate regression model with standard least squares to identify the relationship between a student's sense of class belonging and his social network centrality in a subgroup. Modeling results indicate a significantly negative relationship at 0.90 confidence level when a subgroup has a comparatively large number of students. For example, the subgroup 7 (in yellow color in Figure 4) and subgroup 12 (in dark blue in Figure 4) contain the largest number of nodes (n=11). This is because nodes' centrality in a small network is not sufficiently distinct. Figure 5 displays the model fits for the subgroups 7 and 12, indicating a negative slope. In the subgroup 7, the estimate fit (β) equals -4.51 (t=-3.23, p= 0.03, R Square = 0.72, and RMSE = 0.53). In the subgroup 12, the estimate fit (β) equals -1.58 (t=-1.86, p= 0.09, R Square = 0.30, and RMSE = 0.66). Therefore, SNA and regression results indicate a strong relationship between a student's sense of class belonging and his or her social network position in a class. The finding suggests that a student who has a quicker influence on peers in his or her study group often has a lower sense of belonging.

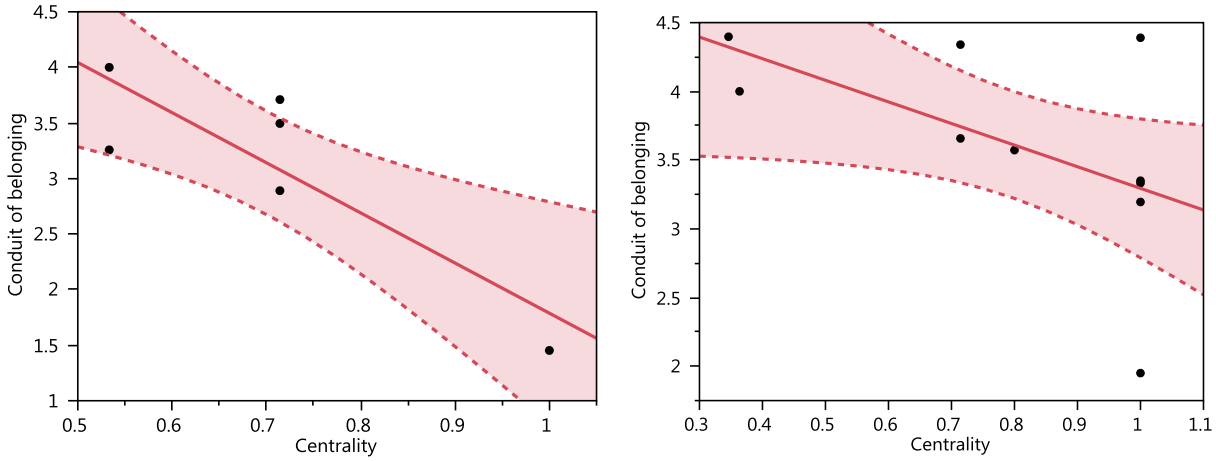

Figure 5. Model fits between class belonging and network centrality in subgroup 7 (L) and subgroup 12 (R).

5 Conclusion

This paper reports a social-network-analysis (SNA) based measurement that can be used to assess a student's class belonging and its relationship to his/her social networks generated from academic progress in a class. Results show that our measurement is highly reliable with a consistency of 0.88 Cronbach's Alpha. Cross-validation indicates the measurement is consistent across demographic attributes including gender, race, ethnicity, and academic grade; while being sensitive to different courses. Our findings reveal that White students often have a higher class belonging than their Black classmates. The SNA identifies a negative relationship between a student's class belonging and his/her group network centrality in a class. The finding implies that a student who has a higher central position in a group network may not has a higher sense of belonging. The finding suggests instructors balance students' social ties in study groups, which would ultimately increase their belonging to class.

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