RELATIONSHIPS BETWEEN ACADEMIC NETWORK AND STUDENT ENGAGEMENT FOR CONSTRUCTION EDUCATION

By

Zhiting Chen

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Construction Management—Master of Science

2020

ABSTRACT

RELATIONSHIPS BETWEEN ACADEMIC NETWORK AND
STUDENT ENGAGEMENT FOR CONSTRUCTION EDUCATION

By

Zhiting Chen

Student engagement is a significant predictor of student's academic performance that has shown essential benefits for collaborative learning in higher education. Activities of social networking are common practices for college students to pursue a higher academic achievement by taking advantages on collaborative learning. Nevertheless, there is a gap in understanding the relationship between student engagement and academic networking patterns. By involving Social Network Analysis (SNA) based research methods, this quantitative study explored the relationships between these two antecedents of academic performance at the individual level as well as the subgroup level in the construction domain. The self-reported interaction and engagement data used in regression analysis was collected from two construction-related undergraduate classes in the United States. The analysis results revealed positive relationship between student engagement and individual direct social connections with classmates. The subgroup-level correlations indicate that a small-sized low eccentricity network with efficient information exchanges is preferred by students to highly engaged in collaborative learning. These prominent findings suggest student leadership as a core motivator to facilitate all favorable engagement predictors uncovered in this study. A Confirmatory Factor Analysis was conducted to validate the student engagement framework. The author discussed implications for construction educators to focus on network-based interventions to advance understandings of student's needs and recommended effective instructional strategies for construction educators regarding student leadership development to optimize the outcomes of advanced course designs.

ACKNOWLEDGEMENTS

I would like to express the deepest appreciation and gratitude to Dr. Dong Zhao, my committee chair, for his valuable guidance and persistent support through the entire process of this thesis.

I am thankful to the contributions of my committee members, Dr. Matt Syal and Dr. Sinem Mollaoglu, whose work demonstrated to me motivates my progress on research and technical writing.

I am grateful to the faculty and staff of Construction Management, School of Planning, Design and Construction for all essential support on guiding my path to future career in the construction industry.

Lastly, I would like to express my gratitude to my family and friends who have constantly supported and inspired me into what I am. Their continuous encouragement plays a significant role throughout my path of education. This accomplishment would not have been possible without them. Thank you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background

Social capital largely influences students' self-efficacy, achievement, and retention that increasingly becomes valuable abilities for their future careers. Academic networking to develop social capital has significant impacts on college students' academic performance and their future career developments. Educational interventions are studied at large on encouraging students' social capital development in higher education. A large body of research has linked active classroom environments to the development of student social capital, with studies investigating the relationship in both directions (e.g., active learning develops social capital 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 (Algan et al. 2013; Chi and Wylie 2014; Johnson et al. 1998a; Johnson et al. 1998b; Rienties et al. 2013; Rienties and Nolan 2014). Social networks not only establish bridges of social capitals for undergraduates in the college life but also facilitate powerful means to maintain social ties for future benefits on job hunting and other opportunities (Ellison et al. 2007).

Student engagement can be thought of as embracing the holistic interactions with all aspects of the university experience. Indeed, research on student engagement, on the whole, has led to positive impacts on the evaluation and improvement of the educational system. Specifically, there is research evidence showing a positive relationship between the three types of engagement and different educational outcomes, including academic achievement (Fredricks et al. 2004;

Hughes et al. 2008; Kuh et al. 2011; Ladd and Dinella 2009), student satisfaction (Filak and Sheldon 2008; Zimmerman and Kitsantas 1997), student persistence in learning (Berger and Milem 1999; Fredricks et al. 2004; Kuh et al. 2011), and even social capital (Harper 2008). However, an instrument/evaluation framework has not been developed for a student's engagement with a particular course. Although the National Survey of Student Engagement (NSSE, 2014) attends to some of these constructs, the institutional-level focus of this instrument provides faculty with no data for course-level revisions.

Many researchers see the classroom environment as social ecology and hence learning in the classroom as a socially organized process. Students who lack social engagement are at higher risk of underachieving and suspending their studies (Astin 1977). Nevertheless, Pascarella and Terenzini (1991) suggest that the best way to enhance student persistence is to focus on social and academic activities they involved in during college and positive outcomes, both in and outside the classroom. Scholars studying in student engagement in college theories posit that merely exposing students to course material or co-curricular activity is unlikely to produce the desired learning outcomes (Tinto 1987; Wolf-Wendel et al. 2009). Although proactive student engagement and social interactions during the learning process have shown positive impacts on student's academic outcomes, there is still a missing understanding of the relationship between student engagement and communication patterns with peers.

Since construction is a project-based domain that involves collaborations throughout all stages of the process, engaging in collaborative learning is an imperative educational approach in construction-related higher education. Active student engagement in collaborative learning has a significant positive correlation with their learning outcomes and academic success (Blasco-Arcas et al. 2013). Developing strong social ties in collaborative learning is also an antecedent of student academic success. Hence, it is especially important for construction educators to advance the understandings of engagement antecedents to optimize collaborative learning outcomes. Student's academic social networking pattern, in particular, is one of the potential candidates correlating to engagement level for the perspective of sociology.

1.2 Need statement

A 2020 vision report of construction education found that approximately 70% of engineering faculty members and instructors reported no formal preparation to teach across the disciplines they studied (Lattuca et al. 2014). Indeed, they are capable to contribute to accommodate equitable learning environments that facilitate students' better social engagement and participation in both inside and outside classroom activities (Tanner 2013). Regarding the concern of serving the current student groups with increasing diversity, the education community must adjust to developing more reliable and efficient instructional interventions in course designs that support faculty development and improvement of their courses. If the education community wants curricular and instructional improvement to prepare a diverse student population for the future workplace, the pedagogical strategies may consider involving SNA in intervention development.

Despite a proliferation of studies on pedagogical strategies, there is a lack of adoption of evidence-based instructional practices (EBIPs) and measures to determine the presence and impact of such EBIPs. As an example, the implementation of EBIPs lags significantly behind the availability of such EBIPs, and extensive research has been done to study this lag, using diffusions of innovations, change, and adoption theories. These practices are broad and diverse, from the implementation of interactive learning in the classroom to the outside of class tutoring programs. However, far less research has been done investigating why and how faculty choose to evaluate their courses and the effectiveness of educational innovations. Considering the critical role of assessment and evaluation in the curricular and teaching improvement process, there is a critical need to narrow the gap by conducting empirical research to obtain a better understanding of the effects of network-based interventions in educational practices within a reliable student engagement evaluation framework.

Social capital is an essential outcome of classroom teaching as well as an antecedent of student academic success. The use of social capital is valuable for students for a variety of outcomes, including learning and retention (Croninger and Lee 2001; Maroulis and Gomez 2008). According to extant studies, the social capital theory is both a result of and a precursor to an active classroom environment, and holistically captures critical features of social engagement. In the learning environment, students build social capital by networking activities that can be measured by Social Network Analysis (SNA). Nevertheless, no evidence shows the link between the student's networking activities and student engagement.

Unlike the well-developed SNA methods in measuring student's academic networking attributes, there is no widely accepted existing framework aiming to evaluate student engagement. Fredricks et al. (2004) identify three types of student engagement: behavioral, emotional, and cognitive engagement. Student engagement with a college course is investigated both inside and outside of the classroom. For instance, students may participate in a multitude of ways with class material outside of the classroom, including, working in groups, alone, with a tutor, or with an instructor on class assignments and studying for quizzes and exams. Students may be additionally required to attend laboratory, recitation, or comparable sessions according to course designs, which automatically assigns them in a collaborative learning environment. Such participation is part of behavioral engagement and plays an important role in developing social networks that help prevent or limit school dropout. Additionally, the classroom experience can range from entirely lecture to interactive. Therefore, to measure student engagement of participants within a reliable framework, the author improved the survey questions explored by Hunsu et al. (2018) to capture participant's engagement level inside and outside of the classroom and conducted a confirmatory factor analysis (CFA) to verify the instrument's validity.

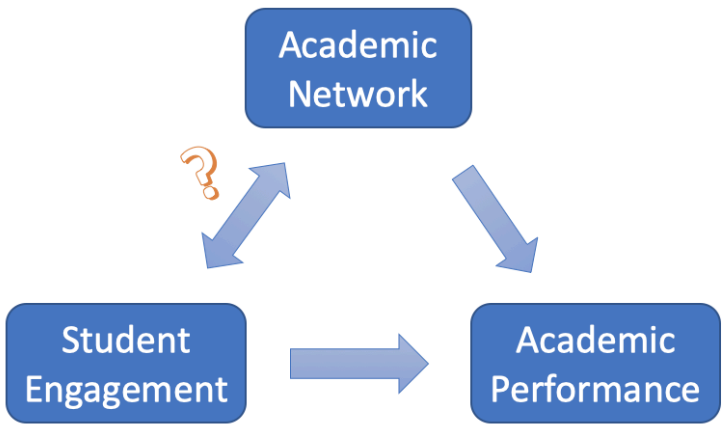


Figure 1.1 The triangle relationships among academic network, student engagement, and academic performance

Substantial changes in Architect, Engineering and Construction (AEC) related courses have occurred on both in- and out-of-class experiences and some innovators have made substantial modifications to their courses. Zunzunegui et al. (2003) examine the effect of social engagement and social networks on the cognitive function of the elders but did not further study the interrelationship between these two social relations in education. However, in the presence of such a large investment, little to no extant research measures the correlation between student academic network and student engagement. Researchers merely focus on how faculty members address the current teaching format to encourage more active engagement of students with no involvement of student academic network (Peterson and Fennema 1985; Tanner 2013). The empirical research conducted by Zhao et al. (2019) suggests that student academic network play an essential role in shaping student engagement. Indeed, either active student engagement or significant academic social network position generates positive impacts on academic achievement. The potential triangle relationship among academic network, student engagement, and academic performance is shown in Figure 1.1.

This research focuses on a subpart of the social network to accommodate the demand of the education domain, which is called the student academic network. If student engagement correlates to student academic network, faculty members can advance interventions on assisting those who have difficulties in engaging in the collaborative learning process to stand at a central position among the groups and obtain positive emotional support. Moreover, the overall learning outcomes are enhanced by modifying class instructions over a semester/term to foster the development of student academic network as well as increasing interactive engagement in the classroom. As a result, the academic network is perceived as one of the predicators of student engagement in future studies. This measure can further adopt in the front-end evaluation of teaching outcomes for faculties to promote instructional approaches designs.

Since there is no substantial empirical study on the correlated relationship between these two constructs, this study intends to examine the potential correlation between student academic network and student engagement by investigating social interaction patterns as well as engagement levels of learning activities. It focuses on student academic network structure within the framework of social network construct to accommodate the essence of the education domain. The research goal is to provide empirical evidence on the correlations between student academic network and student engagement at both the individual level and the subgroup level. This study defines individual level as the nodal level of social network theory. The limited number of work partners contributes to the establishment of communication subgroups. Subgroup-level measures investigate the impacts of social structure regarding the aggregation of individual influences. It is consistent with the discipline of construction project management which fosters proper early project planning to minimize expensive change orders and cost overruns. This study answers two research problems that guide improvements of network-based interventions on collaborative learning in construction education by using regression analysis.

Research Problem 1: The student academic network patterns of the subjects in Architecture, Engineering, and Construction-related courses are unknown.

Research Problem 2: The correlation between student academic network and student engagement in construction education is unknown.

1.3 Research Objectives

To answer the research problems, we define student academic network as the social network generated from student collaboration on academic-related activities that essentially contributes to learning outcomes. Academic-related activities consist of working on homework assignments, lab or project, studying for exams or quizzes, sharing study resources (e.g., class notes), and sharing information on course management (e.g., deadlines). Academic networks are built and strengthened where collaborative learning on coursework is initialized. Group projects and class discussions are common collaborative learning in construction education. We define student engagement as engagement levels constructed by student's sense of trust, reciprocity and belonging when participating in a multitude of ways with collaborative learning inside and outside of the classroom. We hypothesize that student engagement is correlated to attributes of student academic networks.

This research serves as a knowledge base for establishing validated network-based interventions to facilitate student engagement in construction education. The used framework of student engagement obtains a set of well-developed and vetted survey questions as well as subscales that accurately and completely evaluate student engagement. This study aims to provide an insight into the relationships between student academic networks and student engagement in Architecture, Engineering, and Construction education.

Objective 1: To verify the validity of the student engagement framework

Since our data analysis adopts the collected student engagement scores measured by the proposed social engagement framework, it is critical to examine the validity of before further variable manipulations. This objective advances the reliability of the research findings for developing a widely accepted validated instrument for teaching quality evaluation in construction education.

Objective 2: To examine the correlations between student academic network and student engagement in construction education at the individual level.

To address research problem 1, this objective intends to identify student academic network patterns of the research participants at the individual level by adopting centrality analysis. The analysis embraces degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, and local clustering coefficient. Each academic network attribute represents different importance measurement method of students' academic network positions. Analysis and comparison of these academic network attributes provide reliable measurement on their individual-level significance in academic network of the class by involving network theory.

This objective also addresses research problem 2 to measure the coefficient between student academic network nodal attributes and student engagement scores. Through the comparison between these two constructs, the author can further improve the understanding of what interventions have positive influences on student's curricular and co-curricular activities engagement in college at the individual level. Moreover, the findings reverse impacts on their persistence, learning, and entry into the workforce.

Objective 3: To examine the correlations between student academic network and student engagement in construction education at the subgroup level.

Spontaneous student grouping in universities generates prominent subgroup patterns in an academic network sociogram. In order to capture more realistic interaction patterns of the research participants, this study focuses on network measurements at the subgroup level rather than referring to the entire class's network attributes. This objective defines subgroup size, density, diameter, average degree, connected components, and centralization as subgroup-level importance measures to identify the dynamic network characteristics from a macro perspective to further address research problem 1. Each attribute measures a network subgroup's dynamic social structure based on different social network analysis methods. Analysis and comparison of these network attributes provide reliable measurement to capture subgroup-level interaction patterns in the class's academic network by involving network theory.

This objective examines the correlation degree of the regression model between student academic networks at subgroup level and their engagement scores to address the subgroup network structure. Since academic social network and student engagement are social constructs of student's collaborative learning, the author aimed to gain a comprehensive understanding of whether the correlation is a result of personal behaviors or an effect of social behaviors. Hence, the in-depth study assures its reliability to provide empirical evidence for development of student engagement framework to advance the effectiveness of teaching instrument in construction education.

1.4 Proposed Methodology

1.4.1 Research Plan & Strategy

The research conducts a well-defined online survey with Qualtrics to collect empirical data regarding students' academic network attributes and in- and out-of-class activity engagements. The survey questions are properly designed for different purpose on measuring these two constructs. However, all questions are collectively informed as reporting engagement with classmates to minimize the effects of demand characteristics and ensure internal validity. Each question aims to support the proposed instrument of student engagement and capture student academic network patterns through SNA to fulfill the research goals. Additionally, the researchers adopt a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree") in the survey to generate the participants' in- and out-of-class activity engagement scores by taking the mean of the results.

The participants of this study were 112 undergraduate students from upper-level civil and construction engineering courses of two universities at distinct locations in the United States. The researchers quantified the collected responses to measure students' academic network attributes through social network analysis methods and involved confirmatory factor analysis

(CFA) to validate the proposed instrument of student engagement by Hunsu et al. (2018) (see Appendix A). The instrument of student engagement created are Specifically, we defined student engagement and its three constructs as the dependent variables; the study's independent variables were the proposed social network measures at the nodal level and subgroup level within the framework of network theory. Additionally, the demographic factors of participants are collected in the survey to serve as control variables. Using the manipulated independent and dependent variables along with control variables, this research conducted multiple linear regression analysis with SPSS to address the unknown research problems and contribute to reliable and convictive improvements of educational intervention. The methodology plan is visualized in Figure 1.2.

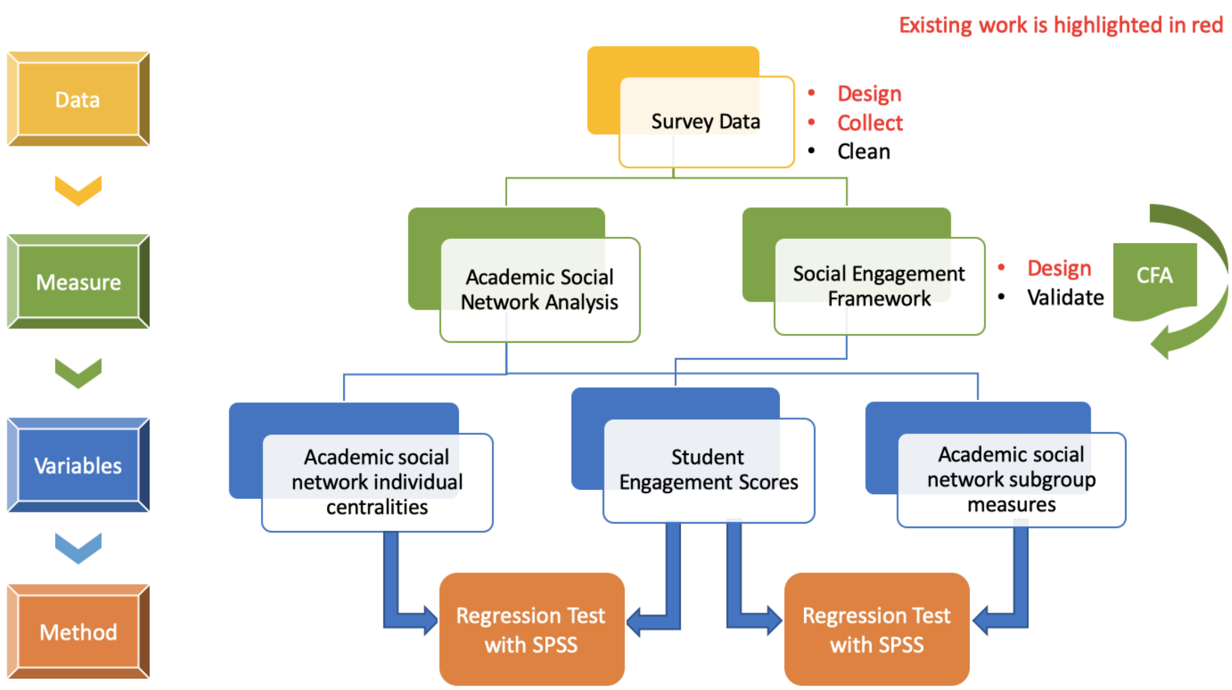


Figure 1.2 Proposed methodology plan

1.4.2 Specific Methods

1.4.2.1 Methods for objective 1

The research analysis gets involved in manipulating student engagement by improving and verifying the validity of measuring instrument through CFA. Validated instrument of student engagement can further address societal challenges by using a suite of formal, informal, and broadly available educational mechanisms and eventually enhance college students' school engagement. The instrument will have stand-alone subscales that can be employed validly and reliably to tailor classroom evaluation to faculty needs. These subscales might serve a wide range of evaluation efforts in the construction field as well.

1.4.2.2 Methods for objective 2

According to the research problems, the study should integrate with regression analysis to support the findings and subsequent theoretical and practical implications. First, we create the participants' academic network sociogram by importing a clean .csv file obtaining self-reported interaction data to *Gephi*. Each student represents a node of the network and their direct communications are indicated by links. With the created sociogram, *Gephi* can analyze and compute each node's degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, and local clustering coefficient of academic network importance measures at nodal level. These indices are independent variables of the individual-level regression test. To manipulate the dependent variable, the researchers quantified respondents' engagement level by averaging their self-reported responses of the given survey questions. Using the generated engagement scores and centrality measures along with demographic factors of control variables, correlation coefficient, t-test and ANOVA of regression analysis was tested with IBM *SPSS Statistics*. The analysis examined the relationship between student engagement and academic network centrality measures at individual level to determine whether the associations are significant compared to a predetermined confidence level of 95%. The direction and strength of the correlation between independent variable and dependent variable were provided in regression analysis results.

1.4.2.3 Methods for objective 3

Given individual interaction data from objective 2, subgroups were identified from the existing network sociogram. Based on the grouping results, *Gephi* produced subgroup-level network sociogram accordingly with merely reserved within-subgroup links. Subgroup importance measures (subgroup size, density, diameter, average degree, connected components and centralization) as independent variables were calculated by referring to our literature review. The subgroup-level dependent variable was generated by computing the mean of individual engagement scores from objective 2. The author replicated regression analysis of research method as objective 2 to investigate the correlation between student engagement and the subgroup-level attributes of academic network.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Social Network

There are many definitions of Social Network. Scott (1988) defines Social Network that invisibly connects individuals together by observing the correlated social interactions, much as a spider web. It converts the complex social relations to accessible relation pattern with the involvement of graph theory. Social Network Analysis is a reliable approach to the analysis of social structure by collectively drawing an intertwined mesh of connections among certain groups. It analyzes the dynamics social structure with visual aid that aligns with the fundamental concepts of sociology. It also aims to criticize sociology from a new perspective by engaging in statistical and mathematical methods.

McCulloh et al. (2013) define it as a *graph* in mathematics that visualizes the relationships between individuals represented by linking line segments (*links* or *edges*) to *nodes* or *vertices*. He explains the graphic aid of social network as: "Moving from one node to another along a single edge or link that joins them is a *step*. A *walk* is a series of steps from one node to another. The number of steps is the *length* of the walk. For instance, there is a walk of three steps from node 1 to node 3 using steps 1 to 4, 4 to 2, and 2 to 3. A *trail* is a walk in which all the links are distinct, although some nodes may be included more than once. The length of a trail is the number of links it contains. For example, the length of the trail between nodes 3 and 4 is 2, where 3 to 2 is the first link, and 2 to 4 is the second link. A *path* is a walk in which all nodes and links are distinct. Note that every path is a trail and every trail is a walk. In application to social networks, we often focus on paths rather than trails or walks. An important property of a pair of nodes is whether or not there is a path between them. If there is a path between nodes n i and n j (say nodes 1 and node 4 in Figure 1.1), then the nodes are said to be *reachable*. A walk that begins and ends with the same node is called a *closed walk*. A *cycle* is a closed walk of at least three nodes. For example, the closed walk 1 to 4, 4 to 2, and 2 to 1 is a cycle as it contains three nodes and begins and ends with node 1. Cycles are important in the study of *balance* and *clusterability* in signed graphs."

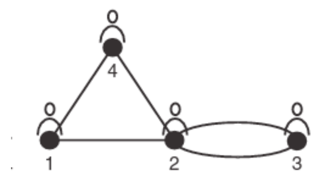


Figure 2.1 Example social network diagram

To draw a sociogram, it is essential to develop an *edge list* to demonstrate the direction of interactions from the source node to the target node. The connections between subjects are mathematically evaluated and presented by an *adjacency matrix* (McCulloh et al. 2013). By navigating the network graph, the significance of each node at the organizational level is identified.

2.2 Social Network Analysis Techniques

Social Network Analysis can integrate with both qualitative and quantitative methods because of its nature of establishing structure with content analysis (Coviello, 2005). SNA-based approaches focus on the constructs of an individual's interactivity, role, and position along with the influence on group cohesion (Saqr et al. 2018).

Centrality in social network analysis evaluates the importance of the centers of attraction based on closeness and communication activity (Scott 1988; Freeman, 1978). It can rank the influence of group members to further demonstrate their social relations in the social structure at the group level (Xie et al., 2018).

2.2.1 Node Level Measures

McCulloh et al. (2013) illustrate four types of centrality to identify the patterns at the individual level, namely, degree centrality, eigenvector centrality, betweenness centrality, and closeness centrality. Degree centrality only focuses on direct interactions between individuals to reflect the authority, whereas eigenvector centrality can find the "hubs" in the network which develop strong connections to the authority. Betweenness centrality and closeness centrality examine the individual's influence in the network as a whole. To measure different centralities, the number of nodes is initially assigned to n while the number of possible links to the rest of groups can represent as $(n-1)$.

2.2.1.1 Degree centrality

Degree centrality generates from counting the number of links related to a single node, including links going into it, *in-degree*, or coming from it, *out-degree*. Since degree centrality sums up the connections either originate or terminate at the particular node *i* related to other nodes, the range of both in- and out-degree centrality should range from 0 to $(n-1)$.

2.2.1.2 Eigenvector centrality

Eigenvector centrality examines the importance of each individual based on the connections to the adjacent significant nodes. Nodes in high eigenvector centrality represent influential members within the group. The eigenvector centrality of the *i*th node x_i computes by aligning with linear algebra and adjacency matrix as:

$$x_i = \frac{1}{\lambda}\sum_{j=1}^{N} a_{ij}x_j$$

where a_{ij} stands for the adjacency matrix and λ is the highest positive eigenvalue of the adjacency matrix.

2.2.1.3 Betweenness centrality

The individual who engages more communication routes between people in the groups generates higher *betweenness centrality*. Betweenness centrality evaluates based on the study of path and *geodesic*. Geodesic, also shown as g_{jk}, is the shortest path between node *j* and node *k*. The way to calculate the geodesics between pairs of nodes is by summing up the *dichotomous paths*, which is the path between the merely two nodes in view. When it is a directed network and order matters, the familiar probability calculation for permutations (nP_r) is examined as:

$$nP_r = \frac{n^!}{(n-r)^!}$$

where *r* is the number of nodes selected which is 2 in this case. Thus, the probability calculations revise as the following:

$$nP_2 = \frac{n^!}{(n-2)^!} = \frac{n(n-1)(n-2)^!}{(n-2)^!} = n(n-1)$$

By contrast, when the network is not directed or bidirectional and order does not matter, the *dichotomous paths* are summarized through the equally familiar probability calculation for combinations (nC_r).

$$nC_r = \frac{n^!}{r^!(n-r)^!}$$

Similarly, the value of the input *r* is determined.

$$nC_2 = \frac{n^!}{2^!(n-2)^!} = \frac{n(n-1)(n-2)^!}{2^!(n-2)^!} = \frac{n(n-1)}{2}$$

The betweenness centrality C_B^* can measure as follows:

$$C_{Bi} = \frac{\sum_{i<j} g_{jk}(Node_i)}{g_{jk}}$$

where g_{jk} is the number of geodesics between node *j* and node *k*, and $g_{jk}(Node_i)$ represents the number of geodesics between node *j* and node *k* that include node *i*.

$$C_{Bi}^* = \frac{C_{Bi}}{(n-1)C_2}$$

where $(n-1)$ is adopted to exclude *n* itself.

2.2.1.4 Closeness centrality

Closeness centrality evaluates how quickly an individual can reach to other people in the organizations as a whole. The standardized measure of closeness centrality C_{Ci}^* defined as:

$$C_{Ci}^* = \frac{(n-1)}{\sum_{j=1}^{n} d(n_i, n_j)}$$

where $d(n_i, n_j)$ represents the geodesic distance between node *i* and node *j* to calculate the closeness of individual *i* to other people in the group. If it is unable to access the distance between node *i* and node *j*, $d(n_i, n_j) = \infty$. In other words, closeness centrality is meaningless while analyzing a segregate network. The range of closeness centrality is between 0 and 1. The *average path lengths* can be measured by inversing the closeness centrality C_{Ci}^*.

2.2.1.5 Local Clustering coefficient

Local Clustering coefficient illustrates the "all-my-friends-know-each-other" property of each node that measures the interconnectivity of a node's neighbors. In other words, the local clustering coefficient examines how much does a node cluster with neighbors. It is calculated by:

$$CC_i = \frac{2N_i}{K_i(K_i - 1)}$$

where N_v is the number of links between node *i* and its neighbors and K_i represents the degree of node *i*. Local clustering coefficient demonstrates a fraction of possible interconnection ranging from 0 to 1.

2.2.2 Group Level Measures

2.2.2.1 Density

McCulloh et al. (2013) also define *density* as a measurement of network patterns at the group level. Density is the ratio of the actual number of links in the network over the total number of possible links between nodes calculated by the probability calculation. When the network is directed, a permutation is used to compute the number of possible links between *n* nodes as discussed in the betweenness centrality:

$$nP_2 = n(n-1)$$

Therefore,

$$Density = \frac{the\ number\ of\ nodes}{n(n-1)}$$

On the other hand, the number of combinations is effective in the undirected or bi-directed network as:

$$nC_2 = \frac{n(n-1)}{2}$$

Therefore,

$$Density = \frac{the\ number\ of\ nodes}{\frac{1}{2}n(n-1)}$$

2.2.2.2 Diameter

The longest geodesic in the network is called *diameter*. It measures the distance from one end of the network to the other, which represents network connectedness.

2.2.2.3 Centralization

The *network centralization* is calculated based on the individual nodal centrality. The formula of centralization given by Freeman et al. (1979) is

$$NC_X = \frac{\sum_{i=1}^{n}(C_{X\,max} - C_{Xi})}{\max\sum_{i=1}^{n}(C_{X\,max} - C_{Xi})}$$

where n is the number of nodes, C_{Xi} is the individual nodal centrality, $C_{X\,max}$ is the maximum value of C_{Xi} in the network, and $\max\sum_{i=1}^{n}(C_{X\,max} - C_{Xi})$ represents the maximum possible total of differences in nodal centrality for a network of *n* nodes.

Degree centralization measures the relative dominance of nodes to the network as a whole. Therefore, the degree centralization is calculated by

$$NC_D = \frac{\sum_{i=1}^{n}(C_{D\,max} - C_{Di})}{(n-2)(n-1)}$$

where $(n-2)(n-1)$ represents the maximum sum of differences in degree centrality.

Betweenness centralization identifies whether a sole gatekeeper controls the network. It ranges from 0 to 1, where 1 represents a single node ultimately determines access to the rest of the nodes and vice versa. The formula of betweenness centralization is

$$NC_B = \frac{\sum_{i=1}^{n}(C_{B\,max}^{*} - C_{Bi}^{*})}{(n-1)}$$

where $(n-1)$ equals to the maximum sum of differences in betweenness centrality.

Closeness centralization demonstrates whether a presiding node is only one step away from every other node within the network. It uses the standardized indices ranging from 0 to 1, where 1 represents a node can reach to the rest of the nodes in a single step and vice versa. The closeness centralization is defined as

$$NC_C = \frac{\sum_{i=1}^{n}(C_{C\,max}^{*} - C_{Ci}^{*})}{[\frac{(n-2)(n-1)}{2n-3}]}$$

where $\frac{(n-2)(n-1)}{2n-3}$ indicates the maximum sum of differences in closeness centrality.

2.2.3 Analysis of Subgroups

Subgroup analysis facilitates a more in-depth study of organizational social structure patterns by identifying network clusters according to the dense interactions within the group (McCulloh et al. 2013). It intends to examine the effectiveness of group collaborations and information sharing. Therefore, a project manager or instructor can escalate productivity and efficiency accordingly.

Once the subgroups are determined, group-level measurement tools (i.e., density) comes into effect to gain more significant insights into the coordination between subgroups within the network. There are two reliable methods to test the degree of intra-subgroup connections. The *input network density approach* is to compare the subgroup density with the network density. If the subgroup density is higher than the network density, it identifies as a cohesive subgroup and vice versa. *The external/internal link analysis* calculates the percentage of external links to other subgroups versus internal links within the subgroup and generates a silo index which ranges from -1 to 1. When half of the links in the subgroup are internal, the soil index is 0. When the portion of internal links is less than 50%, the soil index is negative and vice versa. The *soil index* states the extent of isolation from the other subgroups in the network.

2.3 Social Network & Social Capital

Social capital, which can be difficult to measure, is the resources accrued through social networks (Shea et al. 2014). The formation of social links is a driver-based process by social forces. For example, *reciprocity* is a tendency that people are responsive to maintain relationships with those who actively interact with them. Transitivity enables a social connection to expand to a third party that significantly advances group collaborations and information sharing within the network. The ability of information sharing (i.e., knowledge sharing, resource sharing) through social interactions is termed *social capital* (McCulloh et al. 2013). The instructor in a class, or the construction manager in a project team, acts as a high betweenness node which plays a critical role to facilitate information sharing and foster the formation of social capital of the members. Thus, group cohesion and productivity will significantly increase through optimizing social connections at the nodal level. However, Di Vincenzo and Mascia

(2012) suggest that the benefits from maximizing construction project-based social capacity are critical according to the specific project size.

2.4 Applications of Social Network Analysis

2.4.1 General Applications

Social Network Analysis underlines the pattern of social interactions between subjects. Similarly, the organizational behaviors of knowledge gains and transfers are feasible to manage by network analysis. Knowledge Network Analysis is a well-defined technique that extends from Social Network Analysis by mapping the structure of knowledge clustering and flows (Helms and Buijsrogge 2005). SNA is also a quantitative technique to study causal relationship between social behaviors and social relationships by identifying the interactions in group structures, for example, whether adolescent smoking is mimicking behaviors of peer groups (Ennett and Bauman 1993).

2.4.2 Applications in Education

Social Network Analysis is a widely used tool to reflect the social structure in-class participation that measures the effectiveness of teaching instrument design. The model already applied to the existing study of class structure, perceptions of class, class designation, and affective and cognitive learning outcomes (Jou 2005; Russo and Koesten 2005; Scott 1988).

Instructors and students have limited access to face-to-face interactions in the online collaborative learning environment. Integrating Social Network Analysis to examine the influences of relations among peers provides reliable evidence on evaluating students' class participation (Rabbany et al. 2011). Xie et al. (2018) rank students' contributions in the online learning community according to the centrality in social network analysis to measure their leadership behaviors and understand the performed leadership roles. Furthermore, it can examine the effectiveness of course design from a network perspective and advance teaching instrument to facilitate interactive class activities accordingly (Ouyang and Scharber 2017). Saqr et al. (2018) suggest that the existing social structure of online learning community can enhance with appropriately designed interventions. A considerable number of studies focus on complex behaviors in communications and interactions among students by analyzing their social learning network position to generate the relationship to the academic performances (Mansur and Yusof 2013; Zhao et al. 2019).

2.4.3 Applications in AEC (Architecture, Engineering, and Construction)

Social Network Analysis is beneficial to multiple disciplines, for example, tracking and resolving conflicts by constructing patterns of trust relationship (Liu et al. 2019). Construction projects naturally form a small society of people from diverse disciplines that engage various interactions-related social risks. The risks have snowballing effects on a larger group than the construction project team itself (Zhao et al. 2012). Social conflicts in construction projects are not unusual that social impact becomes a notable concern in the construction industry. This suggests that social relationships and communications among owners, project management teams, architects, engineers and contractors are significantly associated with project success (Yuan et al. 2018; Zhang 2011). Due to the complexity of social relationships among stakeholders in construction projects, mapping the social structure through Social Network Analysis technique can appropriately identify risk factors to reduce the adverse effects of underlying social risks in advance (Yuan et al. 2018).

In recent decades, SNA has been applied to Construction Project Management (CPM) in addressing communication issues by providing insights into the social structure of construction teams as a temporarily project-based organization. The nature of dynamic networks in construction projects determines work-based relational stability (Taylor and Levitt 2007). Furthermore, the engagement of SNA in AEC has extended from the focus of productivity and communications to broader domains, such as project coordination, knowledge exchanges, strategic management, risk analysis, innovations, and so on. The SNA-based project management further develops from the design phase to solve the potential issues at the beginning stage to maximize the overall project outcomes (Zheng et al. 2016).

2.5 Social Engagement in Higher Education

Social engagement has been widely studied regarding the influences in higher education such as motivations, learning outcomes, and academic success (Gordon et al. 2008; Zepke et al. 2010; Zepke et al. 2011). Student disengagement in the behavioral dimension leads to a higher school dropout rate (Archambault et al. 2009). Like the essential coordination in construction projects, collaborative learning in Architecture, Engineering, and Construction-related courses is necessary to facilitate teamwork and communication skills for future career development. Active engagement in collaborative learning significantly affects the students' learning outcomes from project work and is critical for school experiences. Instructors can advise students to develop relationships with peers and fostering their social engagement to build social capital, which makes vital influences on their academic success and even future career.

Social engagement and social networks are common constructs to examine social relations but rare studies analyze their correlations. Ream and Rumberger (2008) suggest that active engagement and networking contribute to lower school dropout rates. Zepke et al. (2011) suggest that non-institutional factors such as family, financial issues and cultural or religious commitments also generate adverse impacts on student engagement in colleges. However, social engagement is a more complex construct to measure compared to the social network. The extant studies suggest diverse approaches measure social engagement regarding different perspectives.

2.6 Factors of Student engagement

While previous network social capital research explained differences in school experiences based on class, gender, and race and/or ethnicity (Lin 2000), the impact of these factors on student engagement in a college classroom is also well studied. Kelly (2009) proposes a framework to study the effect of social identity on student engagement. The researchers involve hierarchical regression analysis in identifying gender-related impacts on student engagement in classroom activities and the effects of age and level of education on cognitive function (Peterson and Fennema 1985; Zunzunegui et al. 2003).

Kahu (2013) understand social engagement as a dynamic network constructed by multidimensional factors and proposed a conceptual framework (see Figure 2.2) to offer a comprehensive view of the causal relationships of social engagement in higher education for further researches. The framework incorporates the behavioral, psychosocial, sociocultural and holistic perspective of the construct of students' social engagement. Student engagement is composed of three dimensions, affect, cognition, and behavior, respectively. Affective engagement refers to a student's enthusiasm, interest, and sense of belonging in college. The cognitive dimension of student engagement represents self-regulated learning and deep learning approach. The behavioral perspective of engagement involves evaluations of a student's time and effort, interaction, and participation. The multidimensional construct of student engagement is not only essentially influenced by student's characteristics but also closely linked with the contributions of university. The benefits of fostering the growth of student engagement are also directed in two aspects. Higher engagement in learning contributes to greater academic performance as well as further social impact which is a notable concern in the construction industry. Moreover, it is remarkable that this framework suggests student engagement is correlated to its antecedents and consequences under the impacts of political, social and cultural environments. Hence, the influences between the dynamic process of student engagement and social structure are bi-directional.

Social capital is another proposed framework to measure student engagement with three dimensions, trust, reciprocity, and belonging, respectively (Hunsu et al. 2018). Student's engagement level can be generated by the mean score of the 5-point Likert scale questions within the student engagement framework. Student behavioral and cognitive engagement inside the classroom has been operationalized by Chi (2009) using the Interactive, Constructive, Active, and Passive (ICAP) framework, and she found that the learning environments listed above are decreasingly effective in the order shown (i.e., I > C > A > P). Nevertheless, while this framework may capture student engagement with a course's lecture and associated individual and group activities, it does not understand student's out-of-class cognitive engagement. A lack of understanding of out-of-class social engagement, which is problematic considering research that suggests such out-of-class time can be as or even more important for social development than in-class time (Astin 1993; Astin 1977; Astin 1999; Pascarella and Terenzini 1991). Therefore, the second framework, social capital, can complement ICAP to fill these gaps and enable the measurement of behavioral social engagement.

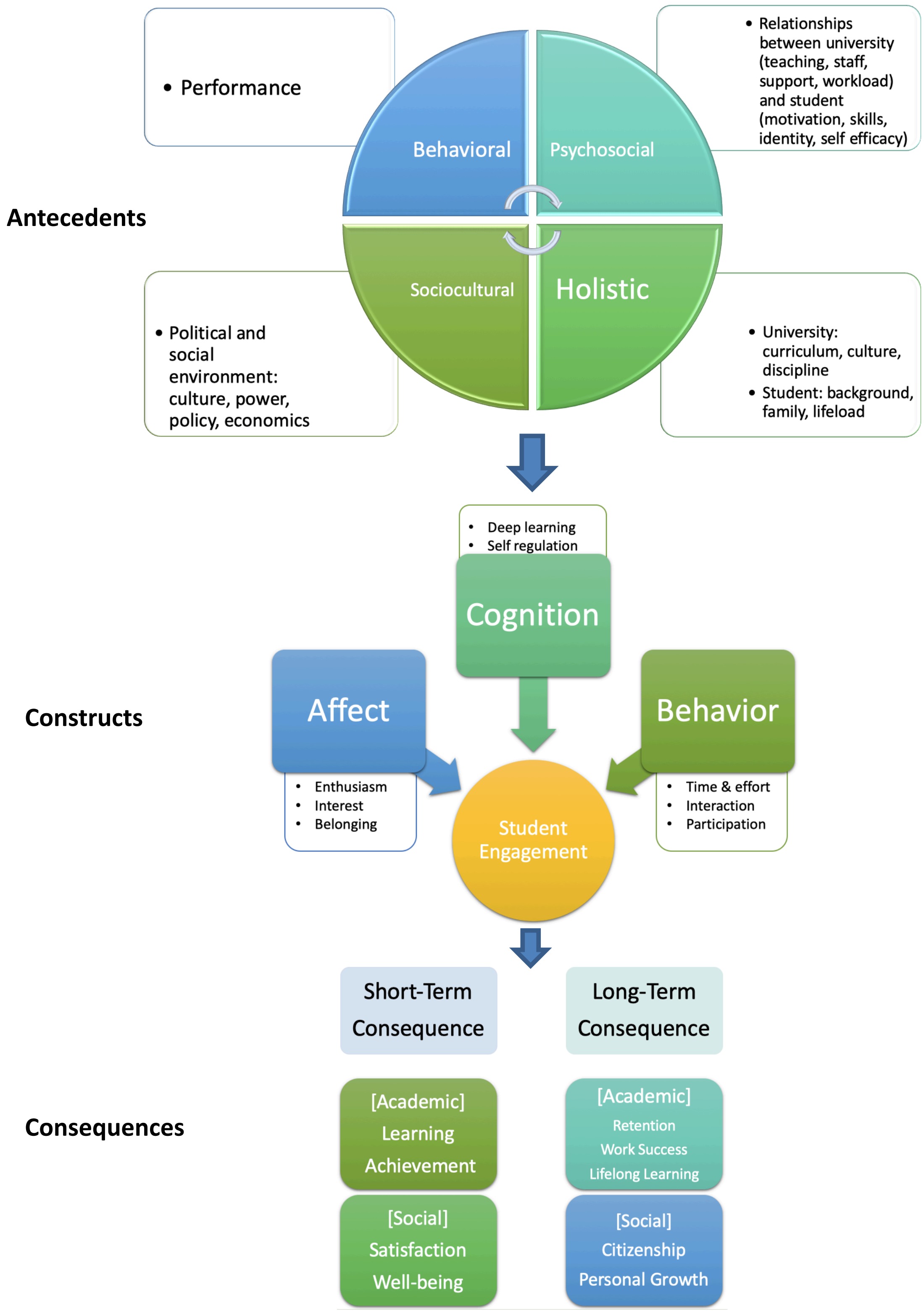


Figure 2.2 Conceptual framework of antecedents, constructs and consequences of student engagement (Kahu 2013)

To validate the student engagement framework by Hunsu, this study conducted a confirmatory factor analysis (CFA) with the collected data. Factor analysis is a reliable statistical method to measure student engagement attributes. Wang et al. (2011) develop a factor measurement model of student engagement to examine the impacts of gender and race/ethnicity by involving CFA with well-defined engagement attributes for each dimension. The model is made up of school attentiveness and compliance for the behavioral dimension, school belonging and valuing of school education regarding the affective dimension, and self-regulation and cognitive strategy use from the cognitive perspective. The results reflect substantial gender and racial/ethnic differences in affective and behavioral engagement but no difference from the cognitive perspective. Females obtain higher engagement than males in both the affective and behavioral dimensions. African American students engage more actively in the affective dimension, whereas European American students achieve more outstanding performances on behavioral engagement. Similarly, Ream and Rumberger (2008) suggest that white students engaged more in both in- and out-of-class activities than Mexican American students. Banhawi and Ali (2011) propose exploratory factor analysis (EFA) to examine engagement attributes from the affective and cognitive perspectives. They found focus attention, novelty endurability, perceived usability and aesthetics as four factors influencing engagement in social network applications.

CHAPTER 3

RELATIONSHIPS BETWEEN ACADEMIC NETWORK AND STUDENT ENGAGEMENT AT THE INDIVIDUAL LEVEL

3.1 Methods

3.1.1 Data Collection

The research conducts a well-defined online survey with Qualtrics to collect empirical data regarding students' academic network attributes and in- and out-of-class activity engagements. The survey questions are designed within the proposed evaluation framework to fulfill the research goals and validated in Chapter 5. Each question aims to support the proposed measurement methods of student engagement and student academic network patterns to address the unknown research problems and contribute to reliable and convictive outcomes.

A total of 132 undergraduate students from upper-level civil and construction engineering courses of two universities at distinct locations in the United States participate in this survey. These institutions have nationally distinguished construction programs. With the detection of missing data, 112 valid responses are adopted as the research subjects, yielding an 85% response rate. Students from University A accounted for 44% and respondents from University B accounted for 56%. The final sample consists of 77% male students and 23% female students whose age ranged from 18 to 43 with a median age of 22. The majority of the participants were majoring in construction-related disciplines. This proportion is consistent with most construction programs in the colleges of the United States (Del Puerto et al. 2011). In terms of ethnicity, 69% of respondents self-identified as White, 21% as Asian, 6% as Hispanic or Latino, and 1% as American Indian or Alaska Native. The distribution of respondents illustrated that White students are the majority groups in this study, which is in line with the race distribution in most engineering programs. The 3rd-year college students hold a majority with respect to years in college, while 2% of participants in the 2nd year, 40% in the 3rd year, 30% in the 4th year, and 28% in their 5th year or beyond.

3.1.2 Analytical approach

In the survey, each participant is allowed to report two to five close classmates that he/she communicates with the most about course content. Course content comprises working on homework or lab, studying for exams or quizzes, sharing resources (e.g., notes, textbooks, etc.), and sharing information on course management (e.g., deadlines, online management systems). The method of communication is provided including but not limited to face to face, email, text messaging, and video chat. We measured the strength of each pair of partners' social ties in networks every week by asking the frequency of their interactions ("Number of times you communicate with this classmate on a weekly") and duration of the collaboration ("The average duration for each time you communicate with this classmate"). We normalized the frequency and duration of interactions to calculate the selected network centrality measures for each student.

SNA is a reliable method to analyze social structure by collectively drawing an intertwined mesh of connections among the targeted social groups (Scott 1988). It quantifies the dynamics of social structure with visual aid by engaging in statistical and mathematical methods. The researchers manipulated the collected responses to produce academic sociograms and measure students' academic network centralities at the individual level. The network centralities measure the significance of each student's network position by different means. According to the research objectives, the author selected the five most popular types of centrality measures from network theory as the alternative independent variables in the regression tests. They are degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, and local clustering coefficient.

Hunsu et al. (2018) developed an instrument of student engagement which consists of three constructs (trust, reciprocity, and sense of belonging) associated with social capital in social networks. According to Hunsu's framework, the dependent variable is manipulated into four categories through different survey questions: student engagement, trust, reciprocity, and belonging. This study involves 13 questions to measure student engagement, including 5 questions for trust, 3 questions for reciprocity, and 5 questions for sense of belonging. Thus, the value of dependent variables for each student are calculated by taking the average scores among the corresponding questions. The factor structure of the measure of student engagement is verified through confirmatory factor analysis (CFA) in Chapter 5.

This study integrates with linear regression with IBM SPSS Statistics to test our hypothesis, where student engagement is the dependent variable and network centralities at the individual level are the independent variables. Based on the survey responses, the author used social network analysis (SNA) to provide visual aid of students' academic social network and generate each respondent's network centrality as needed. To address our research problems, the researchers adopted a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree") in the survey to evaluate participants' student engagement. The dependent variable is measured by taking the means of the responses in terms of the participants' in- and out-of-class activity involvements. Control variables are students' demographic factors such as age, gender, years in college, and ethnicity.

3.2 Results

3.2.1 Network Visualization

The self-reported interactions about coursework are visualized in the sociogram of Figure 3.1 through the social network analysis method. Each student represents a node in the network and a tie refers to direct communication between the closely collaborated partners. The thickness of ties shows the strength of their academic collaboration. For instance, student #34 obtained the strongest social ties with peers in the class. In the sociogram, 112 nodes (students) are split into two different groups because of the university, and the average number of ties (partners) is 3.5 per student. By visualizing students' relative influence in the network, the most influential node refers to the student who stands out for contributions in collaborative learning.

University A

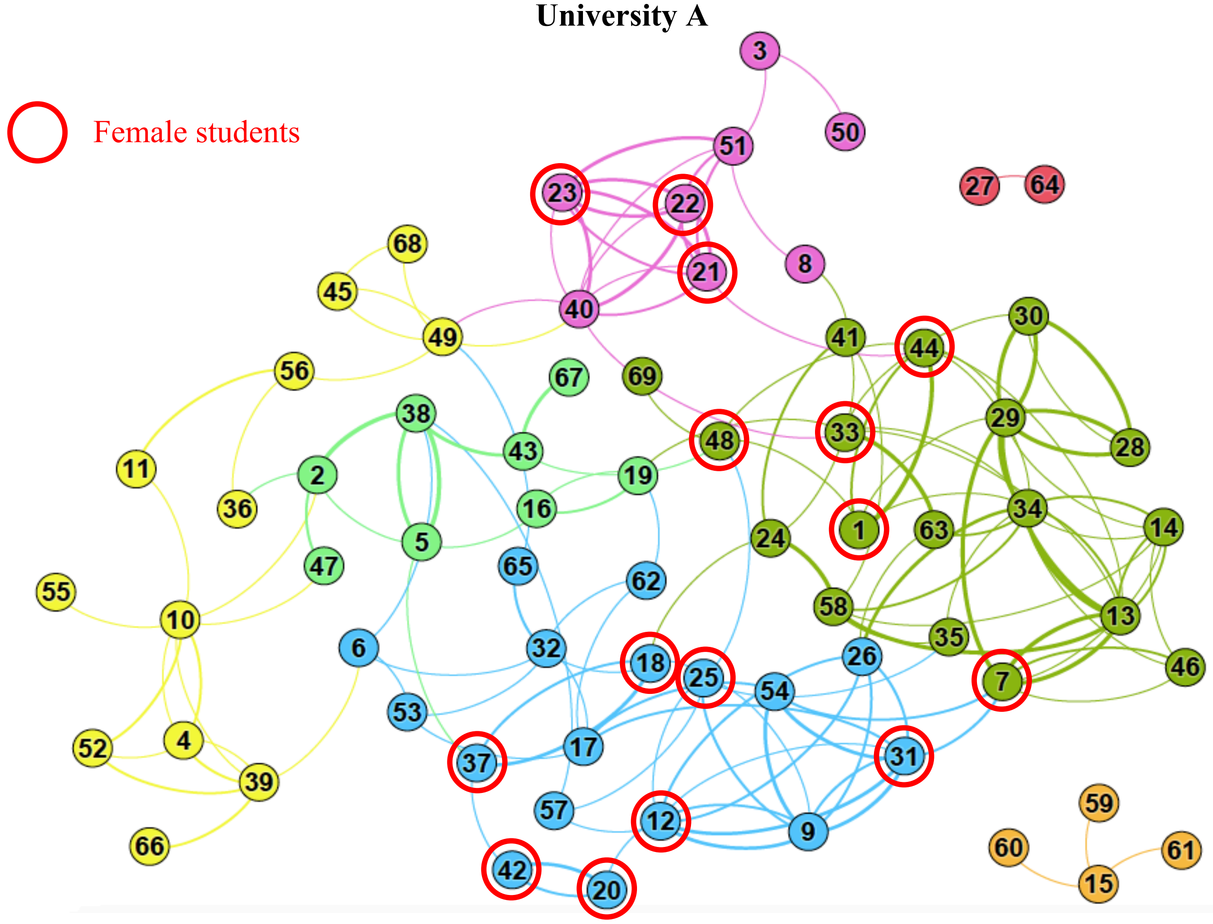
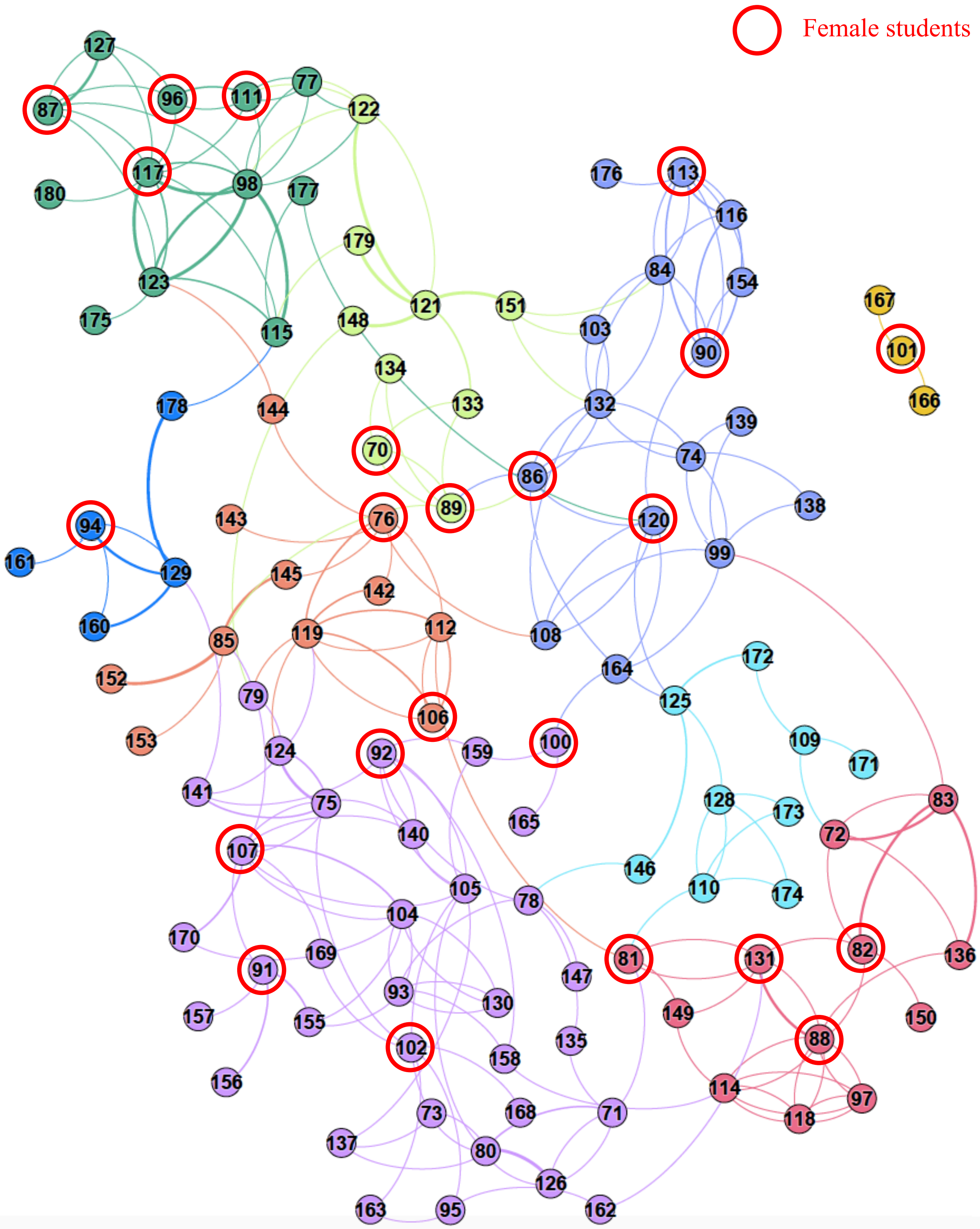


Figure 3.1 Academic network sociograms at the individual level

Figure 3.1 (cont'd)

University B



Gender is one of the important control variables in this research because female is a minority in the construction domain. The above individual-level sociograms highlight female students to visualize the participation of the minority in the collaborative learning environments. The author observed that female students are more willing to communicate and collaborate with each other. One possible explanation is the fear of discrimination to the minority. Additionally, female student's engagement level is higher in the subgroup with a smaller size through descriptive analysis. This suggests the instructors to assign a small fixed project group size to the class with mixed gender to minimize this kind of concerns.

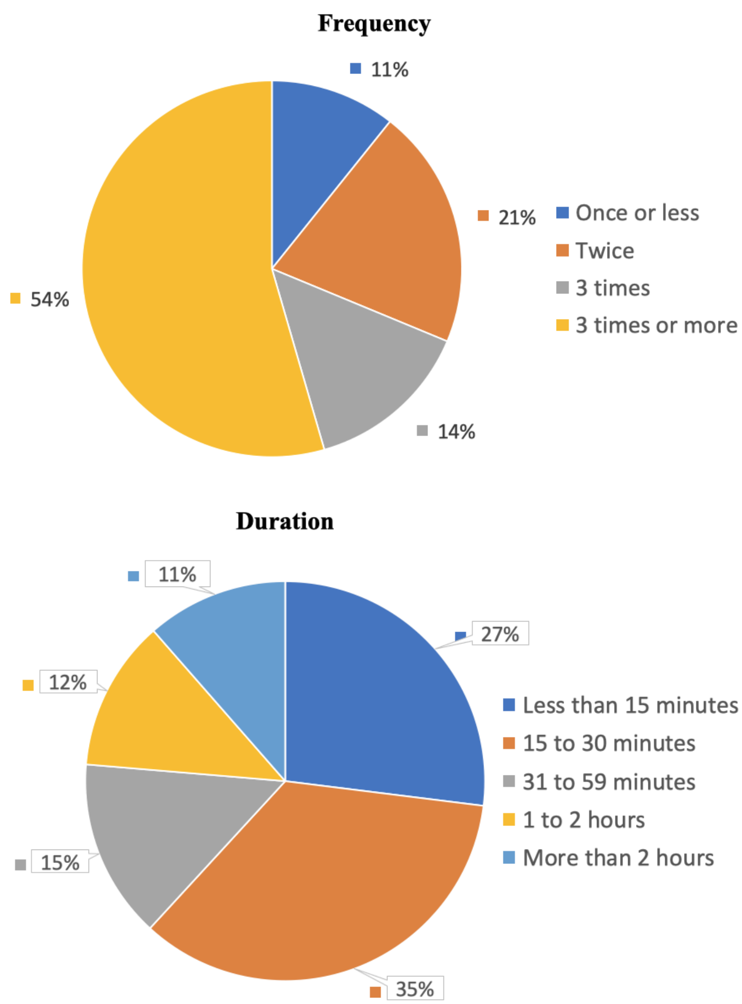


Figure 3.2 Frequency and duration of student partnership on coursework

Pie charts in Figure 3.2 display the distribution of students' interaction frequency and duration regarding course content on a weekly basis. The collaboration includes working on homework or lab, studying for exams or quizzes, sharing resources (e.g., notes, textbooks, etc.), and sharing information on course management (e.g., deadlines, online management systems) via face-to-face discussion, email, text messaging, video chat, etc. The charts illustrate that the majority of students collaborate three times or more (54%) or twice (21%) per week and most communications last for 15 to 30 minutes (35%) or less (27%). 26% of students, in particular, participate in academic collaborations up to seven times or more per week. The descriptive analysis suggests that engineering students contribute initiative extra efforts in collaborative learning, assuming they have a maximum of three classes per week for a course.

3.2.2 Regression Models

To initialize the proposed linear regression tests with SPSS, the first step is to define dependent variables, independent variable, and control variables in the model (see Table 3.1). The next step is to generate frequency tests of control variables (see Table 3.2) to check whether their distributions align with a normal distribution: age, gender (0 – female, 1 – male), year in college, and ethnicity. With the intent of approaching a normal distribution, two control variables are qualified for necessary recoding. Age is recoded into five categories, 20 years old and below, 21 years old, 22 years old, 23 years old, 24 years old and above, respectively (see Table 3.3). Another control variable, ethnicity, is refined with White, Asian, and Others (see Table 3.4). Additionally, the correlation table for independent variables (Table 3.5) illustrates the result is consistent with the definition of unweighted and weighted network centrality. The difference between unweighted network centrality and weighted network centrality is whether or not to take the direction of communications into account.

Table 3.1 Variables of regression tests at the individual level

Dependent Variable	**Independent Variable**		**Control Variable (Demographic Factors)**
	Unweighted (undirected) Centrality	*Weighted (directed) Centrality*	
Student Engagement	Unweighted In-Degree Centrality	Weighted In-Degree Centrality	Age
Trust	Unweighted Out-Degree Centrality	Weighted Out-Degree Centrality	Gender
Reciprocity	Unweighted Degree Centrality	Weighted Degree Centrality	Years in college
Belonging	Unweighted Local Clustering Coefficient	Weighted Local Clustering Coefficient	Ethnicity
	Unweighted Eigenvector Centrality	Weighted Eigenvector Centrality	
	Unweighted Closeness Centrality	Weighted Closeness Centrality	
	Unweighted Betweenness Centrality	Weighted Betweenness Centrality	

Table 3.2 Frequency table of control variables

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18	1	.9	.9	.9
	19	1	.9	.9	1.8
	20	16	14.3	14.3	16.1
	21	27	24.1	24.1	40.2
	22	24	21.4	21.4	61.6
	23	24	21.4	21.4	83.0
	24	2	1.8	1.8	84.8
	25	2	1.8	1.8	86.6
	26	1	.9	.9	87.5
	27	1	.9	.9	88.4
	28	3	2.7	2.7	91.1
	29	2	1.8	1.8	92.9
	30	2	1.8	1.8	94.6
	32	1	.9	.9	95.5
	33	3	2.7	2.7	98.2
	34	1	.9	.9	99.1
	43	1	.9	.9	100.0
	Total	112	100.0	100.0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	25	22.3	22.5	22.5
	1	86	76.8	77.5	100.0
	Total	111	99.1	100.0	
Missing	System	1	.9		
Total		112	100.0		

Year_in_college

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	1.8	1.8	1.8
	3	45	40.2	40.2	42.0
	4	34	30.4	30.4	72.3
	5	31	27.7	27.7	100.0
	Total	112	100.0	100.0	

Ethnicity_O

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		3	2.7	2.7	2.7
	American Indian or Alaska Native	1	.9	.9	3.6
	Asian	24	21.4	21.4	25.0
	Hispanic or Latino	7	6.3	6.3	31.3
	White	77	68.8	68.8	100.0
	Total	112	100.0	100.0	

Table 3.3 Frequency table of recoded Age

Age_r

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	18	16.1	16.1	16.1
	2.00	27	24.1	24.1	40.2
	3.00	24	21.4	21.4	61.6
	4.00	24	21.4	21.4	83.0
	5.00	19	17.0	17.0	100.0
	Total	112	100.0	100.0	

Table 3.4 Frequency table of recoded Ethnicity

Ethnicity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	77	68.8	70.6	70.6
	2.00	24	21.4	22.0	92.7
	3.00	8	7.1	7.3	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

Table 3.5 Paired independent variables correlations at the individual level

		N	Correlation	Sig.
Pair 1	unweighted_indegree_centrality & weighted_indegree	112	.864	.000
Pair 2	unweighted_Outdegree_centrality & weighted_outdegree	112	.595	.000
Pair 3	unweighted_Degree_centrality & Weighted_Degree	112	.789	.000
Pair 4	unweighted_clustering_coefficient & weighted_clustering	112	.932	.000
Pair 5	unweighted_Eigenvector_centrality & weighted_eigenvector_centrality	112	.501	.000
Pair 6	unweighted_Closeness_centrality & weighted_closeness_centrality	112	.328	.000
Pair 7	unweighted_Betweenness_centrality & weighted_betweenness_centrality	112	.473	.000

The following tables demonstrate means, standard deviations and correlations among independent variables and control variables. Table 3.6 focuses on the direction of communications while Table 3.7 only considers the occurrence of communications. Any correlations at the significant level of 99% and 95% are labeled accordingly with defined symbols in the tables.

Through the observations of the significant correlation in Table 3.6, we found that older students and students in higher academic level are more accessible to become the effective bridge of network. The seniors are more trustworthy to talk with regarding academic questions in students' perception. Also, the academic level plays an important role on affecting academic network centralities. Higher-level students are more willing to initialize communications with their peers about the coursework. However, students in lower academic level exert social influence on the academic network in a wider scope.

There are three different observations between Table 3.6 and Table 3.7 in terms of the effect of demographics (control variables) on the independent variable. In Table 3.7, the higher the age, the lower the degree centrality. In other words, older students still build an effective bridge of network but share less direct social ties with peers when taking the direction of communications into account. Another difference is that lower-level students are more likely to receive communication from their peers about the coursework. However, they are able to reach to other students in the network more quickly.

Table 3.6 Means, standard deviations and correlations for independent and control variables (unweighted)

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11
Independent Variable													
1. In-Degree Centrality	2.25	1.69	1										
2. Out-Degree Centrality	3.51	1.24	.18	1									
3. Degree Centrality	5.76	2.27	.84**	.68**	1								
4. Local Clustering Coefficient	.35	.32	.17	-.14	.05	1							
5. Eigenvector Centrality	.20	.17	.59**	.42**	.67**	.33	1						
6. Closeness Centrality	.26	.13	-.18	-.15	-.21*	-.29*	-.05	1					
7. Betweenness Centrality	.013	.14	.09	.48**	.33**	-.48**	.02	-.10	1				
Control Variable													
8. Age	2.99	1.34	-.11	.16	.01	.02	-.08	-.18	.27**	1			
9. Gender	.77	.42	-.04	-.17	-.13	.12	-.16	-.19	-.08	.10	1		
10. Years in college	3.84	.86	-.05	.24*	.09	.01	-.27**	-.13	.45**	.64**	.18	1	
11. Ethnicity	1.37	.62	-.10	-.15	-.16	-.17	-.02	.11	-.05	-.08	.05	-.08	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3.7 Means, standard deviations and correlations for independent and control variables (weighted)

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11
Independent Variable													
1. In-Degree Centrality	4.78	4.41	1										
2. Out-Degree Centrality	7.19	4.43	.44**	1									
3. Degree Centrality	11.96	7.51	.85**	.85**	1								
4. Local Clustering Coefficient	.24	.25	.25**	-.03	.13	1							
5. Eigenvector Centrality	.19	.21	.82**	.46**	.75**	.44**	1						
6. Closeness Centrality	.45	.26	.06	-.06	.01	-.10	.03	1					
7. Betweenness Centrality	.002	.003	.16	.21*	.22*	-.23*	.11	-.30**	1				
Control Variable													
8. Age	2.99	1.34	-.21	-.15	-.22*	.00	-.13	-.17	.22*	1			
9. Gender	.77	.42	-.05	-.12	-.10	.10	-.01	-.19	-.07	.09	1		
10. Years in college	3.84	.86	-.19*	-.09	-.16	.02	-.03	-.21*	.32**	.64**	.18	1	
11. Ethnicity	.37	.62	-.07	-.03	-.06	-.18	-.14	.13	-.19	-.08	.05	-.08	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.2.3 Regression Results

Through descriptive analysis of dependent variables (see Appendix B), outliers are less representative and influential to this relatively small sample size of 112 students. For example, Figure 3.3 displays the distribution and outlier of student engagement. Student #60 has a relatively low engagement score which is qualified to an outlier. Similarly, the outliers are consequently excluded for each dependent variable.

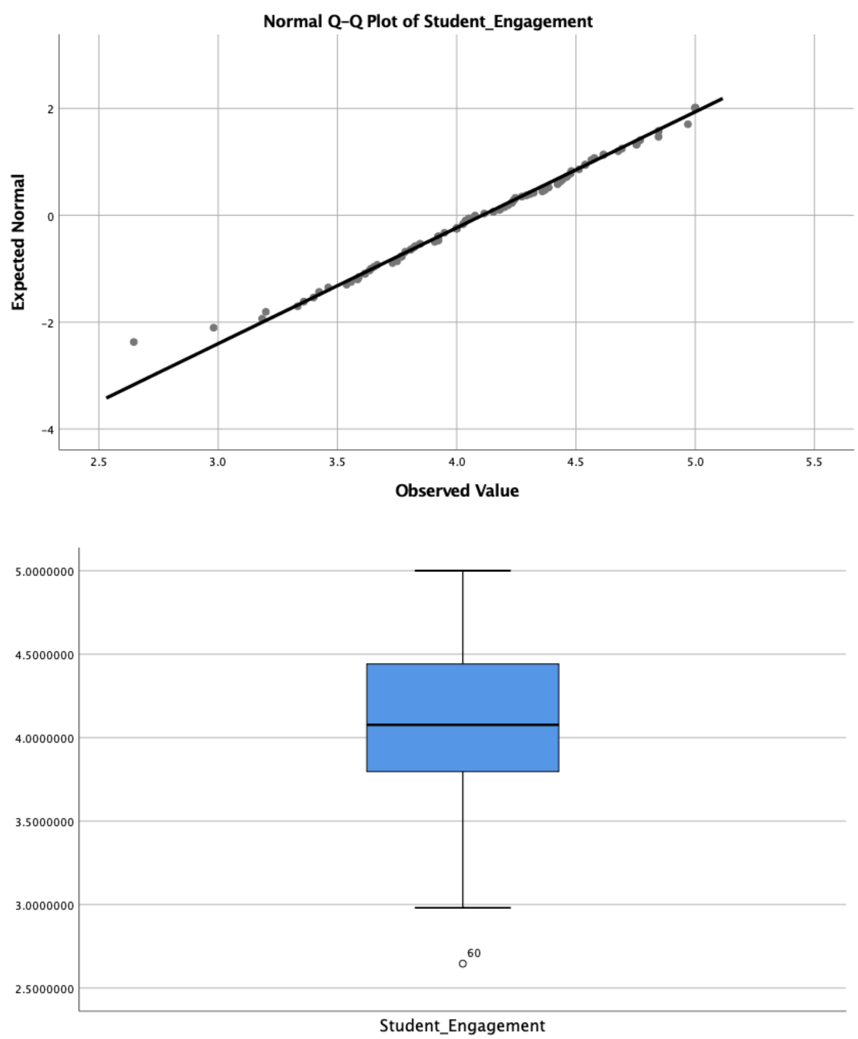


Figure 3.3 Normal Q-Q plot and boxplot of individual student engagement

With the manipulated four dependent variables and fourteen independent variables, 56 linear regression tests are generated accordingly. The regression results are listed in Table 3.8 and more details can be found in Appendix C.

Table 3.8 Regression results at the individual level

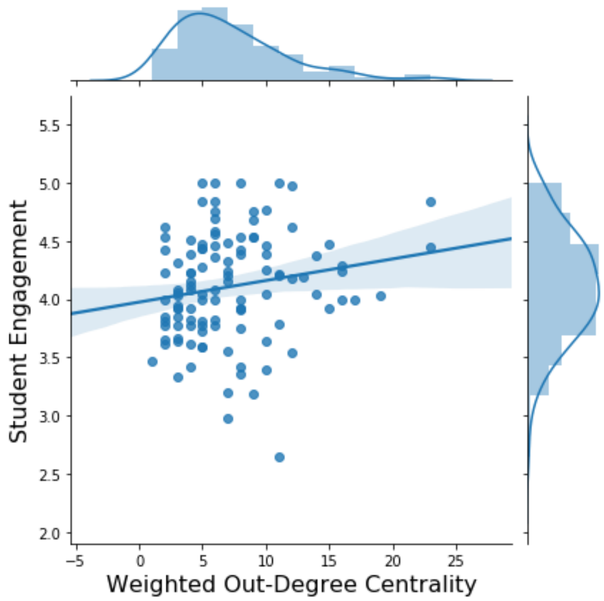
Predictors	**Dependent Variables**			
t-score (p-value)	*Student Engagement*	*Trust*	*Reciprocity*	*Belonging*
Unweighted				
In-Degree Centrality	.997 (.321)	-.552 (.582)	**2.929 (.004)**	.336 (737)
Out-Degree Centrality	.913 (.363)	-.121 (.904)	-.328 (.744)	1.687 (.095)
Degree Centrality	1.244 (.216)	.485 (.628)	**2.016 (.047)**	1.132 (.260)
Local Clustering Coefficient	.632 (.529)	.235 (.815)	.295 (.769)	-.169 (.866)
Eigenvector Centrality	1.848 (.068)	-.208 (.835)	1.840 (.069)	1.674 (.097)
Closeness Centrality	-1.109 (.270)	**-1.834 (.070)**	0.401 (.689)	.631 (.530)
Betweenness Centrality	.935 (.352)	.195 (.846)	1.396 (.166)	1.570 (.120)
Weighted				
In-Degree Centrality	1.412 (.161)	.411 (.682)	**3.309 (.001)**	.193 (.848)
Out-Degree Centrality	**2.013 (.047)**	.667 (.506)	.821 (.414)	1.793 (.076)

Table 3.8 (cont'd)

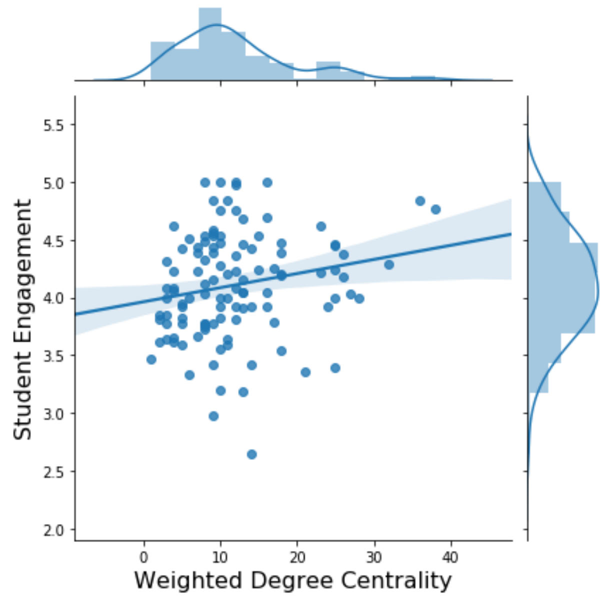
Degree Centrality	**1.999 (.048)**	.626 (.533)	**2.413 (.018)**	1.128 (.262)
Local Clustering Coefficient	.925 (.357)	.526 (.600)	.754 (.452)	-.072 (.943)
Eigenvector Centrality	1.450 (.150)	.345 (.731)	**2.612 (.010)**	.495 (.621)
Closeness Centrality	.897 (.372)	.992 (.323)	.921 (.359)	.618 (.538)
Betweenness Centrality	.041 (.968)	-.227 (.821)	-.160 (.873)	.464 (.644)

* **Bold** number represents a statistically significant relationship when *p*-value < 0.05.

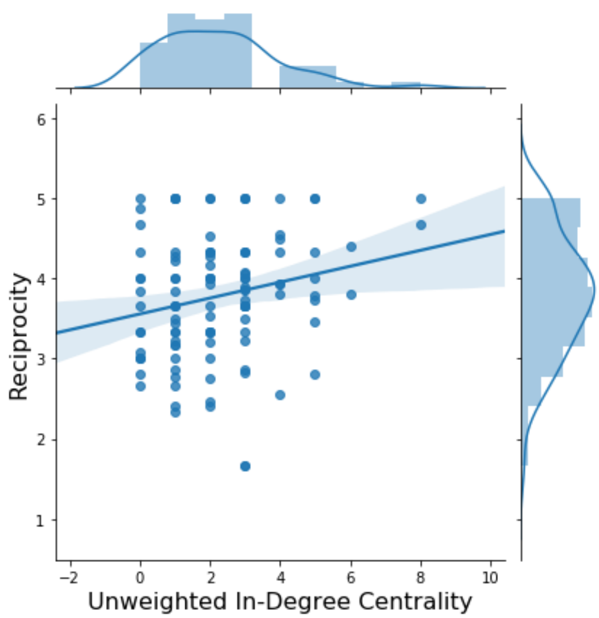
The regression results indicate that seven pairs of combinations have statistically significant relationships at the 95% confidence level. All significant relationships from the above regression tests are displayed in Figure 3.4. The visualizations exclude the control variables due to the limitations of the seaborn plot function by python. The most important finding is the positive relationship between student engagement and weighted degree centrality ($t = 1.999$, $p < 0.05$) that students who build stronger connections in the network perform higher engagement roles. This kind of students can directly reach out to a broader range of peers in discussing about the coursework. Yet this increment is generated by an increase in weighted out-degree centrality ($t = 2.013$, $p < 0.05$), which is a sub-centrality measure of weighted degree centrality. This interprets that students who are proactive in initializing communications with peers and accessible to the other students build a higher level of social capital, and therefore, perform more engaged in collaborative learning. They are more willing to interact with classmates and this kind of social ties brings them fulfillment to actively engage in the academic learning environment.



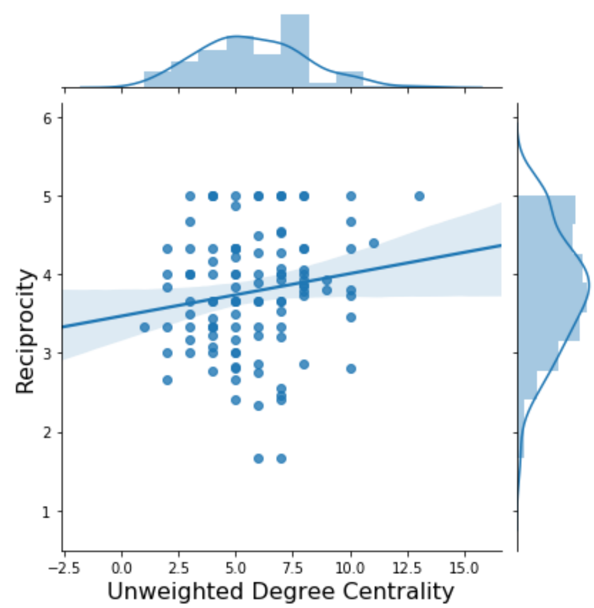
$t = 2.013$, $p < 0.05$



$t = 1.999$, $p < 0.05$



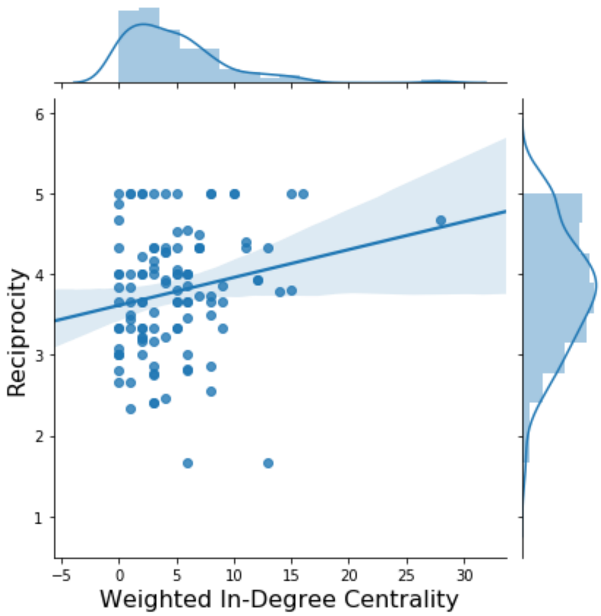
$t = 2.929$, $p < 0.01$



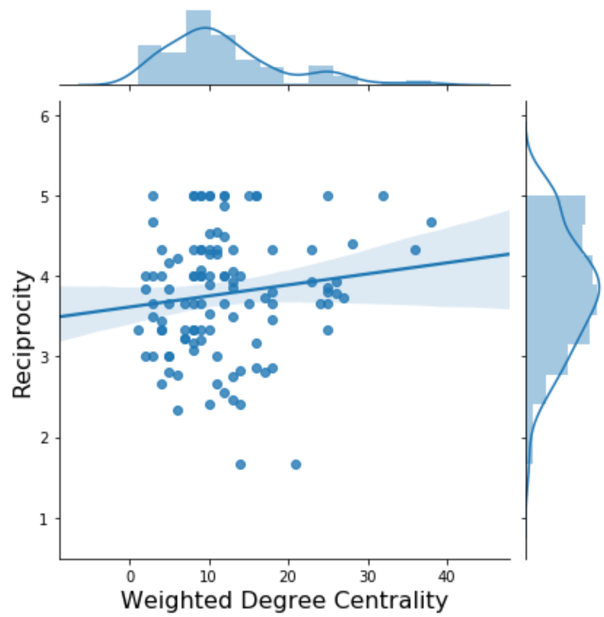
$t = 2.016$, $p < 0.05$

Figure 3.4 Visualizations of individual-level significant relationships

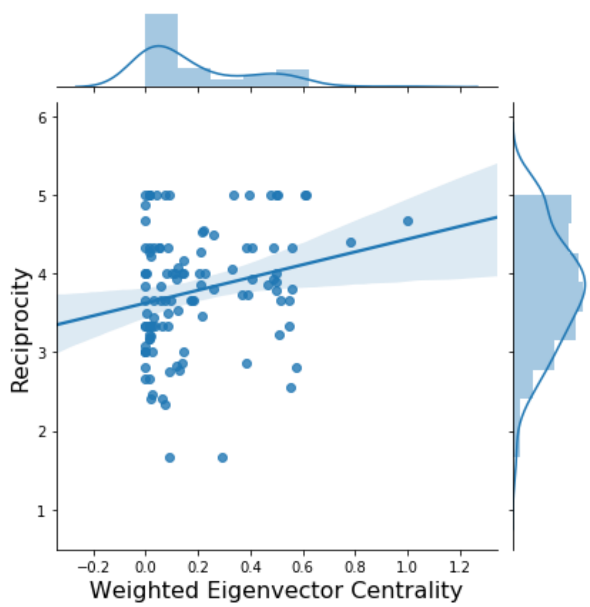
Figure 3.4 (cont'd)



$t = 3.309$, $p < 0.01$



$t = 2.413$, $p < 0.05$



$t = 2.612$, $p < 0.01$

From the observations of regression results, reciprocity is the most essential construct that fosters the increment of student engagement. It has significant relationships with both unweighted degree centrality ($t = 2.016$, $p < 0.05$) and weighted degree centrality ($t = 2.413$, $p < 0.05$). The initiative is influential on student engagement, yet reciprocity already represents the willingness of interactions. Since the sequence of communication is not the prerequisite of facilitating reciprocity, the positive contribution of developing stronger social ties on reciprocity is not influenced by the direction of communications. Reciprocity is even more significantly related to unweighted in-degree centrality ($t = 2.929$, $p < 0.01$) and weighted in-degree centrality ($t = 3.309$, $p < 0.01$). To be specific, even students who play a reactive role in communications can facilitate stronger interconnectivity in the academic network. Hence, their contributions should not be neglected.

Reciprocity also generates significant relationship with weighted eigenvector centrality ($t = 2.612$, $p < 0.01$). Degree centrality evaluates the number of direct ties related to a student, while eigenvector centrality examines all direct and indirect connections that state the influence of a student's contributions to the network. In short, the higher the eigenvector centrality, the larger the scale of influence in the network. Thus, the sense of reciprocity is more susceptible to whether a student is able to reach more partners to contribute to coursework collaborations.

CHAPTER 4

RELATIONSHIPS BETWEEN ACADEMIC NETWORK AND STUDENT ENGAGEMENT AT THE SUBGROUP LEVEL

4.1 Methods

To identify essential subgroups from the existing academic network of the 112 collected valid responses, the study involves social network analysis (SNA) to facilitate reliable grouping activities. Based on the self-reported interactions among the subgroups, the author also produced network sociograms of participants to provide visual aid of their academic network at the subgroup level. Additionally, the most vital benefit of using SNA is to understand the network structure of each subgroup by generating their critical network measure index accordingly. They are validated to statistically measure subgroup's network pattern by different means. According to the research objectives, the author selected the seven popular types of subgroup measures from network theory as the alternative independent variables in the regression tests. They are subgroup size, density, diameter, average degree, connected components, degree centralization, closeness centralization, and betweenness centralization.

With the assigned subgroup members, the student engagement score of each subgroup was generated by calculating the mean of group member's individual engagement levels. Engagement scores at the individual level are the analytical results of chapter 3 in terms of the participants' in- and out-of-class activity involvements. To advance dependent variable manipulation, the researchers address a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree") in the survey design of the student engagement section.

To address the gap of unknown relationships between the academic network and student engagement at the subgroup level, this chapter integrates linear regression tests with IBM SPSS Statistics to test our hypothesis. In the proposed tests, student engagement and its three constructs are the dependent variables while independent variables are network subgroup measures (i.e., density, diameter, degree centralization) generated by SNA.

4.2 Results

4.2.1 Network Visualization

The research applied the modularity function in Gephi to divide 112 students into 13 subgroups based on the participants' self-reported interactions about coursework. The frequency and duration of interactions are reported on a weekly basis. Their social ties are visualized in the sociogram of Figure 4.1 through the social network analysis method. Subgroups of three students or less are excluded. The sociogram of each subgroup displays the communication patterns and the most influential node which refers to the student who stands out for contributions in collaborative learning. Each student represents a node in the network and a tie refers to direct communication between the closely collaborated partners. The thickness of ties shows the strength of their academic collaboration. The collaboration includes working on homework or lab, studying for exams or quizzes, sharing resources (e.g., notes, textbooks, etc.), and sharing information on course management (e.g., deadlines, online management systems) via face-to-face discussion, email, text messaging, video chat, etc. The descriptive analysis in chapter 3 suggests that the majority of students collaborate three times or more (54%) and twice (21%) per week and most communications last for 15 to 30 minutes (35%) or less (27%). 26% of students, in particular, participate in academic collaborations up to seven times or more per week. This finding indicates that engineering students contribute initiative extra efforts in collaborative learning, assuming they have maximum three classes per week for a course.

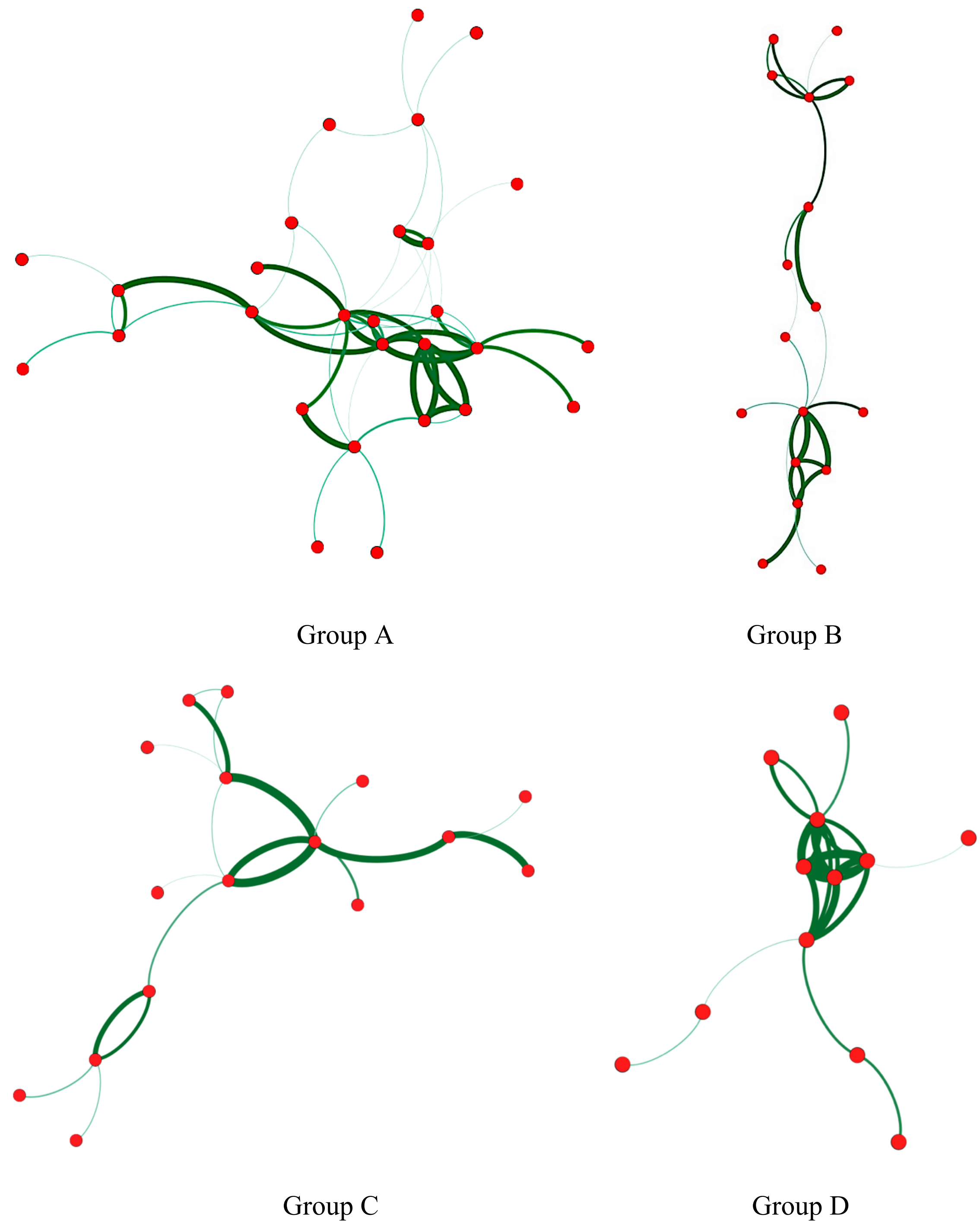
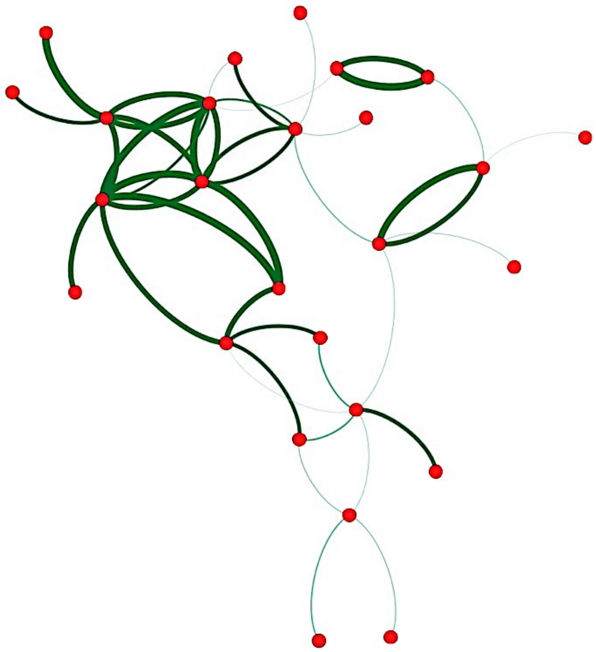
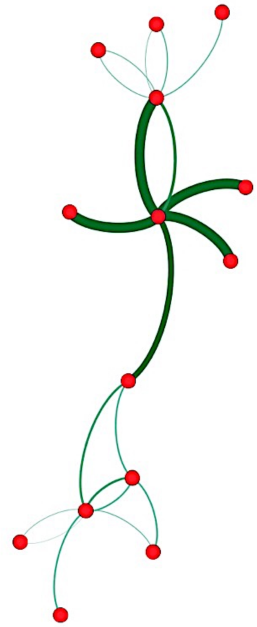


Figure 4.1 Academic network sociograms at the subgroup level

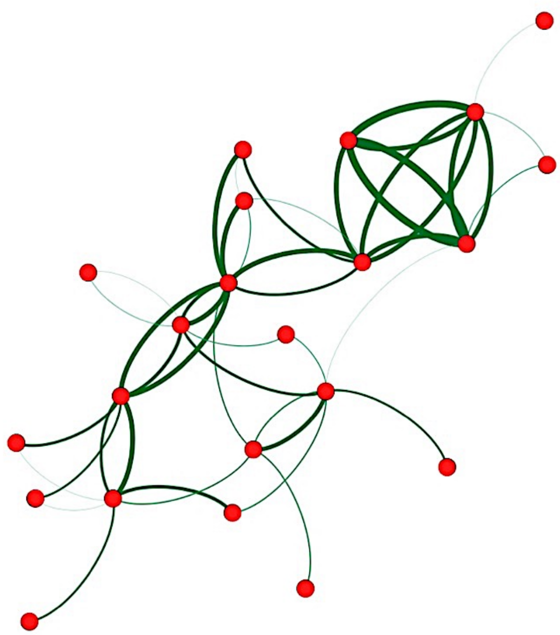
Figure 4.1 (cont'd)



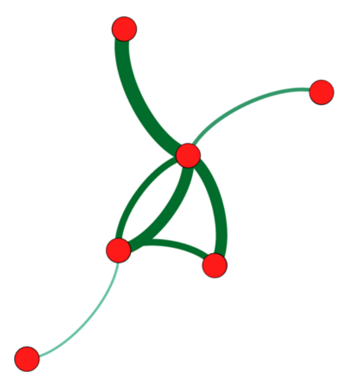
Group E



Group F

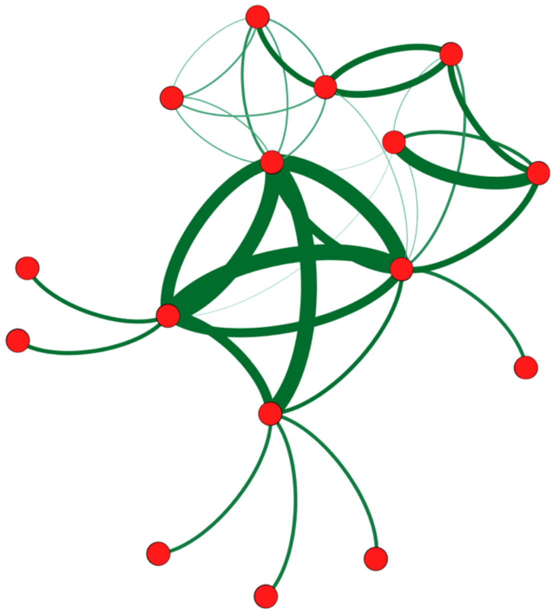


Group G

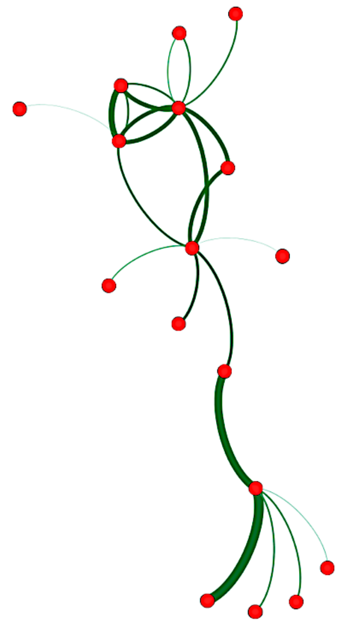


Group H

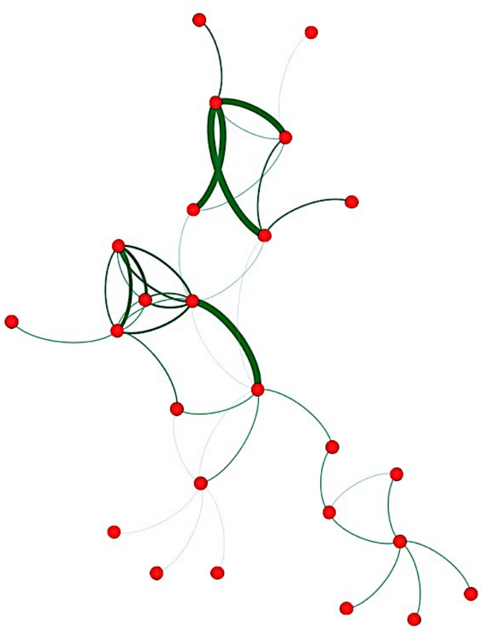
Figure 4.1 (cont'd)



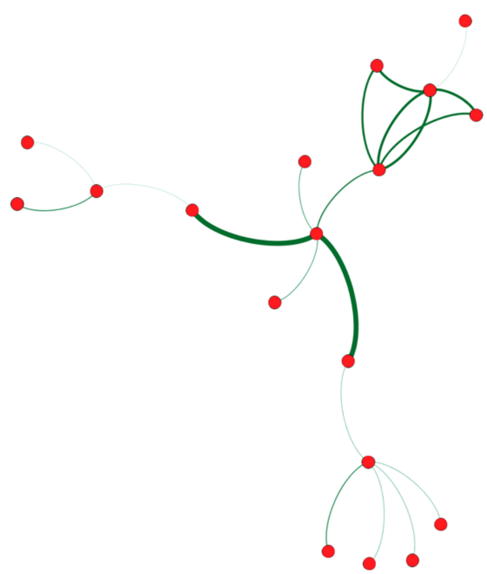
Group I



Group J

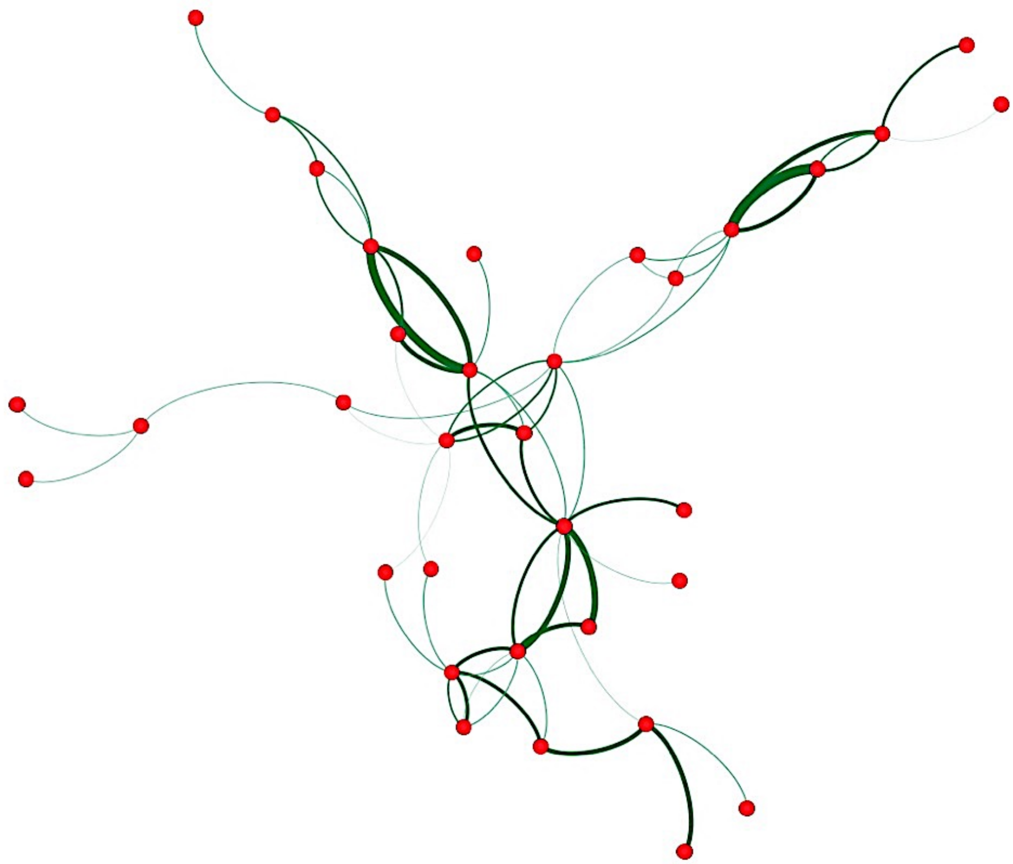


Group J



Group K

Figure 4.1 (cont'd)



Group L (the biggest subgroup)

4.2.2 Regression Models

To initialize the proposed linear regression tests with SPSS, the first step is to define dependent variables, independent variable, and control variables in the model (see Table 4.1). The difference between unweighted network centrality and weighted network centrality is whether or not to take the direction of communications into account. The correlation table for independent variables (Table 4.2) illustrates the result is consistent with the definition of unweighted and weighted subgroup network measures except for closeness centralization. This interprets that edge weights extend the distances between nodes resulting in variance on the estimated maximum possible total of differences in nodal centrality.

Table 4.1 Variables of regression tests at the subgroup level

Dependent Variable	**Independent Variable**	
	Unweighted (undirected) Measures	*Weighted (directed) Measures*
Student Engagement	Subgroup Size	Density
Trust	Density	Diameter
Reciprocity	Diameter	Average Degree
Belonging	Average Degree	Degree Centralization
	Degree Centralization	Closeness Centralization
	Closeness Centralization	Betweenness Centralization
	Betweenness Centralization	Strongly Connected Components

* The weakly connected components of unweighted measures were excluded because there was no difference among the subgroups, which makes the regression test meaningless.

Table 4.2 Paired independent variables Correlations at the subgroup level

		N	Correlation	Sig.
Pair 1	Unweighted_Density & Weighted_Density	13	.983	.000
Pair 2	Unweighted_Diameter & Weighted_Diameter	13	.703	.007
Pair 3	Unweighted_Average_Degree & Weighted_Average_Degree	13	.656	.015
Pair 4	Unweighted_Degree_centralization & Weighted_Degree_centralization	13	.820	.001
Pair 5	Unweighted_closeness_centralization & Weighted_closeness_centralization	13	.139	.651
Pair 6	Unweighted_Betweenness_centralization & Weighted_Betweenness_centralization	13	-.307	.308

4.2.3 Regression Results

The descriptive analysis of dependent variables at the subgroup level demonstrates proximate normal distribution with no need for outlier manipulation (see Appendix D). For instance, Figure 4.2 displays the distribution plots of student engagement at the subgroup level where there is no outlier in the boxplot. With the manipulated four dependent variables and fourteen independent variables, fifty-six linear regression tests are generated accordingly. The regression results are described in Table 4.3 and more details are listed in Appendix E.

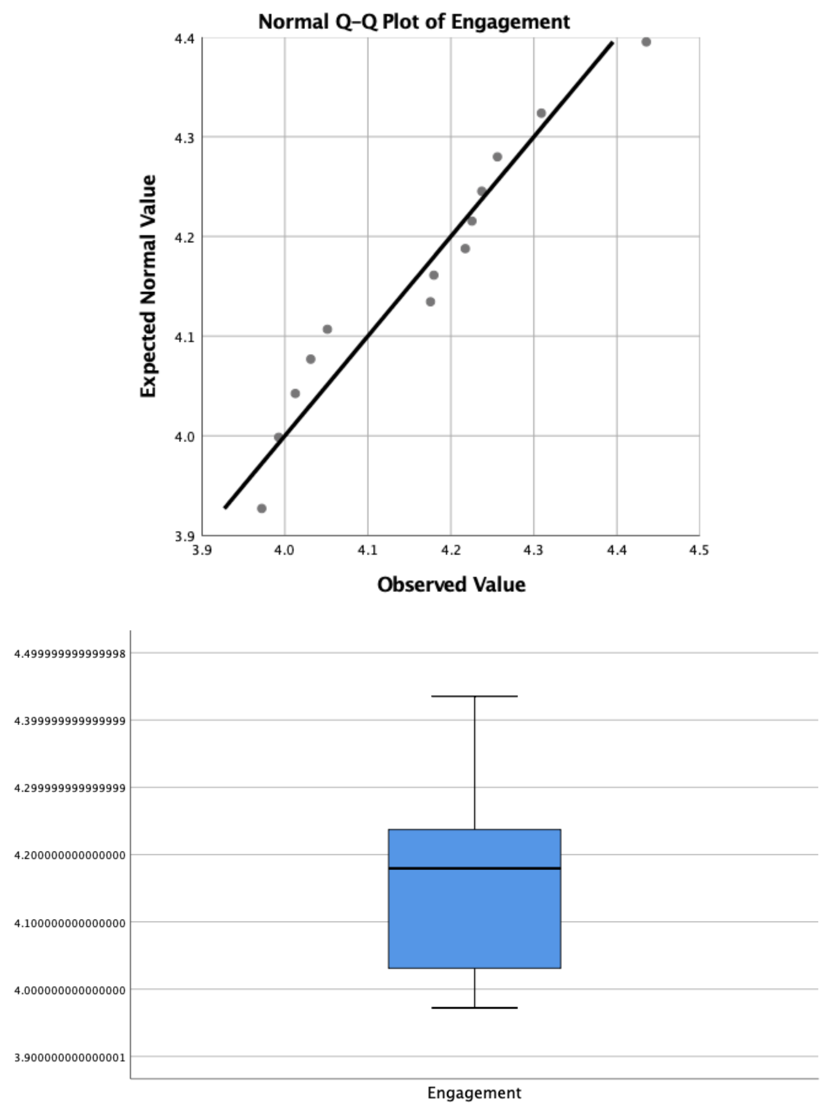


Figure 4.2 Normal Q-Q plot and boxplot of subgroup student engagement

Table 4.3 Regression results at the subgroup level

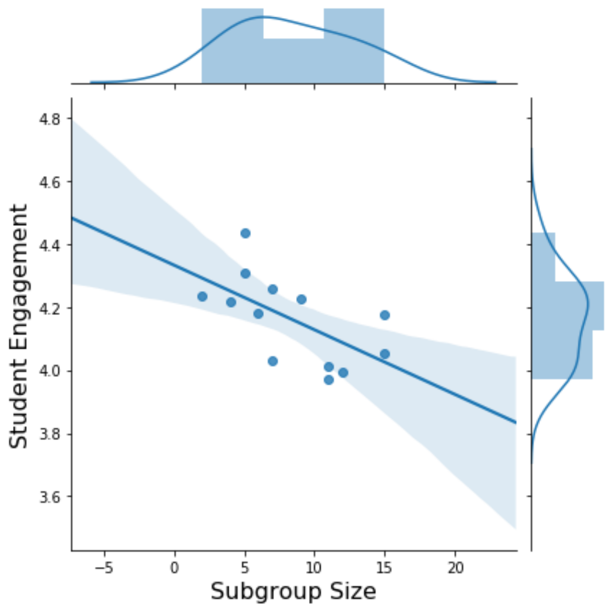
Predictors	**Dependent Variables**			
t-score (p-value)	*Student Engagement*	*Trust*	*Reciprocity*	*Belonging*
Unweighted				
Subgroup Size	**-2.541 (.027)**	**-2.620 (.024)**	-1.014 (.332)	-.558 (588)
Density	.955 (.360)	1.992 (.072)	1.005 (.337)	-.893 (.391)
Diameter	-1.790 (.101)	-1.585 (.141)	-1.350 (.204)	-.140 (.891)
Average Degree	-1.258 (.234)	**-2.268 (.044)**	-.247 (.810)	-.037 (.971)
Degree Centralization	1.355 (.203)	2.086 (.061)	933 (.371)	-.333 (.746)
Closeness Centralization	2.108 (.059)	**3.922 (.002)**	1.931 (.080)	-.872 (.402)
Betweenness Centralization	**3.115 (.010)**	**2.837 (.016)**	1.310 (.217)	.653 (.527)
Weighted				
Density	.860 (.408)	1.567 (.146)	.901 (.387)	-.683 (.509)
Diameter	**-2.610 (.024)**	**-2.330 (.040)**	-1.529 (.155)	-.360 (.726)
Average Degree	-0.255 (.803)	-.247 (.810)	-0.137 (.894)	-.068 (.947)
Degree Centralization	.675 (.513)	1.655 (.126)	. 058 (.954)	-.270 (.792)

Table 4.3 (cont'd)

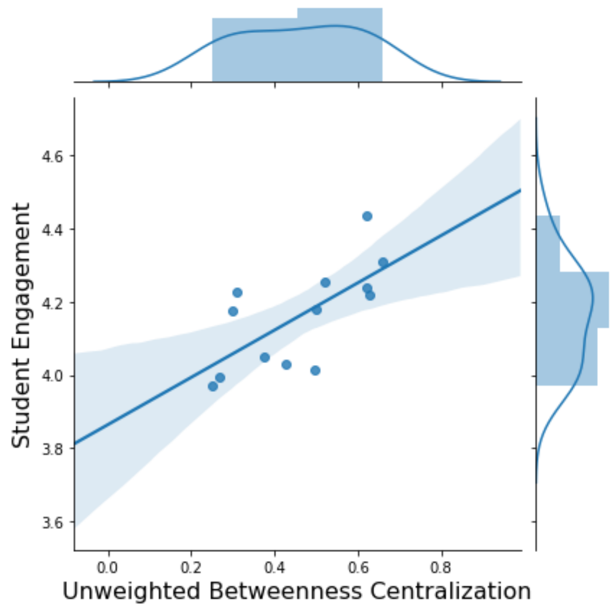
Closeness Centralization	1.355 (.203)	.347 (.735)	1.325 (.212)	.580 (.573)
Betweenness Centralization	-1.009 (.335)	-.922 (.376)	-.851 (.413)	-.024 (.981)
Strongly Connected Components	-1.291 (.223)	-1.526 (.155)	-.481 (.640)	-.285 (.781)

* **Bold** number represents a statistically significant relationship when *p*-value < 0.05.

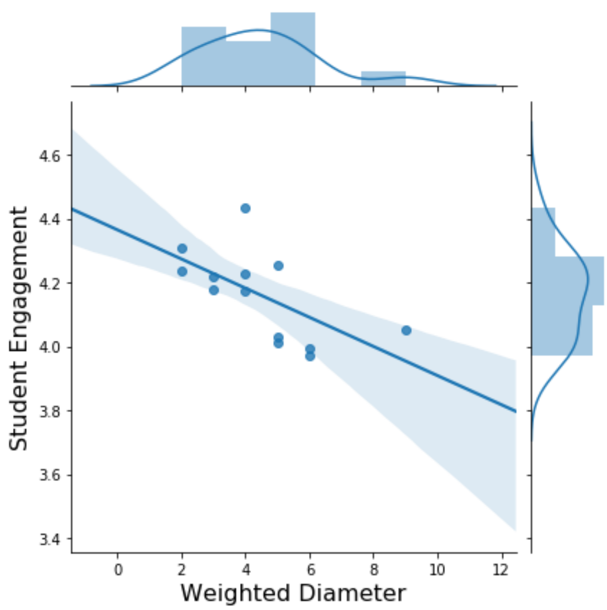
The regression results indicate that eight pairs of combinations have statistically significant relationships at the 95% confidence level. All significant relationships from the above regression tests are displayed in Figure 4.3. The visualizations exclude the control variables due to the limitations of the seaborn plot function by python. The most outstanding finding is the negative significant relationship between student engagement and weighted diameter (t = -2.610, $p <$ 0.05). Weighted network diameter is a path with the maximum sum of edge weights which extend the distance between nodes. The diameter is representative of the linear size of a network. A shorter network diameter determines a node can reach other nodes in the subgroup to make contributions to coursework collaborations with fewer steps. In other words, the pattern of social ties in this kind of subgroup spreads out. From the perspective of social network structure (i.e., line, star, ring, mesh, hybrid), star is a typical structure with a short network diameter (see Figure 4.4). Figure 4.5 displays other example sociograms of subgroup H and K which are proximate to the star structure and have the shortest network diameter in this study. This kind of structure fosters frequent information exchanges among group members. Thus, this finding interprets that those who make closer and more frequent connections with partners in the group contribute to higher student engagement in collaborative learning.



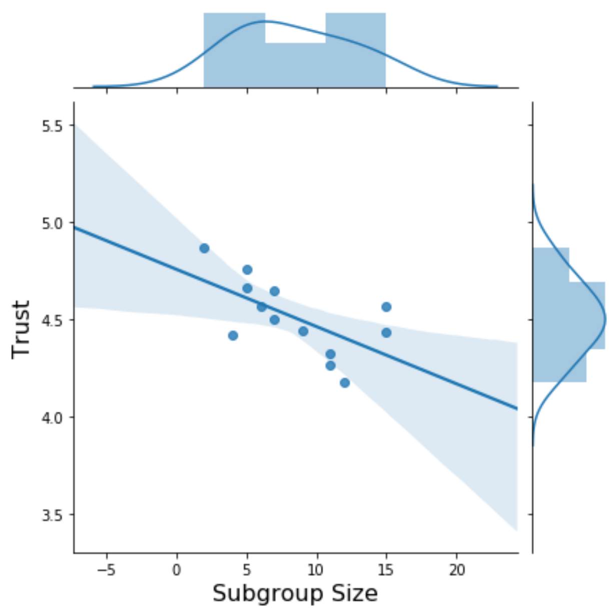
t = -2.541, $p < 0.05$



t = 3.115, $p < 0.01$



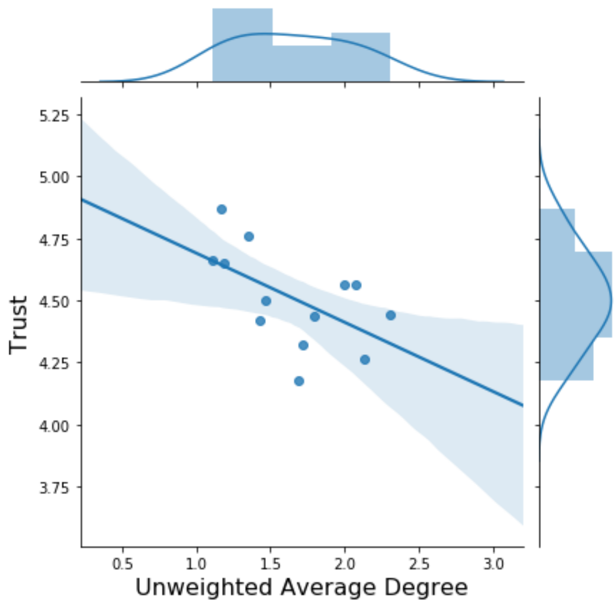
t = -2.610, $p < 0.05$



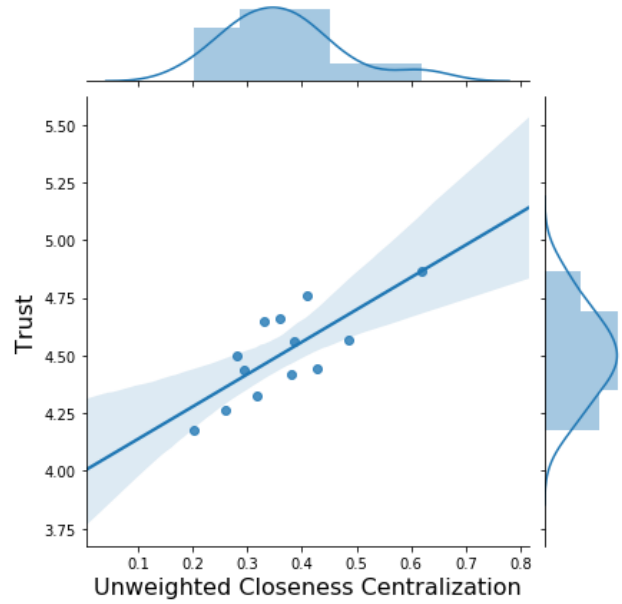
t = -2.620, $p < 0.05$

Figure 4.3 Visualizations of subgroup-level significant relationships

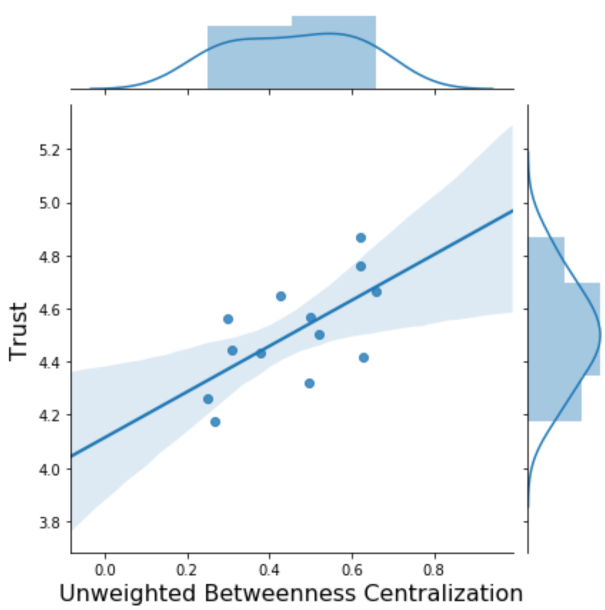
Figure 4.3 (cont'd)



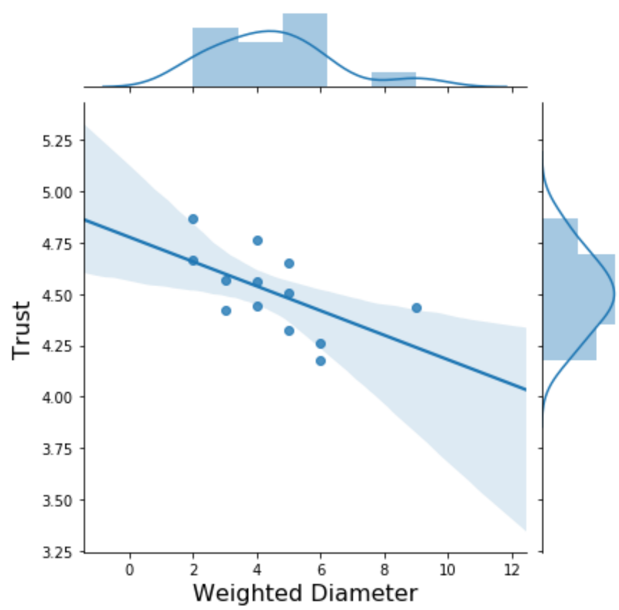
$t = -2.268$, $p < 0.05$



$t = 3.922$, $p < 0.01$



$t = 2.837$, $p < 0.05$



$t = -2.330$, $p < 0.05$

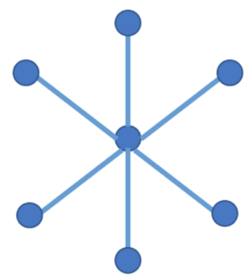
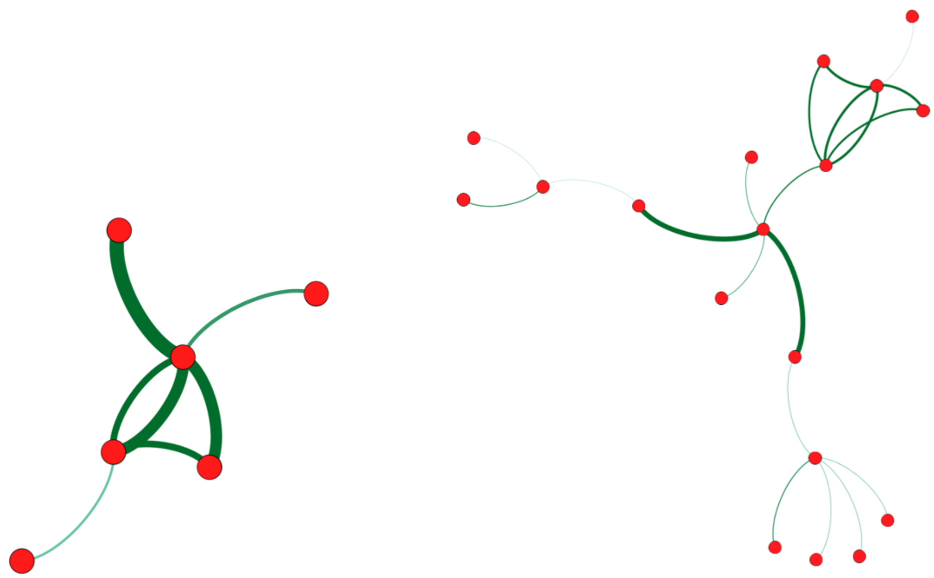


Figure 4.4 A typical star network



Group H   Group K

Figure 4.5 Example subgroup sociogram with short diameter

The increment of student engagement is also influenced by the size of the subgroup network (t = -2.541, $p < 0.05$) and unweighted betweenness centralization (t = 3.115, $p < 0.01$). A higher unweighted betweenness centralization indicates a shorter distance between any two nodes in the network. Hence, more efficient communications with easier information exchanges are accessible to the members of the subgroup. These additional relationships confirm that academic collaboration is positively encouraged in a highly intensive small-size subgroup. By intensive, it suggests that the academic network subgroup is required a critical “hub” to diffuse efficient information exchanges.

Through the observed relationships, trust has consistent relationships with student engagement regarding these three subgroup measures. It is clearly identified that trust is the construct which significantly contributes to the impacts on student engagement. Trust relationship is influential on student engagement as group-level behaviors. In other words, student engages in group collaborative learning more actively with the presence of trust relationships. In short, effective academic collaborations require trust relationships. Additionally, trust is correlated with unweighted average degree (t = -2.268, p < 0.05) which is the total number of interactions shared among the subgroup members. This suggests that stronger interconnectivity in the academic network facilitates the establishment of trust relationships among group members. Frequently built social ties with peers is beneficial to group performances in collaborative learning. Lastly, unweighted closeness centralization generates the most significant relationship with trust relationships (t = 3.922, p < 0.01). Students who can reach to other subgroup members in fewer steps are able to build firmer trust relationships with peers. This kind of social capital facilitates closer connections in collaborative learning among the subgroup in return.

The observations of regression results suggest that merely the significant relationships with diameter consider the direction of communications. Weighted diameter involves weight on the distance between any two nodes based on the strength of social ties, which enhances the measurement of network connectedness. Thus, it further confirms that lower eccentricity in the academic network results in higher students’ willingness of engagement in collaborative learning.

CHAPTER 5

CONFIRMATORY FACTOR ANALYSIS FOR STUDENT ENGAGEMENT

Confirmatory Factor Analysis is a reliable statistical technique that allows the researcher to examine the established factor structure of a pool of observed variables underlying broader theoretically derived constructs. Hence, it is used to verify how well the created instrument of a construct from the researcher's understanding can measure the nature of that construct. This function is commonly used as a foundation for latent regression analysis to identify the reliability of the manipulated variables.

In order to test the validity of the proposed social engagement framework, we conducted a CFA analysis by involving the research data via structural equation modeling (SEM) of our measurement model. The analysis was conducted on SPSS AMOS® with the responses of 112 participants. Since each participant is required to report two to five close partners in collaborative learning, we only reserved the first two mandatory responses of every participant in the CFA analysis to minimize potential bias. The results suggest that participants' response patterns on the survey reasonably support the hypothesized model.

The underlying items of the factor structure are described in Table 5.1 below. Initial CFA suggests the factor structure of the current model was not ideal (CFI = .888, RMSEA = .086). Referring to the modification indices provided by the AMOS outputs, we added a double-headed covariance line between Q25_3 and Q25_5 to improve the factor structure of the instrument (see Figure 5.1 below). According to the AMOS outputs in Table 5.2, the final model yielded an acceptable fit statistic, CMIN/DF = 2.017; TLI = 0.913; CFI = 0.932; RMSEA = .067. Theorists recommend that the satisfactory fit of a good model should have CFI and TLI statistics exceeding 0.9 while RMSEA less than 0.08. Additionally, we conducted a reliability test with SPSS on the proposed student engagement framework. The computed reliability coefficient, Cronbach's Alpha, exceeds the acceptable threshold of 0.70 according to a rule of thumb (see Appendix F). Therefore, the analysis results suggest the structure of the latent factors underlying items successfully validates the instrument measuring student engagement in this research.

Table 5.1 Description of observed variables (Hunsu et al. 2018)

Question #	Coding	Description
		Trust
Question 17	Q17	Communications with this classmate are pleasant.
Question 18	Q18	I help this classmate even if they don't help me.
Question 19	Q19_r	Interactions with this classmate are not productive/useful.
Question 20	Q20	When given the option, I choose to work with this person on course assignments and/or projects.
Question 21	Q21	My interactions with this person are valuable/helpful.
		Reciprocity
Question 22	Q22	I help this person because they help me.
Question 23	Q23	We understand each other without effort.
Question 24	Q24	When I work with this classmate, I accomplish tasks faster than I would have alone.

Table 5.1 (cont'd)

Belonging		
Question 25_1	Q25_1	I feel comfortable in the class
Question 25_2	Q25_2	I feel like a part of the class.
Question 25_3	Q25_3	I feel supported by my classmates in this class.
Question 25_4	Q25_4_r	I often feel like an outsider in this class.
Question 25_5	Q25_5	I feel committed to the individuals in this class.

* All thirteen variables are measured on a 5-point Likert scale from 1 = Strongly disagree to 5 = Strongly agree.

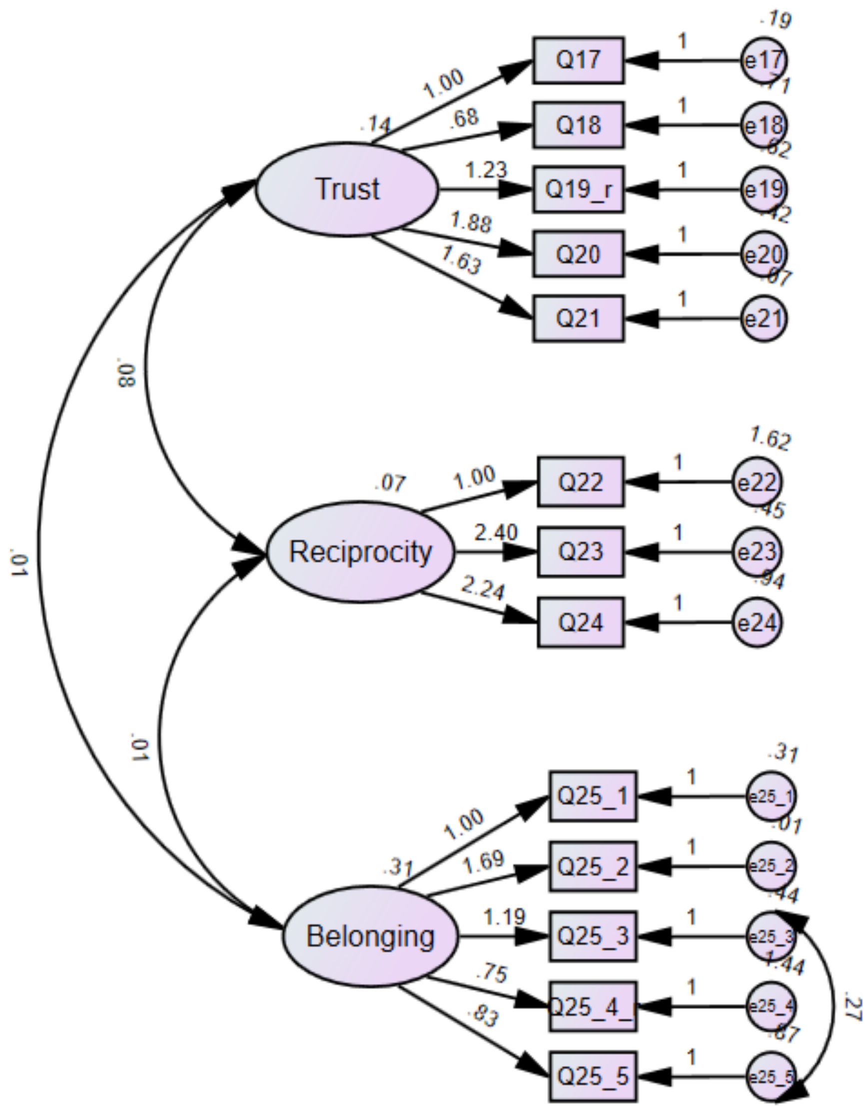


Figure 5.1 Three-factor model for CFA analysis

Table 5.2 SPSS AMOS® outputs of CFA analysis

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	30	123.018	61	.000	2.017
Saturated model	91	.000	0		
Independence model	13	992.407	78	.000	12.723

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.876	.841	.933	.913	.932
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.067	.050	.084	.051
Independence model	.228	.216	.241	.000

CHAPTER 6

DISCUSSIONS AND CONCLUSION

6.1 Discussions

6.1.1 Implications

At the individual level, the primary finding is the positive relationship between student engagement and weighted network degree centrality. This suggests college instructors encourage students to proactively develop direct social ties with as many as classmates to maximize student engagement in general. Incentives can be assigned in a proper manner in a collaborative learning environment (i.e., laboratories, group discussions, team projects, and capstone projects) to foster highly responsive engagement. Additionally, a high sense of reciprocity between partners facilitates efficient collaborations and triggers strong interconnectivity of the academic network. Thus, course designs should appropriately involve interactive activities in collaborative learning to improve the effectiveness of interventions in terms of student engagement.

At the subgroup level, there is a strong negative correlation between student engagement and weighted diameter. In other words, an academic subgroup network with low eccentricity is beneficial to retain and sustain high-level student engagement among group members. Eccentricity is the distance from a given starting node to the farthest node from it in the network. Low eccentricity consequently optimizes information exchange in the network, where students spontaneously build strong connections with partners. Therefore, the network subgroup as a whole contributes to essential engagement in collaborative learning. Other significant findings regarding student engagement confirm that an ideal network structure of a subgroup is expected to be small sized as well as strongly tied to facilitate efficient information exchanges. To advance educational interventions to the subgroup performances, the research findings suggest instructors pay attention to supporting the establishment of trust relationships among group members as reflected on the connectedness of academic network structures.

Throughout the findings at both the individual level and the subgroup level, this interprets that leadership is the core of the concurrently lower eccentricity of the network and develop stronger direct social ties with peers. Consequently, the network under controls of highly effective leadership can theoretically produce sustainable cross-discipline engagement in collaborative learning. In other words, there is a high demand for involving leadership-based academic network structure in the pursuit of high-level student engagement in higher education. The present research also affirmed a strong correlation between instructional leadership behaviors and student engagement (Crumpton 2018). The findings of this study shed light on the vital development of student leadership for any collaboration required learning environments. Moreover, it can apply to cross-discipline collaborations, such as construction projects.

Nevertheless, course designs of construction education ought to focus on not only leadership development but also followers' engagement. Followers are the majority who influences the learning outcomes. In the absence of responsive followers, the essential effects of leadership skills on student engagement are questionable. The extant study uncovered that high-exchange relationship between followers and leaders creates follower engagement (Burch and Guarana 2014). Yang et al. (2017) suggest that the proactive personalities of both followers and leaders are aligned and follower engagement stays active by achieving goal congruence with leaders aiming at maximizing outcomes.

6.1.2 Recommendations

6.1.2.1 General Recommendations

However, there are missing empirical instructions for college instructors and course designers to play an appropriate role to proactively intervene in students to optimize collaborative learning engagement. This research intends to constitute feasible guidelines of interventions on emergent academic network structure by aggregating the effects of network interventions at the nodal level as well as the subgroup level. To promote instructional efforts on student engagement development, the primary goal is to make a tight connection between student engagement development and leadership development with promising practical implications.

Empirical research confirms that leader assignment is a less promising intervention due to the dynamic nature of emergent leadership behaviors (Xie et al. 2018). College students also show preference for personalized rather than group-oriented leadership development (Allen and Hartman 2009). Additionally, Jenkins (2012) also recommended educators to implicate effective discussion-based instructional strategies to facilitate leadership development. From the perception of college students, leadership development requires essential self-discovery learning through real-life scenarios (Morrison et al. 2003). In short, leadership is an emergent built skill. As an instructor, instructional strategies of collaboration-based course design are recommended to involve leadership-building activities such as role-play to advance students' personal skill growth (Jenkins 2013). Therefore, this suggest instructors assign and rotate the coordinator role for each project team which fosters every group member to reach out to other partners in a logical manner.

Additionally, some network-based interventions are applicable according to facilitate small sized and strongly tied subgroup. For instance, instructors can minimize the subgroup network diameter by assigning a fixed project group size to the class with an equal number of students. Besides, Interventions of student leadership development can assign a critical “hub” for efficient communications and information exchanges among the subgroup. Leadership development is a mutual process that requires reciprocal efforts from both leaders and followers. In this setting, our goal is to convert coordinators into leaders to perform multiple leadership roles and eventually build emergent and sustain leadership in the collaboration groups. Meanwhile, the performed leadership roles in return facilitate proactive student engagement in collaborative learning. Additional empirical research would be required to further examine the validity of this proposed pedagogical strategy.

6.1.2.2 Recommendations for Construction Management Courses

The research findings uncovered the significant impacts of student leadership development for any collaboration required learning environments. Construction management is a project-based discipline that involves essential cross-discipline collaborations with Architect and Engineering domain. For the educational purpose, construction management courses engage in collaborative learning through team project assignments for project scheduling, project management, BIM, etc. The instructors can manage project teams with network-based interventions to facilitate favorable network features, such as small group size. Some necessary discussion activities can foster the establishment of trust relationship and reciprocity. Assigning and rotating dynamic coordinator is another recommended instructional strategy to ensure efficient communications and information exchanges by assigning a “hub”. This kind of role-play facilitate development of student leadership. Additionally, instructors should keep track of the validity of role-play activities through additional task assignment and other empirical practices for flexibility. Students should achieve goal congruence with instructors to develop leadership skills not only for academic performances but also for future career success to develop social capital. Therefore, I suggested students to play different leadership roles to make essential contributions to communications and information exchanges in the project team.

6.1.3 Limitations

Nevertheless, this study has a few notable limitations. First, our survey did not involve a wide range of participants to get access to every student's engagement and networking data in the class. Consequently, it shrinks our sample size and affects the generalizability of our results. Future research can replicate our study within the same framework of measuring student engagement by using a complete dataset. Another limitation is due to the undifferentiated effects of participant's demographic factor as a subgroup at the stage of data pretreatment. As a result, control variables were excluded from the regression tests when examining the relationship between student engagement and group-level network attributes. Hence, this research findings may not be applicable to some extreme cases, for example, a project team consisting of only female students.

6.2 Conclusion

The current study used Social Network Analysis method to investigate the relationships between student engagement and academic network attributes at the individual level (i.e., degree centrality, closeness centrality) as well as at the subgroup level (i.e., density, diameter) for construction education. The validity of student engagement framework was confirmed through Confirmatory Factor Analysis. By exploring significant correlations from multiple combinations of variables, it advances educators' understanding of the influences of student engagement and outcomes of network-based interventions. The research findings confirm the importance to increase students' social ties individually in collaborative learning and highlight the contributions of reciprocity in promoting student engagement. The subgroup-level findings reveal an important student engagement predictor that constructing low-eccentricity cohesive academic subgroup network can ensure efficient information exchange among the group members. This kind of tight connections are mainly established based on trust relationships. Finally, it concluded the involvement of leadership as a core motivator to facilitate college student engagement in collaborative learning and proposed promising practical interventions according to the research findings. Therefore, this research contributes to network-based intervention improvements in student engagement for educators who are experts in collaboration-focused construction education.

This study is monitored and approved to be exempt from the MSU institutional review board (IRB) review under case #STUDY00002232.

APPENDICES

Appendix A. List of the items of student engagement instrument

*5-point Likert scale from 1 = “Strongly disagree” to 5 = “Strongly agree”

Question 1

Communications with this classmate are pleasant.

Question 2

I help this classmate even if they don't help me.

Question 3

Interactions with this classmate are not productive/useful.

Question 4

When given the option, I choose to work with this person on course assignments and/or projects.

Question 5

My interactions with this person are valuable/helpful.

Question 6

I help this person because they help me.

Question 7

We understand each other without effort.

Question 8

When I work with this classmate, I accomplish tasks faster than I would have alone.

Question 9

I feel comfortable in the class

Question 10

I feel like a part of the class.

Question 11

I feel supported by my classmates in this class.

Question 12

I often feel like an outsider in this class.

Question 13

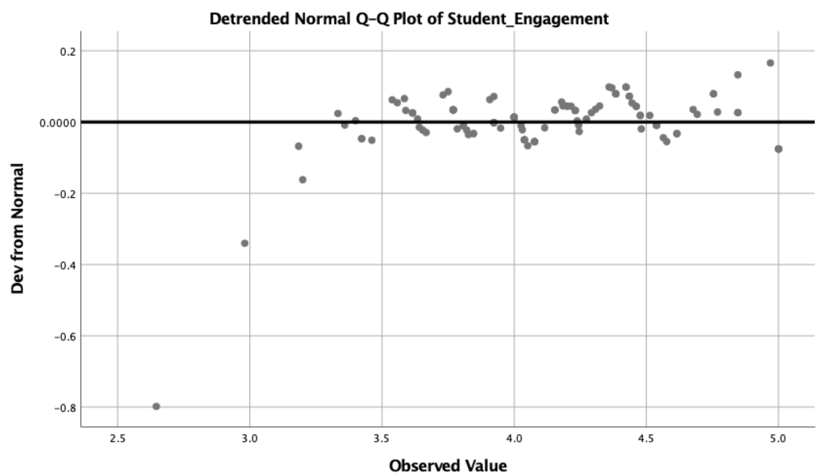
I feel committed to the individuals in this class.

Appendix B. Descriptive analysis of individual-level dependent variables

Table B.1 Descriptive statistic of student engagement

Descriptives

			Statistic	Std. Error
Student_Engagement	Mean		4.10749771	.043558346
	95% Confidence Interval for Mean	Lower Bound	4.02118394	
		Upper Bound	4.19381148	
	5% Trimmed Mean		4.11510480	
	Median		4.07692308	
	Variance		.213	
	Std. Deviation		.460978209	
	Minimum		2.6461538	
	Maximum		5.0000000	
	Range		2.3538462	
	Interquartile Range		.6532051	
	Skewness		-.253	.228
	Kurtosis		.123	.453




```
Student_Engagement Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

     1.00 Extremes    (=<2.6)
     1.00        2 .  9
     1.00        3 .  1
     3.00        3 .  233
     8.00        3 .  44445555
    14.00        3 .  66666677777777
    14.00        3 .  88888899999999
    20.00        4 .  00000000000000011111
    18.00        4 .  222222222223333333
    17.00        4 .  44444444445555555
     7.00        4 .  6666777
     4.00        4 .  8889
     4.00        5 .  0000
```

Figure B.1 Distribution plots of student engagement

Table B.2 Descriptive statistic of trust

Descriptives

			Statistic	Std. Error
Trust	Mean		4.4390	.05030
	95% Confidence Interval for Mean	Lower Bound	4.3393	
		Upper Bound	4.5386	
	5% Trimmed Mean		4.4823	
	Median		4.5600	
	Variance		.283	
	Std. Deviation		.53231	
	Minimum		2.84	
	Maximum		5.00	
	Range		2.16	
	Interquartile Range		.85	
	Skewness		-.944	.228
	Kurtosis		.344	.453

```
Trust Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

     1.00 Extremes    (=<2.8)
     2.00        3 .  00
     3.00        3 .  223
     4.00        3 .  4455
     3.00        3 .  667
     5.00        3 .  88999
    11.00        4 .  00000000011
    11.00        4 .  22222222333
    18.00        4 .  444444444444455555
    14.00        4 .  66666666666677
    14.00        4 .  88888888999999
    26.00        5 .  00000000000000000000000000
```

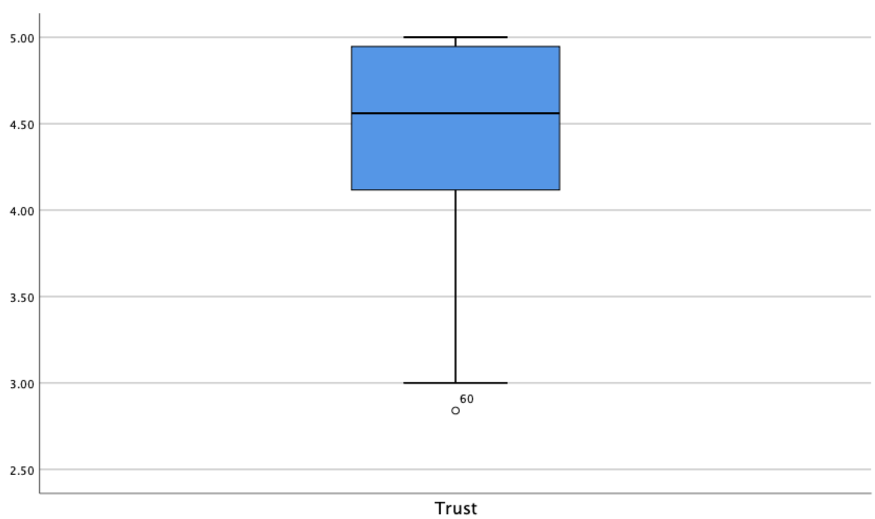


Figure B.2 Distribution plots of trust

Table B.3 Descriptive statistic of reciprocity

Descriptives

			Statistic	Std. Error
Reciprocity	Mean		3.7913	.07187
	95% Confidence Interval for Mean	Lower Bound	3.6489	
		Upper Bound	3.9337	
	5% Trimmed Mean		3.8151	
	Median		3.8333	
	Variance		.573	
	Std. Deviation		.75722	
	Minimum		1.67	
	Maximum		5.00	
	Range		3.33	
	Interquartile Range		1.00	
	Skewness		-.269	.229
	Kurtosis		-.114	.455

```
Reciprocity Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

     2.00 Extremes    (=<1.7)
     1.00        2 .  3
     3.00        2 .  445
     4.00        2 .  6677
     5.00        2 .  88888
     8.00        3 .  00000011
    12.00        3 .  222333333333
     5.00        3 .  44555
    13.00        3 .  6666666666777
    10.00        3 .  8888888999
    14.00        4 .  00000000000001
    13.00        4 .  2223333333333
     4.00        4 .  4555
     2.00        4 .  66
     1.00        4 .  8
    14.00        5 .  00000000000000
```

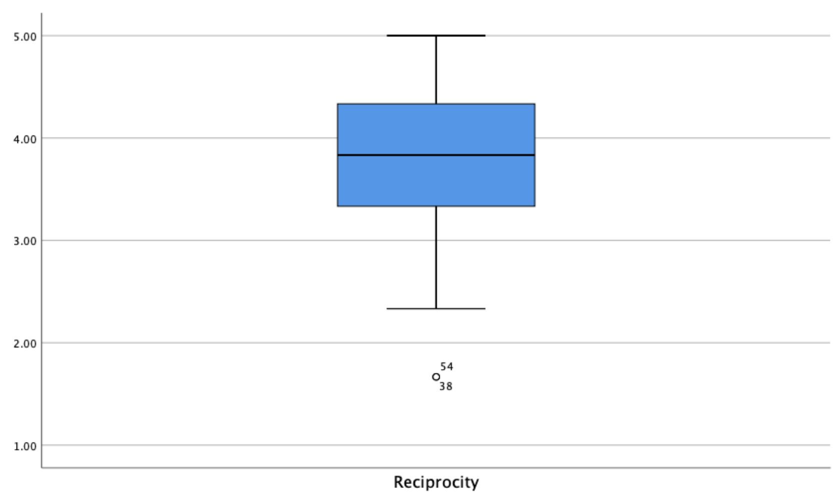


Figure B.3 Distribution plots of reciprocity

Table B.4 Descriptive statistic of belonging

Descriptives

			Statistic	Std. Error
Belonging	Mean		3.9727	.07000
	95% Confidence Interval for Mean	Lower Bound	3.8340	
		Upper Bound	4.1115	
	5% Trimmed Mean		4.0121	
	Median		4.0000	
	Variance		.539	
	Std. Deviation		.73421	
	Minimum		1.80	
	Maximum		5.00	
	Range		3.20	
	Interquartile Range		1.00	
	Skewness		-.602	.230
	Kurtosis		.140	.457

```
Belonging Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

     2.00 Extremes    (=<1.8)
      .00        2 .
     1.00        2 .  2
      .00        2 .
     3.00        2 .  666
     2.00        2 .  88
     6.00        3 .  000000
     6.00        3 .  222222
     5.00        3 .  44444
    11.00        3 .  66666666666
    14.00        3 .  88888888888888
     9.00        4 .  000000000
    13.00        4 .  2222222222222
     6.00        4 .  444444
    11.00        4 .  66666666666
     9.00        4 .  888888888
    12.00        5 .  000000000000
```

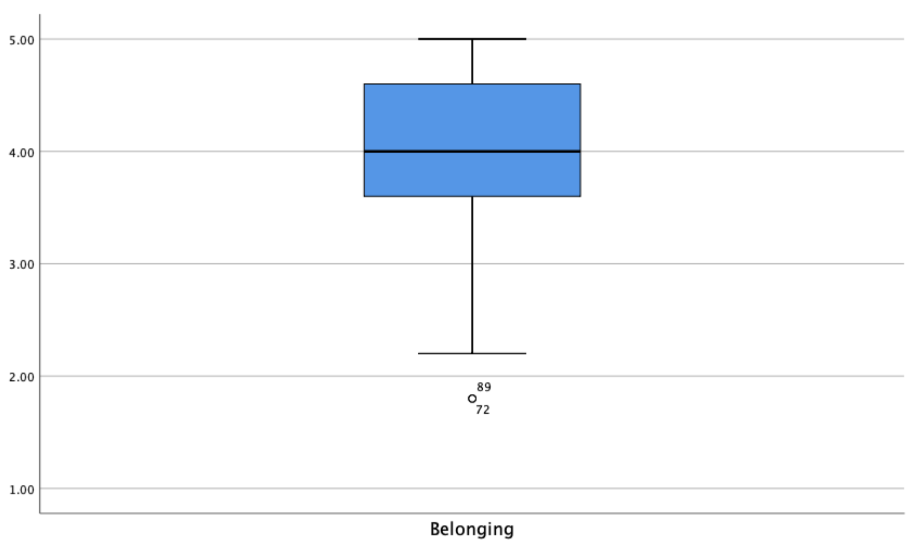


Figure B.4 Distribution plots of belonging

Appendix C. Regression results at the individual level

Table C.1 Student Engagement vs. Unweighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.234[a]	.055	.008	.439899387

a. Predictors: (Constant), Ethnicity, Gender, unweighted_indegree_centrality, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.134	5	.227	1.172	.328[b]
	Residual	19.545	101	.194		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), Ethnicity, Gender, unweighted_indegree_centrality, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.907	.244		15.995	.000
	unweighted_indegree_centrality	.025	.025	.098	.997	.321
	Age_r	-.056	.042	-.170	-1.356	.178
	Gender	.160	.102	.154	1.567	.120
	Year_in_college	.061	.066	.117	.932	.354
	Ethnicity	-.022	.070	-.032	-.323	.747

a. Dependent Variable: Student_Engagement

Table C.2 Student Engagement vs. Unweighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.231[a]	.053	.006	.440244339

a. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.103	5	.221	1.139	.345[b]
	Residual	19.575	101	.194		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.884	.257		15.104	.000
	Age_r	-.060	.041	-.182	-1.460	.148
	Gender	.178	.105	.172	1.703	.092
	Year_in_college	.050	.067	.097	.751	.454
	Ethnicity	-.023	.070	-.032	-.323	.747
	unweighted_Outdegree_centrality	.034	.037	.094	.913	.363

a. Dependent Variable: Student_Engagement

Table C.3 Student Engagement vs. Unweighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.245[a]	.060	.013	.438711837

a. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.239	5	.248	1.288	.275[b]
	Residual	19.439	101	.192		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.837	.260		14.772	.000
	Age_r	-.056	.041	-.168	-1.347	.181
	Gender	.175	.103	.168	1.702	.092
	Year_in_college	.052	.066	.101	.796	.428
	Ethnicity	-.017	.070	-.024	-.241	.810
	unweighted_Degree_centrality	.024	.019	.124	1.244	.216

a. Dependent Variable: Student_Engagement

Table C.4 Student Engagement vs. Unweighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.222[a]	.049	.002	.441187431

a. Predictors: (Constant), unweighted_clustering_coefficient, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.019	5	.204	1.047	.394[b]
	Residual	19.659	101	.195		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), unweighted_clustering_coefficient, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.950	.239		16.560	.000
	Age_r	-.061	.041	-.186	-1.486	.140
	Gender	.148	.103	.143	1.432	.155
	Year_in_college	.063	.066	.122	.964	.337
	Ethnicity	-.023	.070	-.033	-.328	.744
	unweighted_clustering_coefficient	.086	.137	.063	.632	.529

a. Dependent Variable: Student_Engagement

Table C.5 Student Engagement vs. Unweighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.277[a]	.077	.031	.434768530

a. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.587	5	.317	1.680	.146[b]
	Residual	19.091	101	.189		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.762	.258		14.559	.000
	Age_r	-.069	.041	-.210	-1.695	.093
	Gender	.177	.102	.171	1.748	.084
	Year_in_college	.096	.067	.185	1.431	.155
	Ethnicity	-.026	.068	-.037	-.379	.705
	unweighted_Eigenvector_centrality	.483	.261	.186	1.848	.068

a. Dependent Variable: Student_Engagement

Table C.6 Student Engagement vs. Unweighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.239[a]	.057	.010	.439389617

a. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.179	5	.236	1.222	.304[b]
	Residual	19.499	101	.193		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.107	.254		16.160	.000
	Age_r	-.065	.041	-.196	-1.571	.119
	Gender	.136	.104	.131	1.314	.192
	Year_in_college	.063	.065	.122	.968	.335
	Ethnicity	-.018	.070	-.026	-.260	.795
	unweighted_Closeness_centrality	-.444	.400	-.111	-1.109	.270

a. Dependent Variable: Student_Engagement

Table C.7 Student Engagement vs. Unweighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.232[a]	.054	.007	.440157443

a. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.111	5	.222	1.147	.341[b]
	Residual	19.568	101	.194		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.026	.234		17.190	.000
	Age_r	-.060	.041	-.181	-1.453	.149
	Gender	.175	.104	.168	1.683	.095
	Year_in_college	.037	.071	.070	.515	.608
	Ethnicity	-.030	.069	-.042	-.433	.666
	unweighted_Betweenness_centrality	3.295	3.523	.102	.935	.352

a. Dependent Variable: Student_Engagement

Table C.8 Student Engagement vs. Weighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.253[a]	.064	.018	.437762192

a. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.324	5	.265	1.381	.238[b]
	Residual	19.355	101	.192		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.856	.248		15.575	.000
	Age_r	-.053	.041	-.159	-1.267	.208
	Gender	.159	.102	.153	1.561	.122
	Year_in_college	.069	.065	.132	1.051	.296
	Ethnicity	-.021	.069	-.029	-.301	.764
	weighted_indegree	.014	.010	.141	1.412	.161

a. Dependent Variable: Student_Engagement

Table C.9 Student Engagement vs. Weighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.287[a]	.082	.037	.433453177

a. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.703	5	.341	1.813	.117[b]
	Residual	18.976	101	.188		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.759	.254		14.799	.000
	Age_r	-.048	.041	-.145	-1.169	.245
	Gender	.184	.101	.177	1.812	.073
	Year_in_college	.066	.065	.126	1.020	.310
	Ethnicity	-.024	.068	-.034	-.356	.723
	weighted_outdegree	.021	.010	.199	2.013	.047

a. Dependent Variable: Student_Engagement

Table C.10 Student Engagement vs. Weighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.286[a]	.082	.036	.433566869

a. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.693	5	.339	1.801	.119[b]
	Residual	18.986	101	.188		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.747	.257		14.584	.000
	Age_r	-.046	.041	-.140	-1.124	.264
	Gender	.173	.101	.167	1.717	.089
	Year_in_college	.070	.065	.133	1.076	.285
	Ethnicity	-.019	.068	-.026	-.271	.787
	Weighted_Degree	.012	.006	.200	1.999	.048

a. Dependent Variable: Student_Engagement

Table C.11 Student Engagement vs. Weighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.231[a]	.054	.007	.440196604

a. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.108	5	.222	1.143	.343[b]
	Residual	19.571	101	.194		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.940	.236		16.680	.000
	Age_r	-.060	.041	-.182	-1.463	.147
	Gender	.146	.103	.140	1.416	.160
	Year_in_college	.062	.066	.119	.942	.349
	Ethnicity	-.019	.070	-.027	-.268	.789
	weighted_clustering	.162	.175	.092	.925	.357

a. Dependent Variable: Student_Engagement

Table C.12 Student Engagement vs. Weighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.255[a]	.065	.019	.437527280

a. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Ethnicity, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.344	5	.269	1.404	.229[b]
	Residual	19.334	101	.191		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Ethnicity, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.905	.236		16.542	.000
	Age_r	-.051	.042	-.155	-1.234	.220
	Gender	.156	.102	.150	1.532	.129
	Year_in_college	.056	.065	.108	.861	.391
	Ethnicity	-.015	.070	-.021	-.219	.827
	weighted_eigenvector_centrality	.290	.200	.143	1.450	.150

a. Dependent Variable: Student_Engagement

Table C.13 Student Engagement vs. Weighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.230[a]	.053	.006	.440307315

a. Predictors: (Constant), weighted_closeness_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.098	5	.220	1.133	.348[b]
	Residual	19.581	101	.194		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), weighted_closeness_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.906	.248		15.764	.000
	Age_r	-.061	.041	-.185	-1.481	.142
	Gender	.136	.105	.131	1.297	.198
	Year_in_college	.073	.066	.139	1.092	.278
	Ethnicity	-.038	.070	-.054	-.552	.582
	weighted_closeness_centrality	.155	.173	.092	.897	.372

a. Dependent Variable: Student_Engagement

Table C.14 Student Engagement vs. Weighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.213[a]	.046	-.002	.442055161

a. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.942	5	.188	.964	.444[b]
	Residual	19.737	101	.195		
	Total	20.679	106			

a. Dependent Variable: Student_Engagement

b. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.988	.232		17.221	.000
	Age_r	-.061	.041	-.185	-1.482	.142
	Gender	.158	.104	.152	1.524	.131
	Year_in_college	.062	.068	.119	.912	.364
	Ethnicity	-.031	.070	-.043	-.436	.664
	weighted_betweenness_centrality	.738	18.095	.004	.041	.968

a. Dependent Variable: Student_Engagement

Table C.15 Trust vs. Unweighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.157[a]	.025	-.024	.522219665

a. Predictors: (Constant), unweighted_indegree_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.694	5	.139	.509	.769[b]
	Residual	27.544	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_indegree_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.428	.290		15.271	.000
	Age_r	.001	.049	.003	.026	.979
	Gender	.179	.121	.148	1.480	.142
	Year_in_college	-.019	.078	-.031	-.241	.810
	Ethnicity	-.013	.083	-.016	-.162	.872
	unweighted_indegree_centrality	-.017	.030	-.055	-.552	.582

a. Dependent Variable: Trust

Table C.16 Trust vs. Unweighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.148[a]	.022	-.027	.522968548

a. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.615	5	.123	.450	.812[b]
	Residual	27.623	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.391	.305		14.376	.000
	Age_r	.004	.049	.011	.091	.928
	Gender	.178	.124	.147	1.430	.156
	Year_in_college	-.018	.079	-.029	-.224	.823
	Ethnicity	-.009	.083	-.011	-.109	.913
	unweighted_Outdegree_centrality	-.005	.044	-.013	-.121	.904

a. Dependent Variable: Trust

Table C.17 Trust vs. Unweighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.155[a]	.024	-.024	.522397643

a. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.676	5	.135	.495	.779[b]
	Residual	27.563	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.445	.309		14.371	.000
	Age_r	.002	.049	.005	.040	.968
	Gender	.173	.122	.143	1.414	.161
	Year_in_college	-.015	.078	-.025	-.191	.849
	Ethnicity	-.014	.083	-.017	-.172	.864
	unweighted_Degree_centrality	-.011	.023	-.049	-.485	.628

a. Dependent Variable: Trust

Table C.18 Trust vs. Unweighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.149[a]	.022	-.026	.522863783

a. Predictors: (Constant), unweighted_clustering_coefficient, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.626	5	.125	.458	.806[b]
	Residual	27.612	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_clustering_coefficient, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.358	.283		15.417	.000
	Age_r	.005	.049	.012	.094	.925
	Gender	.177	.123	.146	1.446	.151
	Year_in_college	-.019	.078	-.032	-.250	.803
	Ethnicity	-.004	.084	-.005	-.050	.961
	unweighted_clustering_coefficient	.038	.162	.024	.235	.815

a. Dependent Variable: Trust

Table C.19 Trust vs. Unweighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.149[a]	.022	-.026	.522894427

a. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.623	5	.125	.456	.808[b]
	Residual	27.615	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.405	.311		14.176	.000
	Age_r	.006	.049	.015	.116	.908
	Gender	.179	.122	.147	1.463	.147
	Year_in_college	-.024	.081	-.040	-.301	.764
	Ethnicity	-.008	.082	-.010	-.102	.919
	unweighted_Eigenvector_centrality	-.065	.314	-.022	-.208	.835

a. Dependent Variable: Trust

Table C.20 Trust vs. Unweighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.231[a]	.053	.006	.514513545

a. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.501	5	.300	1.134	.347[b]
	Residual	26.737	101	.265		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.606	.298		15.478	.000
	Age_r	-.002	.048	-.005	-.042	.966
	Gender	.141	.121	.116	1.158	.250
	Year_in_college	-.018	.077	-.030	-.240	.811
	Ethnicity	.017	.082	.021	.211	.833
	unweighted_Closeness_centrality	-.859	.469	-.184	-1.834	.070

a. Dependent Variable: Trust

Table C.21 Trust vs. Unweighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.148[a]	.022	-.026	.522908704

a. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.622	5	.124	.455	.809[b]
	Residual	27.617	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.384	.278		15.758	.000
	Age_r	.005	.049	.013	.102	.919
	Gender	.186	.123	.153	1.504	.136
	Year_in_college	-.026	.085	-.043	-.310	.757
	Ethnicity	-.007	.082	-.009	-.090	.928
	unweighted_Betweenness_centrality	.814	4.186	.022	.195	.846

a. Dependent Variable: Trust

Table C.22 Trust vs. Weighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.153[a]	.023	-.025	.522570600

a. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.657	5	.131	.481	.789[b]
	Residual	27.581	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.329	.296		14.649	.000
	Age_r	.008	.050	.020	.156	.877
	Gender	.182	.121	.150	1.498	.137
	Year_in_college	-.018	.078	-.029	-.227	.821
	Ethnicity	-.004	.083	-.005	-.050	.961
	weighted_indegree	.005	.012	.042	.411	.682

a. Dependent Variable: Trust

Table C.23 Trust vs. Weighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.161[a]	.026	-.022	.521857021

a. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.733	5	.147	.538	.747[b]
	Residual	27.506	101	.272		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.283	.306		14.009	.000
	Age_r	.010	.050	.026	.201	.841
	Gender	.192	.122	.158	1.571	.119
	Year_in_college	-.018	.078	-.030	-.238	.813
	Ethnicity	-.005	.082	-.006	-.060	.952
	weighted_outdegree	.008	.013	.068	.667	.506

a. Dependent Variable: Trust

Table C.24 Trust vs. Weighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.159[a]	.025	-.023	.521995797

a. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.718	5	.144	.527	.755[b]
	Residual	27.520	101	.272		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.284	.309		13.849	.000
	Age_r	.010	.050	.027	.207	.837
	Gender	.187	.122	.154	1.541	.126
	Year_in_college	-.017	.078	-.028	-.221	.826
	Ethnicity	-.003	.082	-.004	-.036	.972
	Weighted_Degree	.004	.007	.064	.626	.533

a. Dependent Variable: Trust

Table C.25 Trust vs. Weighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.156[a]	.024	-.024	.522292570

a. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.687	5	.137	.503	.773[b]
	Residual	27.552	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.343	.280		15.495	.000
	Age_r	.005	.049	.014	.109	.913
	Gender	.174	.122	.143	1.421	.159
	Year_in_college	-.020	.078	-.033	-.262	.794
	Ethnicity	.001	.084	.001	.007	.994
	weighted_clustering	.109	.207	.053	.526	.600

a. Dependent Variable: Trust

Table C.26 Trust vs. Weighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.151[a]	.023	-.026	.522698597

a. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Ethnicity, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.644	5	.129	.471	.797[b]
	Residual	27.595	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Ethnicity, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.352	.282		15.428	.000
	Age_r	.007	.050	.019	.151	.880
	Gender	.181	.121	.149	1.490	.139
	Year_in_college	-.022	.078	-.035	-.277	.783
	Ethnicity	-.003	.083	-.004	-.038	.970
	weighted_eigenvector_centrality	.082	.239	.035	.345	.731

a. Dependent Variable: Trust

Table C.27 Trust vs. Weighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.176[a]	.031	-.017	.520475188

a. Predictors: (Constant), weighted_closeness_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.878	5	.176	.648	.663[b]
	Residual	27.360	101	.271		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), weighted_closeness_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.269	.293		14.573	.000
	Age_r	.005	.049	.013	.103	.918
	Gender	.154	.124	.126	1.238	.219
	Year_in_college	-.007	.079	-.011	-.086	.931
	Ethnicity	-.017	.082	-.021	-.209	.835
	weighted_closeness_centrality	.203	.204	.102	.992	.323

a. Dependent Variable: Trust

Table C.28 Trust vs. Weighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.149[a]	.022	-.026	.522873232

a. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.625	5	.125	.457	.807[b]
	Residual	27.613	101	.273		
	Total	28.238	106			

a. Dependent Variable: Trust

b. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.374	.274		15.969	.000
	Age_r	.004	.049	.011	.090	.928
	Gender	.177	.123	.146	1.448	.151
	Year_in_college	-.015	.080	-.025	-.190	.850
	Ethnicity	-.011	.083	-.013	-.130	.897
	weighted_betweenness_centrality	-4.861	21.403	-.024	-.227	.821

a. Dependent Variable: Trust

Table C.29 Reciprocity vs. Unweighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.313[a]	.098	.053	.701870731

a. Predictors: (Constant), unweighted_indegree_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.366	5	1.073	2.179	.062[b]
	Residual	49.262	100	.493		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_indegree_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.099	.389		7.969	.000
	Age_r	.031	.066	.058	.471	.639
	Gender	.203	.164	.120	1.244	.216
	Year_in_college	.047	.104	.056	.449	.654
	Ethnicity	.028	.112	.024	.252	.801
	unweighted_indegree_centrality	.119	.041	.283	2.929	.004

a. Dependent Variable: Reciprocity

Table C.30 Reciprocity vs. Unweighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.148[a]	.022	-.027	.730975903

a. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.196	5	.239	.448	.814[b]
	Residual	53.433	100	.534		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.537	.424		8.333	.000
	Age_r	.007	.069	.013	.099	.921
	Gender	.175	.174	.104	1.004	.318
	Year_in_college	.062	.111	.074	.561	.576
	Ethnicity	-.018	.116	-.016	-.156	.877
	unweighted_Outdegree_centrality	-.020	.062	-.034	-.328	.744

a. Dependent Variable: Reciprocity

Table C.31 Reciprocity vs. Unweighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.243[a]	.059	.012	.716946314

a. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.227	5	.645	1.256	.289[b]
	Residual	51.401	100	.514		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.081	.423		7.286	.000
	Age_r	.023	.068	.042	.333	.740
	Gender	.236	.169	.139	1.398	.165
	Year_in_college	.026	.107	.031	.243	.809
	Ethnicity	.026	.115	.022	.223	.824
	unweighted_Degree_centrality	.064	.032	.202	2.016	.047

a. Dependent Variable: Reciprocity

Table C.32 Reciprocity vs. Unweighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.147[a]	.022	-.027	.731049876

a. Predictors: (Constant), unweighted_clustering_coefficient, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.185	5	.237	.443	.817[b]
	Residual	53.443	100	.534		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_clustering_coefficient, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.447	.395		8.730	.000
	Age_r	.008	.068	.014	.110	.913
	Gender	.180	.172	.107	1.047	.297
	Year_in_college	.055	.109	.066	.509	.612
	Ethnicity	-.007	.117	-.006	-.058	.954
	unweighted_clustering_coefficient	.067	.227	.030	.295	.769

a. Dependent Variable: Reciprocity

Table C.33 Reciprocity vs. Unweighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.230[a]	.053	.006	.719292656

a. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.890	5	.578	1.117	.356[b]
	Residual	51.738	100	.517		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.104	.427		7.269	.000
	Age_r	-.006	.068	-.010	-.083	.934
	Gender	.220	.168	.130	1.304	.195
	Year_in_college	.110	.111	.131	.994	.323
	Ethnicity	-.005	.114	-.004	-.044	.965
	unweighted_Eigenvector_centrality	.796	.433	.189	1.840	.069

a. Dependent Variable: Reciprocity

Table C.34 Reciprocity vs. Unweighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.150[a]	.022	-.026	.730779492

a. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.225	5	.245	.459	.806[b]
	Residual	53.404	100	.534		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.405	.422		8.068	.000
	Age_r	.010	.069	.018	.139	.889
	Gender	.200	.173	.119	1.158	.250
	Year_in_college	.054	.108	.064	.499	.619
	Ethnicity	-.021	.117	-.018	-.176	.860
	unweighted_Closeness_centrality	.267	.666	.041	.401	.689

a. Dependent Variable: Reciprocity

Table C.35 Reciprocity vs. Unweighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.199[a]	.040	-.008	.724348075

a. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.160	5	.432	.824	.536[b]
	Residual	52.468	100	.525		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.569	.384		9.286	.000
	Age_r	.011	.068	.020	.159	.874
	Gender	.233	.172	.138	1.355	.178
	Year_in_college	-.009	.117	-.010	-.074	.941
	Ethnicity	-.010	.114	-.008	-.084	.934
	unweighted_Betweenness_centrality	8.089	5.796	.155	1.396	.166

a. Dependent Variable: Reciprocity

Table C.36 Reciprocity vs. Weighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.343[a]	.117	.073	.694350097

a. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.416	5	1.283	2.662	.027[b]
	Residual	48.212	100	.482		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.986	.392		7.618	.000
	Age_r	.040	.066	.075	.614	.541
	Gender	.200	.162	.118	1.237	.219
	Year_in_college	.074	.103	.088	.716	.475
	Ethnicity	.031	.110	.027	.279	.781
	weighted_indegree	.053	.016	.322	3.309	.001

a. Dependent Variable: Reciprocity

Table C.37 Reciprocity vs. Weighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.166[a]	.027	-.021	.728917153

a. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.496	5	.299	.563	.728[b]
	Residual	53.132	100	.531		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.324	.424		7.838	.000
	Age_r	.017	.069	.031	.241	.810
	Gender	.206	.171	.122	1.201	.232
	Year_in_college	.056	.108	.066	.514	.608
	Ethnicity	-.008	.115	-.007	-.067	.947
	weighted_outdegree	.014	.017	.084	.821	.414

a. Dependent Variable: Reciprocity

Table C.38 Reciprocity vs. Weighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.273[a]	.075	.028	.710961448

a. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.082	5	.816	1.615	.163[b]
	Residual	50.547	100	.505		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.007	.420		7.167	.000
	Age_r	.037	.068	.069	.549	.584
	Gender	.223	.166	.132	1.340	.183
	Year_in_college	.065	.106	.077	.615	.540
	Ethnicity	.015	.113	.013	.134	.893
	Weighted_Degree	.023	.010	.243	2.413	.018

a. Dependent Variable: Reciprocity

Table C.39 Reciprocity vs. Weighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.162[a]	.026	-.022	.729295926

a. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.441	5	.288	.542	.744[b]
	Residual	53.187	100	.532		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3.411	.391		8.724	.000
	Age_r	.009	.068	.017	.132	.895
	Gender	.171	.171	.101	1.001	.319
	Year_in_college	.054	.108	.064	.497	.620
	Ethnicity	.003	.117	.003	.029	.977
	weighted_clustering	.219	.290	.076	.754	.452

a. Dependent Variable: Reciprocity

Table C.40 Reciprocity vs. Weighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.289[a]	.083	.038	.707625468

a. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Ethnicity, Year_in_college, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.555	5	.911	1.819	.116[b]
	Residual	50.073	100	.501		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Ethnicity, Year_in_college, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.231	.382		8.467	.000
	Age_r	.037	.067	.068	.545	.587
	Gender	.183	.165	.108	1.112	.269
	Year_in_college	.039	.105	.046	.368	.714
	Ethnicity	.031	.113	.027	.274	.785
	weighted_eigenvector_centrality	.844	.323	.256	2.612	.010

a. Dependent Variable: Reciprocity

Table C.41 Reciprocity vs. Weighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.171[a]	.029	-.019	.728284088

a. Predictors: (Constant), weighted_closeness_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.589	5	.318	.599	.701[b]
	Residual	53.040	100	.530		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), weighted_closeness_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.336	.410		8.138	.000
	Age_r	.008	.068	.015	.118	.906
	Gender	.151	.174	.089	.867	.388
	Year_in_college	.072	.110	.086	.658	.512
	Ethnicity	-.026	.116	-.022	-.222	.825
	weighted_closeness_centrality	.264	.286	.096	.921	.359

a. Dependent Variable: Reciprocity

Table C.42 Reciprocity vs. Weighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.145[a]	.021	-.028	.731274440

a. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.152	5	.230	.431	.826[b]
	Residual	53.476	100	.535		
	Total	54.628	105			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.475	.382		9.091	.000
	Age_r	.007	.069	.014	.107	.915
	Gender	.184	.172	.109	1.068	.288
	Year_in_college	.059	.112	.070	.527	.599
	Ethnicity	-.016	.117	-.014	-.137	.891
	weighted_betweenness_centrality	-4.802	30.017	-.017	-.160	.873

a. Dependent Variable: Reciprocity

Table C.43 Belonging vs. Unweighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.215[a]	.046	-.001	.667275824

a. Predictors: (Constant), unweighted_indegree_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.157	5	.431	.969	.441[b]
	Residual	44.526	100	.445		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_indegree_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.086	.370		11.028	.000
	Age_r	-.099	.065	-.196	-1.532	.129
	Gender	.189	.155	.121	1.217	.227
	Year_in_college	.039	.100	.051	.393	.695
	Ethnicity	-.072	.106	-.067	-.677	.500
	unweighted_indegree_centrality	.013	.039	.033	.336	.737

a. Dependent Variable: Belonging

Table C.44 Belonging vs. Unweighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.267[a]	.072	.025	.658353704

a. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.339	5	.668	1.541	.184[b]
	Residual	43.343	100	.433		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_Outdegree_centrality, Age_r, Ethnicity, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.842	.384		10.010	.000
	Age_r	-.098	.064	-.194	-1.544	.126
	Gender	.246	.157	.157	1.566	.120
	Year_in_college	.004	.101	.005	.036	.971
	Ethnicity	-.051	.105	-.048	-.492	.624
	unweighted_Outdegree_centrality	.095	.056	.173	1.687	.095

a. Dependent Variable: Belonging

Table C.45 Belonging vs. Unweighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.239[a]	.057	.010	.663415846

a. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.670	5	.534	1.213	.308[b]
	Residual	44.012	100	.440		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_Degree_centrality, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.919	.393		9.979	.000
	Age_r	-.094	.064	-.186	-1.465	.146
	Gender	.212	.156	.135	1.357	.178
	Year_in_college	.026	.100	.033	.256	.798
	Ethnicity	-.056	.106	-.052	-.527	.599
	unweighted_Degree_centrality	.033	.030	.113	1.132	.260

a. Dependent Variable: Belonging

Table C.46 Belonging vs. Unweighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.213[a]	.045	-.002	.667557519

a. Predictors: (Constant), unweighted_clustering_coefficient, Year_in_college, Ethnicity, Gender, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.119	5	.424	.951	.452[b]
	Residual	44.563	100	.446		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_clustering_coefficient, Year_in_college, Ethnicity, Gender, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.143	.362		11.459	.000
	Age_r	-.101	.065	-.200	-1.570	.120
	Gender	.192	.157	.123	1.220	.225
	Year_in_college	.039	.100	.051	.392	.696
	Ethnicity	-.080	.107	-.075	-.744	.458
	unweighted_clustering_coefficient	-.035	.210	-.017	-.169	.866

a. Dependent Variable: Belonging

Table C.47 Belonging vs. Unweighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.267[a]	.071	.025	.658491092

a. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.321	5	.664	1.532	.187[b]
	Residual	43.361	100	.434		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_Eigenvector_centrality, Ethnicity, Age_r, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.815	.392		9.734	.000
	Age_r	-.115	.064	-.226	-1.789	.077
	Gender	.214	.154	.137	1.388	.168
	Year_in_college	.088	.103	.113	.854	.395
	Ethnicity	-.068	.104	-.064	-.655	.514
	unweighted_Eigenvector_centrality	.666	.398	.170	1.674	.097

a. Dependent Variable: Belonging

Table C.48 Belonging vs. Unweighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.221[a]	.049	.001	.666327936

a. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.283	5	.457	1.028	.405[b]
	Residual	44.399	100	.444		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_Closeness_centrality, Year_in_college, Ethnicity, Gender, Age_r

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.231	.385		10.986	.000
	Age_r	-.105	.065	-.207	-1.623	.108
	Gender	.170	.158	.108	1.075	.285
	Year_in_college	.040	.100	.052	.405	.686
	Ethnicity	-.065	.106	-.061	-.611	.543
	unweighted_Closeness_centrality	-.383	.607	-.064	-.631	.530

a. Dependent Variable: Belonging

Table C.49 Belonging vs. Unweighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.261[a]	.068	.022	.659570767

a. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.179	5	.636	1.461	.209[b]
	Residual	43.503	100	.435		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), unweighted_Betweenness_centrality, Ethnicity, Gender, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.226	.351		12.053	.000
	Age_r	-.095	.064	-.188	-1.489	.140
	Gender	.236	.157	.151	1.506	.135
	Year_in_college	-.028	.108	-.036	-.260	.795
	Ethnicity	-.075	.104	-.071	-.727	.469
	unweighted_Betweenness_centrality	8.421	5.363	.172	1.570	.120

a. Dependent Variable: Belonging

Table C.50 Belonging vs. Weighted In-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.213[a]	.045	-.002	.667528808

a. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.123	5	.425	.953	.451[b]
	Residual	44.559	100	.446		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), weighted_indegree, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.100	.378		10.847	.000
	Age_r	-.100	.065	-.198	-1.540	.127
	Gender	.188	.155	.120	1.209	.229
	Year_in_college	.041	.100	.053	.413	.681
	Ethnicity	-.074	.106	-.069	-.700	.486
	weighted_indegree	.003	.015	.019	.193	.848

a. Dependent Variable: Belonging

Table C.51 Belonging vs. Weighted Out-Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.274[a]	.075	.029	.657177991

a. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.494	5	.699	1.618	.162[b]
	Residual	43.188	100	.432		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), weighted_outdegree, Ethnicity, Gender, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.823	.383		9.969	.000
	Age_r	-.085	.064	-.168	-1.329	.187
	Gender	.221	.154	.141	1.435	.155
	Year_in_college	.044	.098	.056	.443	.659
	Ethnicity	-.065	.104	-.061	-.628	.531
	weighted_outdegree	.028	.016	.178	1.793	.076

a. Dependent Variable: Belonging

Table C.52 Belonging vs. Weighted Degree Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.239[a]	.057	.010	.663448873

a. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.666	5	.533	1.211	.309[b]
	Residual	44.016	100	.440		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_Degree, Ethnicity, Gender, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.920	.393		9.973	.000
	Age_r	-.090	.065	-.178	-1.388	.168
	Gender	.200	.155	.128	1.293	.199
	Year_in_college	.046	.100	.060	.467	.641
	Ethnicity	-.064	.105	-.060	-.613	.542
	Weighted_Degree	.010	.009	.114	1.128	.262

a. Dependent Variable: Belonging

Table C.53 Belonging vs. Weighted Local Clustering Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.213[a]	.045	-.003	.667635451

a. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.109	5	.422	.946	.455[b]
	Residual	44.574	100	.446		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), weighted_clustering, Age_r, Gender, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.133	.359		11.523	.000
	Age_r	-.102	.065	-.201	-1.577	.118
	Gender	.189	.157	.121	1.207	.230
	Year_in_college	.040	.100	.051	.398	.691
	Ethnicity	-.078	.107	-.073	-.725	.470
	weighted_clustering	-.019	.268	-.007	-.072	.943

a. Dependent Variable: Belonging

Table C.54 Belonging vs. Weighted Eigenvector Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.218[a]	.047	.000	.666835003

a. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Age_r, Ethnicity, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.215	5	.443	.996	.424[b]
	Residual	44.467	100	.445		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), weighted_eigenvector_centrality, Gender, Age_r, Ethnicity, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.083	.360		11.340	.000
	Age_r	-.097	.065	-.191	-1.490	.139
	Gender	.187	.155	.119	1.202	.232
	Year_in_college	.037	.100	.048	.373	.710
	Ethnicity	-.068	.106	-.063	-.638	.525
	weighted_eigenvector_centrality	.151	.305	.050	.495	.621

a. Dependent Variable: Belonging

Table C.55 Belonging vs. Weighted Closeness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.221[a]	.049	.001	.666382530

a. Predictors: (Constant), weighted_closeness_centrality, Ethnicity, Age_r, Gender, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.276	5	.455	1.025	.407[b]
	Residual	44.407	100	.444		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), weighted_closeness_centrality, Ethnicity, Age_r, Gender, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.041	.376		10.759	.000
	Age_r	-.100	.064	-.198	-1.559	.122
	Gender	.166	.159	.106	1.044	.299
	Year_in_college	.050	.101	.064	.493	.623
	Ethnicity	-.085	.106	-.079	-.801	.425
	weighted_closeness_centrality	.166	.269	.064	.618	.538

a. Dependent Variable: Belonging

Table C.56 Belonging vs. Weighted Betweenness Centrality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.217[a]	.047	.000	.666935860

a. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.202	5	.440	.990	.428[b]
	Residual	44.480	100	.445		
	Total	46.682	105			

a. Dependent Variable: Belonging

b. Predictors: (Constant), weighted_betweenness_centrality, Gender, Ethnicity, Age_r, Year_in_college

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.131	.349		11.839	.000
	Age_r	-.101	.064	-.199	-1.569	.120
	Gender	.198	.157	.127	1.262	.210
	Year_in_college	.028	.103	.036	.269	.788
	Ethnicity	-.068	.106	-.064	-.638	.525
	weighted_betweenness_centrality	12.654	27.282	.049	.464	.644

a. Dependent Variable: Belonging

Appendix D. Distribution plots of subgroup-level dependent variables

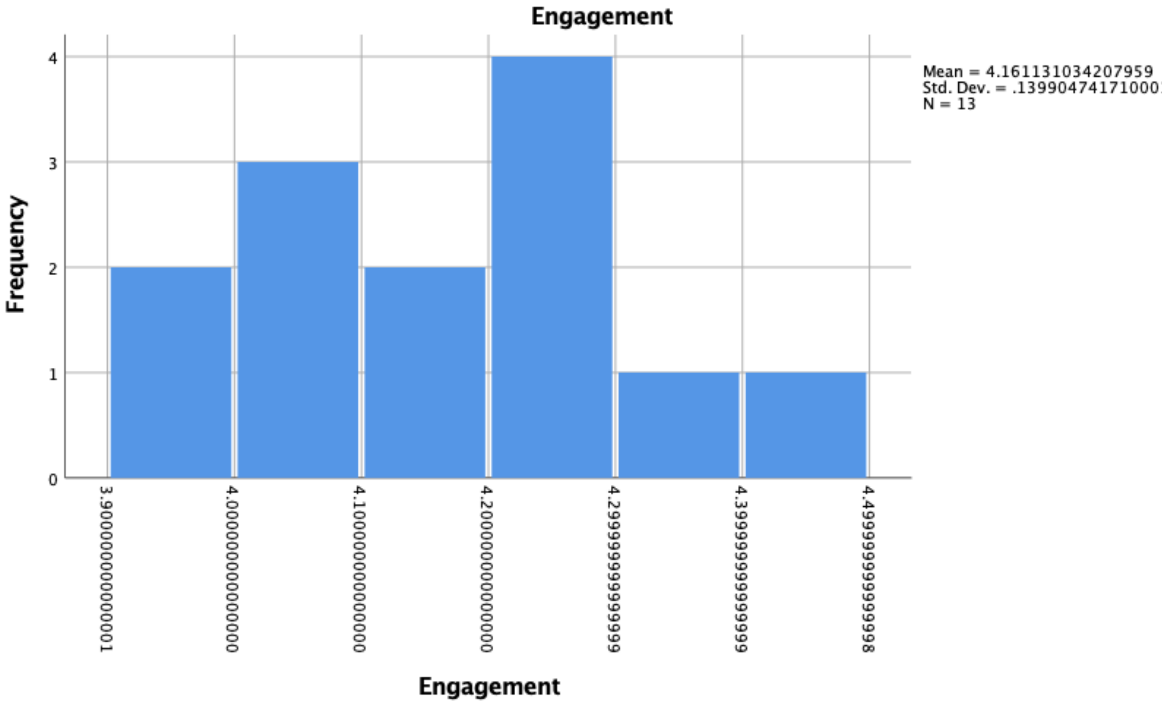


Figure D.1 Distribution plots of subgroup-level student engagement

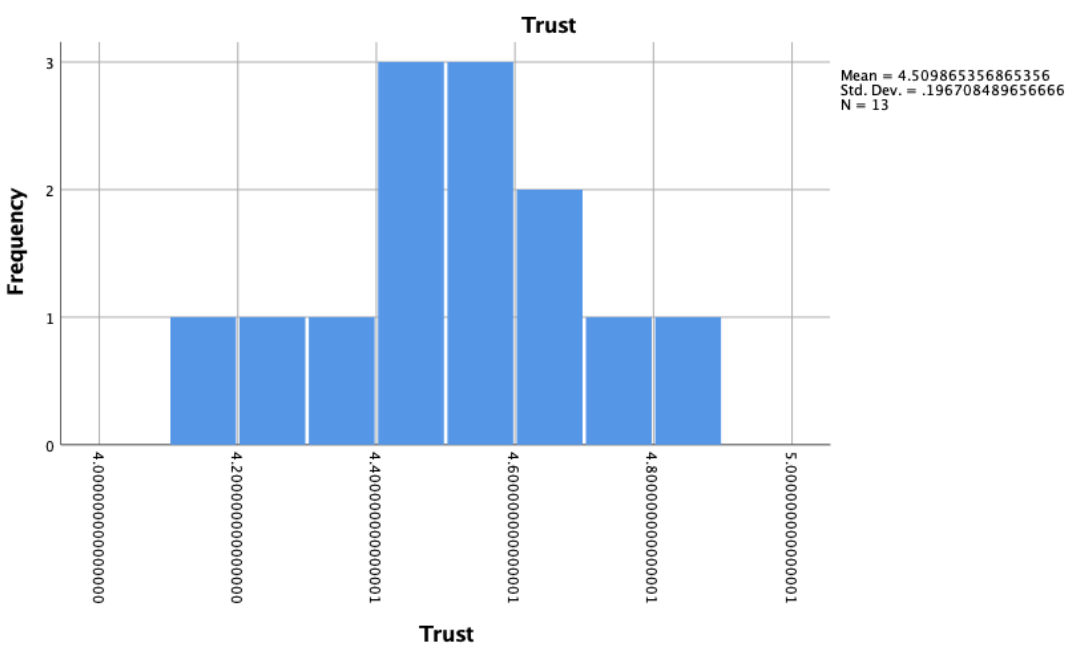


Figure D.2 Distribution plots of subgroup-level trust

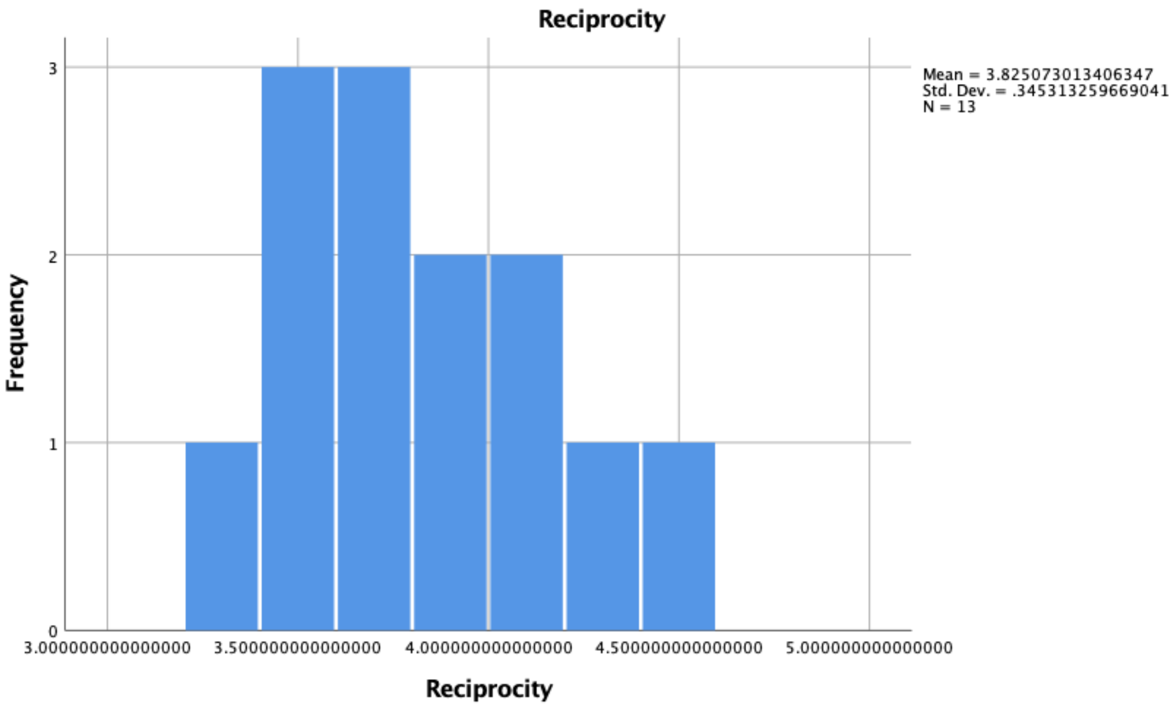


Figure D.3 Distribution plots of subgroup-level reciprocity

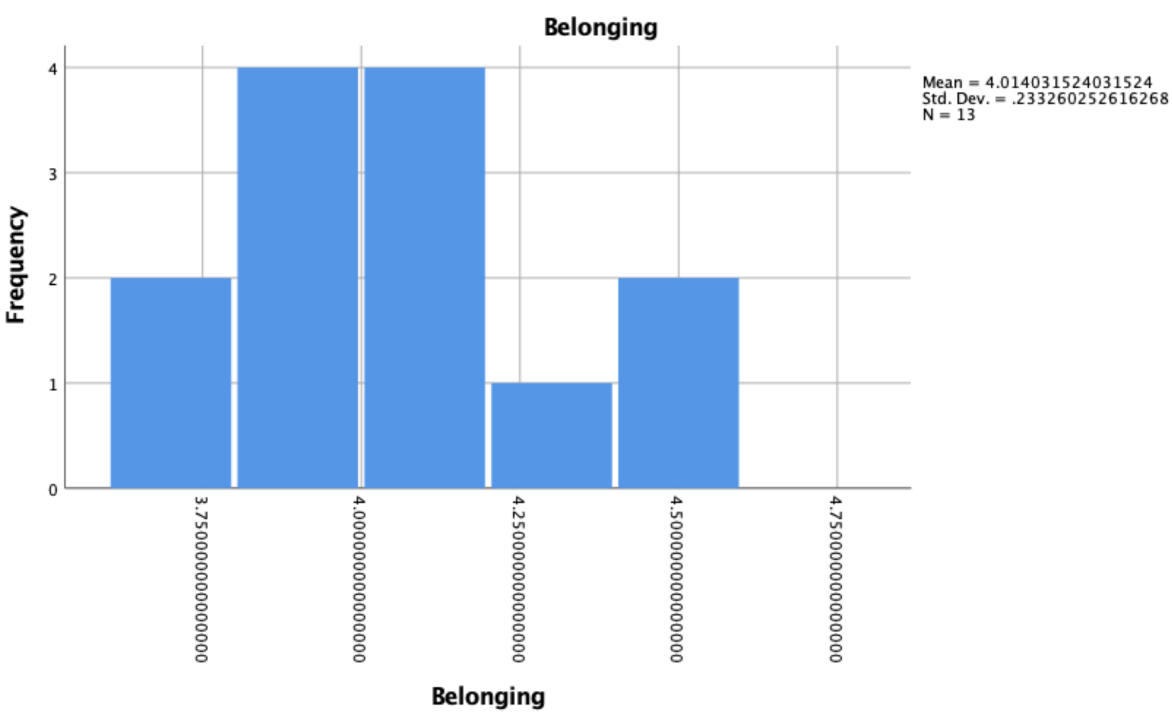


Figure D.4 Distribution plots of subgroup-level belonging

Appendix E. Regression results at the subgroup level

Table E.1 Student Engagement vs. Subgroup Size

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.608[a]	.370	.313	.115994927

a. Predictors: (Constant), Size

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.087	1	.087	6.457	.027[b]
	Residual	.148	11	.013		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Size

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.333	.075		57.886	.000
	Size	-.020	.008	-.608	-2.541	.027

a. Dependent Variable: Engagement

Table E.2 Student Engagement vs. Unweighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.277[a]	.077	-.007	.140414877

a. Predictors: (Constant), Unweighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.018	1	.018	.913	.360[b]
	Residual	.217	11	.020		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Unweighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.082	.091		44.655	.000
	Unweighted_Density	.464	.485	.277	.955	.360

a. Dependent Variable: Engagement

Table E.3 Student Engagement vs. Unweighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.475[a]	.226	.155	.128587103

a. Predictors: (Constant), Unweighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.053	1	.053	3.205	.101[b]
	Residual	.182	11	.017		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Unweighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.411	.144		30.574	.000
	Unweighted_Diameter	-.046	.026	-.475	-1.790	.101

a. Dependent Variable: Engagement

Table E.4 Student Engagement vs. Unweighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.355[a]	.126	.046	.136625648

a. Predictors: (Constant), Unweighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.030	1	.030	1.583	.234[b]
	Residual	.205	11	.019		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Unweighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.366	.168		26.068	.000
	Unweighted_Average_Degree	-.124	.099	-.355	-1.258	.234

a. Dependent Variable: Engagement

Table E.5 Student Engagement vs. Unweighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.378[a]	.143	.065	.135268190

a. Predictors: (Constant), Unweighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.034	1	.034	1.837	.203[b]
	Residual	.201	11	.018		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Unweighted_Degree_centralization

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.047	.092		43.982	.000
	Unweighted_Degree_centralization	.297	.220	.378	1.355	.203

a. Dependent Variable: Engagement

Table E.6 Student Engagement vs. Unweighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.536[a]	.288	.223	.123330418

a. Predictors: (Constant), Unweighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.068	1	.068	4.442	.059[b]
	Residual	.167	11	.015		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Unweighted_closeness_centralization

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.905	.126		30.960	.000
	Unweighted_closeness_centralization	.701	.332	.536	2.108	.059

a. Dependent Variable: Engagement

Table E.7 Student Engagement vs. Unweighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.685[a]	.469	.420	.106511319

a. Predictors: (Constant), Unweighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.110	1	.110	9.704	.010[b]
	Residual	.125	11	.011		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Unweighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.864	.100		38.749	.000
	Unweighted_Betweenness_centralization	.645	.207	.685	3.115	.010

a. Dependent Variable: Engagement

Table E.8 Student Engagement vs. Weighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.251[a]	.063	-.022	.141449597

a. Predictors: (Constant), Weighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.015	1	.015	.739	.408[b]
	Residual	.220	11	.020		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Weighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.091	.091		45.135	.000
	Weighted_Density	.665	.774	.251	.860	.408

a. Dependent Variable: Engagement

Table E.9 Student Engagement vs. Weighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.618[a]	.383	.326	.114825857

a. Predictors: (Constant), Weighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.090	1	.090	6.814	.024[b]
	Residual	.145	11	.013		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Weighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.365	.084		51.852	.000
	Weighted_Diameter	-.046	.017	-.618	-2.610	.024

a. Dependent Variable: Engagement

Table E.10 Student Engagement vs. Weighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.077[a]	.006	-.084	.145695516

a. Predictors: (Constant), Weighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.001	1	.001	.065	.803[b]
	Residual	.233	11	.021		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Weighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.187	.111		37.768	.000
	Weighted_Average_Degree	-.001	.005	-.077	-.255	.803

a. Dependent Variable: Engagement

Table E.11 Student Engagement vs. Weighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.199[a]	.040	-.047	.143188592

a. Predictors: (Constant), Weighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.009	1	.009	.456	.513[b]
	Residual	.226	11	.021		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Weighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.119	.073		56.085	.000
	Weighted_Degree_centralization	.006	.009	.199	.675	.513

a. Dependent Variable: Engagement

Table E.12 Student Engagement vs. Weighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.378[a]	.143	.065	.135276671

a. Predictors: (Constant), Weighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.034	1	.034	1.835	.203[b]
	Residual	.201	11	.018		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Weighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.959	.154		25.714	.000
	Weighted_closeness_centralization	.157	.116	.378	1.355	.203

a. Dependent Variable: Engagement

Table E.13 Student Engagement vs. Weighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.291[a]	.085	.001	.139802271

a. Predictors: (Constant), Weighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.020	1	.020	1.018	.335[b]
	Residual	.215	11	.020		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Weighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.255	.101		42.095	.000
	Weighted_Betweenness_centralization	-.894	.886	-.291	-1.009	.335

a. Dependent Variable: Engagement

Table E.14 Student Engagement vs. Strongly Connected Components

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363[a]	.132	.053	.136175113

a. Predictors: (Constant), Strongly_Connected_Components

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.031	1	.031	1.666	.223[b]
	Residual	.204	11	.019		
	Total	.235	12			

a. Dependent Variable: Engagement

b. Predictors: (Constant), Strongly_Connected_Components

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.294	.109		39.288	.000
	Strongly_Connected_Components	-.010	.007	-.363	-1.291	.223

a. Dependent Variable: Engagement

Table E.15 Trust vs. Subgroup Size

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.620[a]	.384	.328	.161215354

a. Predictors: (Constant), Size

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.178	1	.178	6.865	.024[b]
	Residual	.286	11	.026		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Size

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.756	.104		45.716	.000
	Size	-.029	.011	-.620	-2.620	.024

a. Dependent Variable: Trust

Table E.16 Trust vs. Unweighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.515[a]	.265	.198	.176134515

a. Predictors: (Constant), Unweighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.123	1	.123	3.967	.072[b]
	Residual	.341	11	.031		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Unweighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.303	.115		37.528	.000
	Unweighted_Density	1.213	.609	.515	1.992	.072

a. Dependent Variable: Trust

Table E.17 Trust vs. Unweighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.431[a]	.186	.112	.185379615

a. Predictors: (Constant), Unweighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.086	1	.086	2.511	.141[b]
	Residual	.378	11	.034		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Unweighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.829	.208		23.216	.000
	Unweighted_Diameter	-.058	.037	-.431	-1.585	.141

a. Dependent Variable: Trust

Table E.18 Trust vs. Unweighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.565[a]	.319	.257	.169588628

a. Predictors: (Constant), Unweighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.148	1	.148	5.145	.044[b]
	Residual	.316	11	.029		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Unweighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.969	.208		23.900	.000
	Unweighted_Average_Degree	-.278	.123	-.565	-2.268	.044

a. Dependent Variable: Trust

Table E.19 Trust vs. Unweighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.532[a]	.283	.218	.173911506

a. Predictors: (Constant), Unweighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.132	1	.132	4.352	.061[b]
	Residual	.333	11	.030		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Unweighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.284	.118		36.215	.000
	Unweighted_Degree_centralization	.589	.282	.532	2.086	.061

a. Dependent Variable: Trust

Table E.20 Trust vs. Unweighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.764[a]	.583	.545	.132663388

a. Predictors: (Constant), Unweighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.271	1	.271	15.383	.002[b]
	Residual	.194	11	.018		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Unweighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.998	.136		29.463	.000
	Unweighted_closeness_centralization	1.402	.358	.764	3.922	.002

a. Dependent Variable: Trust

Table E.21 Trust vs. Unweighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.650[a]	.423	.370	.156127597

a. Predictors: (Constant), Unweighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.196	1	.196	8.049	.016[b]
	Residual	.268	11	.024		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Unweighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.114	.146		28.140	.000
	Unweighted_Betweenness_centralization	.861	.304	.650	2.837	.016

a. Dependent Variable: Trust

Table E.22 Trust vs. Weighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.427[a]	.182	.108	.185775169

a. Predictors: (Constant), Weighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.085	1	.085	2.454	.146[b]
	Residual	.380	11	.035		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.342	.119		36.474	.000
	Weighted_Density	1.592	1.016	.427	1.567	.146

a. Dependent Variable: Trust

Table E.23 Trust vs. Weighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.575[a]	.330	.270	.168125243

a. Predictors: (Constant), Weighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.153	1	.153	5.427	.040[b]
	Residual	.311	11	.028		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.776	.123		38.749	.000
	Weighted_Diameter	-.060	.026	-.575	-2.330	.040

a. Dependent Variable: Trust

Table E.24 Trust vs. Weighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.074[a]	.005	-.085	.204890106

a. Predictors: (Constant), Weighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.003	1	.003	.061	.810[b]
	Residual	.462	11	.042		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.546	.156		29.153	.000
	Weighted_Average_Degree	-.002	.008	-.074	-.247	.810

a. Dependent Variable: Trust

Table E.25 Trust vs. Weighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.447[a]	.199	.127	.183837950

a. Predictors: (Constant), Weighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.093	1	.093	2.739	.126[b]
	Residual	.372	11	.034		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.379	.094		46.432	.000
	Weighted_Degree_centralization	.019	.011	.447	1.655	.126

a. Dependent Variable: Trust

Table E.26 Trust vs. Weighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.104[a]	.011	-.079	.204340281

a. Predictors: (Constant), Weighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.005	1	.005	.120	.735[b]
	Residual	.459	11	.042		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.432	.233		19.056	.000
	Weighted_closeness_centralization	.061	.175	.104	.347	.735

a. Dependent Variable: Trust

Table E.27 Trust vs. Weighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.268[a]	.072	-.013	.197952254

a. Predictors: (Constant), Weighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.033	1	.033	.850	.376[b]
	Residual	.431	11	.039		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Weighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.632	.143		32.359	.000
	Weighted_Betweenness_centralization	-1.157	1.255	-.268	-.922	.376

a. Dependent Variable: Trust

Table E.28 Trust vs. Strongly Connected Components

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.418[a]	.175	.100	.186636729

a. Predictors: (Constant), Strongly_Connected_Components

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.081	1	.081	2.330	.155[b]
	Residual	.383	11	.035		
	Total	.464	12			

a. Dependent Variable: Trust

b. Predictors: (Constant), Strongly_Connected_Components

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.724	.150		31.542	.000
	Strongly_Connected_Components	-.016	.010	-.418	-1.526	.155

a. Dependent Variable: Trust

Table E.29 Reciprocity vs. Subgroup Size

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.292[a]	.085	.002	.344907107

a. Predictors: (Constant), Size

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.122	1	.122	1.028	.332[b]
	Residual	1.309	11	.119		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Size

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.029	.223		18.102	.000
	Size	-.024	.024	-.292	-1.014	.332

a. Dependent Variable: Reciprocity

Table E.30 Reciprocity vs. Unweighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.290[a]	.084	.001	.345172751

a. Predictors: (Constant), Unweighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.120	1	.120	1.010	.337[b]
	Residual	1.311	11	.119		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Unweighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.621	.225		16.113	.000
	Unweighted_Density	1.199	1.193	.290	1.005	.337

a. Dependent Variable: Reciprocity

Table E.31 Reciprocity vs. Unweighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.377[a]	.142	.064	.334056229

a. Predictors: (Constant), Unweighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.203	1	.203	1.822	.204[b]
	Residual	1.228	11	.112		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Unweighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.315	.375		11.512	.000
	Unweighted_Diameter	-.090	.067	-.377	-1.350	.204

a. Dependent Variable: Reciprocity

Table E.32 Reciprocity vs. Unweighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.074[a]	.006	-.085	.359673123

a. Predictors: (Constant), Unweighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.008	1	.008	.061	.810[b]
	Residual	1.423	11	.129		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Unweighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.931	.441		8.915	.000
	Unweighted_Average_Degree	-.064	.260	-.074	-.247	.810

a. Dependent Variable: Reciprocity

Table E.33 Reciprocity vs. Unweighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.271[a]	.073	-.011	.347180287

a. Predictors: (Constant), Unweighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.105	1	.105	.871	.371[b]
	Residual	1.326	11	.121		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Unweighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.624	.236		15.343	.000
	Unweighted_Degree_centralization	.526	.563	.271	.933	.371

a. Dependent Variable: Reciprocity

Table E.34 Reciprocity vs. Unweighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.503[a]	.253	.185	.311700961

a. Predictors: (Constant), Unweighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.362	1	.362	3.728	.080[b]
	Residual	1.069	11	.097		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Unweighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.233	.319		10.140	.000
	Unweighted_closeness_centralization	1.622	.840	.503	1.931	.080

a. Dependent Variable: Reciprocity

Table E.35 Reciprocity vs. Unweighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.367[a]	.135	.056	.335447227

a. Predictors: (Constant), Unweighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.193	1	.193	1.716	.217[b]
	Residual	1.238	11	.113		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Unweighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.432	.314		10.927	.000
	Unweighted_Betweennes s_centralization	.855	.652	.367	1.310	.217

a. Dependent Variable: Reciprocity

Table E.36 Reciprocity vs. Weighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.262[a]	.069	-.016	.348041231

a. Predictors: (Constant), Weighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.098	1	.098	.813	.387[b]
	Residual	1.332	11	.121		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.644	.223		16.339	.000
	Weighted_Density	1.716	1.904	.262	.901	.387

a. Dependent Variable: Reciprocity

Table E.37 Reciprocity vs. Weighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.419[a]	.175	.100	.327548019

a. Predictors: (Constant), Weighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.251	1	.251	2.337	.155[b]
	Residual	1.180	11	.107		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.165	.240		17.346	.000
	Weighted_Diameter	-.076	.050	-.419	-1.529	.155

a. Dependent Variable: Reciprocity

Table E.38 Reciprocity vs. Weighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.041[a]	.002	-.089	.360362580

a. Predictors: (Constant), Weighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.002	1	.002	.019	.894[b]
	Residual	1.428	11	.130		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.860	.274		14.075	.000
	Weighted_Average_Degree	-.002	.013	-.041	-.137	.894

a. Dependent Variable: Reciprocity

Table E.39 Reciprocity vs. Weighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.018[a]	.000	-.091	.360612074

a. Predictors: (Constant), Weighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.000	1	.000	.003	.954[b]
	Residual	1.430	11	.130		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.816	.185		20.629	.000
	Weighted_Degree_centralization	.001	.022	.018	.058	.954

a. Dependent Variable: Reciprocity

Table E.40 Reciprocity vs. Weighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.371[a]	.138	.059	.334931061

a. Predictors: (Constant), Weighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.197	1	.197	1.755	.212[b]
	Residual	1.234	11	.112		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.335	.381		8.750	.000
	Weighted_closeness_centralization	.379	.286	.371	1.325	.212

a. Dependent Variable: Reciprocity

Table E.41 Reciprocity vs. Weighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.248[a]	.062	-.024	.349362452

a. Predictors: (Constant), Weighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.088	1	.088	.723	.413[b]
	Residual	1.343	11	.122		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Weighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.024	.253		15.927	.000
	Weighted_Betweenness_centralization	-1.884	2.215	-.248	-.851	.413

a. Dependent Variable: Reciprocity

Table E.42 Reciprocity vs. Strongly Connected Components

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.144[a]	.021	-.068	.356934425

a. Predictors: (Constant), Strongly_Connected_Components

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.029	1	.029	.231	.640[b]
	Residual	1.401	11	.127		
	Total	1.431	12			

a. Dependent Variable: Reciprocity

b. Predictors: (Constant), Strongly_Connected_Components

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.954	.286		13.805	.000
	Strongly_Connected_Components	-.009	.020	-.144	-.481	.640

a. Dependent Variable: Reciprocity

Table E.43 Belonging vs. Subgroup Size

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.166[a]	.028	-.061	.240254913

a. Predictors: (Constant), Size

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.018	1	.018	.311	.588[b]
	Residual	.635	11	.058		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Size

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.092	.155		26.395	.000
	Size	-.009	.017	-.166	-.558	.588

a. Dependent Variable: Belonging

Table E.44 Belonging vs. Unweighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.260[a]	.068	-.017	.235252540

a. Predictors: (Constant), Unweighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.044	1	.044	.798	.391[b]
	Residual	.609	11	.055		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Unweighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.138	.153		27.017	.000
	Unweighted_Density	-.726	.813	-.260	-.893	.391

a. Dependent Variable: Belonging

Table E.45 Belonging vs. Unweighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.042[a]	.002	-.089	.243414091

a. Predictors: (Constant), Unweighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.001	1	.001	.020	.891[b]
	Residual	.652	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Unweighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.051	.273		14.832	.000
	Unweighted_Diameter	-.007	.048	-.042	-.140	.891

a. Dependent Variable: Belonging

Table E.46 Belonging vs. Unweighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.011[a]	.000	-.091	.243617308

a. Predictors: (Constant), Unweighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.000	1	.000	.001	.971[b]
	Residual	.653	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Unweighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.025	.299		13.475	.000
	Unweighted_Average_Degree	-.007	.176	-.011	-.037	.971

a. Dependent Variable: Belonging

Table E.47 Belonging vs. Unweighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.100[a]	.010	-.080	.242417009

a. Predictors: (Constant), Unweighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.006	1	.006	.111	.746[b]
	Residual	.646	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Unweighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.064	.165		24.644	.000
	Unweighted_Degree_centralization	-.131	.393	-.100	-.333	.746

a. Dependent Variable: Belonging

Table E.48 Belonging vs. Unweighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.254[a]	.065	-.020	.235615960

a. Predictors: (Constant), Unweighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.042	1	.042	.761	.402[b]
	Residual	.611	11	.056		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Unweighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.216	.241		17.497	.000
	Unweighted_closeness_centralization	-.554	.635	-.254	-.872	.402

a. Dependent Variable: Belonging

Table E.49 Belonging vs. Unweighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.193[a]	.037	-.050	.239045596

a. Predictors: (Constant), Unweighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.024	1	.024	.426	.527[b]
	Residual	.629	11	.057		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Unweighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.874	.224		17.310	.000
	Unweighted_Betweenness_centralization	.304	.465	.193	.653	.527

a. Dependent Variable: Belonging

Table E.50 Belonging vs. Weighted Density

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.202[a]	.041	-.046	.238620871

a. Predictors: (Constant), Weighted_Density

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.027	1	.027	.467	.509[b]
	Residual	.626	11	.057		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_Density

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.108	.153		26.869	.000
	Weighted_Density	-.892	1.305	-.202	-.683	.509

a. Dependent Variable: Belonging

Table E.51 Belonging vs. Weighted Diameter

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.108[a]	.012	-.078	.242208809

a. Predictors: (Constant), Weighted_Diameter

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.008	1	.008	.130	.726[b]
	Residual	.645	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_Diameter

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.073	.178		22.941	.000
	Weighted_Diameter	-.013	.037	-.108	-.360	.726

a. Dependent Variable: Belonging

Table E.52 Belonging vs. Weighted Average Degree

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.021[a]	.000	-.090	.243581070

a. Predictors: (Constant), Weighted_Average_Degree

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.000	1	.000	.005	.947[b]
	Residual	.653	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_Average_Degree

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.026	.185		21.718	.000
	Weighted_Average_Degree	-.001	.009	-.021	-.068	.947

a. Dependent Variable: Belonging

Table E.53 Belonging vs. Weighted Degree Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.081[a]	.007	-.084	.242830310

a. Predictors: (Constant), Weighted_Degree_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.004	1	.004	.073	.792[b]
	Residual	.649	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_Degree_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.042	.125		32.452	.000
	Weighted_Degree_centralization	-.004	.015	-.081	-.270	.792

a. Dependent Variable: Belonging

Table E.54 Belonging vs. Weighted Closeness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.172[a]	.030	-.058	.239984373

a. Predictors: (Constant), Weighted_closeness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.019	1	.019	.337	.573[b]
	Residual	.634	11	.058		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_closeness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.860	.273		14.134	.000
	Weighted_closeness_centralization	.119	.205	.172	.580	.573

a. Dependent Variable: Belonging

Table E.55 Belonging vs. Weighted Betweenness Centralization

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.007[a]	.000	-.091	.243625871

a. Predictors: (Constant), Weighted_Betweenness_centralization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.000	1	.000	.001	.981[b]
	Residual	.653	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Weighted_Betweenness_centralization

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.018	.176		22.809	.000
	Weighted_Betweenness_centralization	-.037	1.544	-.007	-.024	.981

a. Dependent Variable: Belonging

Table E.56 Belonging vs. Strongly Connected Components

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.086[a]	.007	-.083	.242738892

a. Predictors: (Constant), Strongly_Connected_Components

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.005	1	.005	.081	.781[b]
	Residual	.648	11	.059		
	Total	.653	12			

a. Dependent Variable: Belonging

b. Predictors: (Constant), Strongly_Connected_Components

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.066	.195		20.873	.000
	Strongly_Connected_Components	-.004	.013	-.086	-.285	.781

a. Dependent Variable: Belonging

Appendix F. Reliability tests of student engagement measures

Table F.1 Student engagement instrument reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.742	.781	13

Table F.2 Student engagement instrument item statistics

	Mean	Std. Deviation	N
@17	4.68050595238	.489611234678	112
@18	4.35386904762	.878966719057	112
@19	4.40416666667	.851638296347	112
@20	4.28749999998	.817821087606	112
@21	4.46874999998	.605476859371	112
@22	3.48616071429	1.275667185722	112
@23	3.94732142858	.825863074404	112
@24	3.90312499998	1.043094291977	112
@25_1	4.38392857143	.796903192085	112
@25_2	4.08928571429	.944911182523	112
@25_3	4.08035714286	.940944444628	112
@25_4	3.82142857143	1.274944165633	112
@25_5	3.49107142857	1.048340909017	112

Table F.3 Student engagement instrument inter-item correlation matrix

	@17	@18	@19	@20	@21	@22	@23	@24	@25_1	@25_2	@25_3	@25_4	@25_5
@17	1.000	.302	.427	.507	.674	.121	.369	.321	.124	-.012	.044	-.017	.067
@18	.302	1.000	.246	.266	.368	-.031	.320	.060	.112	.040	.187	.073	.248
@19	.427	.246	1.000	.390	.524	-.023	.224	.215	.081	.000	.030	.134	.077
@20	.507	.266	.390	1.000	.669	.175	.432	.426	.183	.114	.222	.059	.190
@21	.674	.368	.524	.669	1.000	.138	.496	.356	.251	.082	.153	-.050	.163
@22	.121	-.031	-.023	.175	.138	1.000	.291	.257	.068	.027	.071	-.102	.177
@23	.369	.320	.224	.432	.496	.291	1.000	.334	.152	.094	.256	.020	.252
@24	.321	.060	.215	.426	.356	.257	.334	1.000	-.013	-.049	.089	-.090	.104
@25_1	.124	.112	.081	.183	.251	.068	.152	-.013	1.000	.708	.451	.237	.322
@25_2	-.012	.040	.000	.114	.082	.027	.094	-.049	.708	1.000	.711	.327	.446
@25_3	.044	.187	.030	.222	.153	.071	.256	.089	.451	.711	1.000	.350	.590
@25_4	-.017	.073	.134	.059	-.050	-.102	.020	-.090	.237	.327	.350	1.000	.154
@25_5	.067	.248	.077	.190	.163	.177	.252	.104	.322	.446	.590	.154	1.000

* None of the inter-item correlations is more than **0.8**. In other words, there is no overlap among what the survey questions measure.

Appendix G. IRB approval letter

Template:MSU_IRB_T_Post-Review_Approved

Notification of Approval

To:	Dong Zhao
Link:	STUDY00002232
P.I.:	Dong Zhao
Title:	Relationships between Student Social Engagement and Social Network
Description:	This IRB project's submission, Initial Study, has been approved. Please click on the link above to access the project's workspace, the approval correspondence letter, and any finalized documents (e.g. approved consent document(s), Protected Health Information Forms). You can also access the correspondence letter directly using the following link: Correspondence_for_STUDY00002232.doc.pdf(0.02) As a reminder: • the Principal Investigator is responsible for ensuring that all individuals engaged in human subject research have completed human research protection training prior to engaging in human subject research. • for non-exempt research where the IRB has required a consent document, a copy of the consent form must be provided to the subjects. If you have any questions, please contact the IRB Coordinator, Jenny Babbitt , directly at +15173552180.

BIBLIOGRAPHY

BIBLIOGRAPHY

Algan, Y., Cahuc, P., and Shleifer, A. (2013). "Teaching practices and social capital." *American Economic Journal: Applied Economics*, 5(3), 189-210.

Archambault, I., Janosz, M., Fallu, J.-S., and Pagani, L. S. (2009). "Student engagement and its relationship with early high school dropout." *Journal of adolescence*, 32(3), 651-670.

Astin, A. (1993). "What matters in college? four critical years revisited Jossey-Bass." *Inc., Publishers: San Francisco*.

Astin, A. W. (1977). "Four Critical Years. Effects of College on Beliefs, Attitudes, and Knowledge."

Astin, A. W. (1999). "Student involvement: A developmental theory for higher education."

Banhawi, F., and Ali, N. M. "Measuring user engagement attributes in social networking application." *Proc., 2011 International Conference on Semantic Technology and Information Retrieval*, IEEE, 297-301.

Berger, J. B., and Milem, J. F. (1999). "The role of student involvement and perceptions of integration in a causal model of student persistence." *Research in higher Education*, 40(6), 641-664.

Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., and Sese, F. J. (2013). "Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance." *Computers & Education*, 62, 102-110.

Chi, M. T. (2009). "Active-constructive-interactive: A conceptual framework for differentiating learning activities." *Topics in cognitive science*, 1(1), 73-105.

Chi, M. T., and Wylie, R. (2014). "The ICAP framework: Linking cognitive engagement to active learning outcomes." *Educational psychologist*, 49(4), 219-243.

Croninger, R. G., and Lee, V. E. (2001). "Social capital and dropping out of high school: Benefits to at-risk students of teachers' support and guidance." *Teachers college record*.

Algan, Y., Cahuc, P., and Shleifer, A. (2013). "Teaching practices and social capital." *American Economic Journal: Applied Economics*, 5(3), 189-210.

Allen, S. J., and Hartman, N. S. (2009). "Sources of learning in student leadership development programming." *Journal of Leadership Studies*, 3(3), 6-16.

Archambault, I., Janosz, M., Fallu, J.-S., and Pagani, L. S. (2009). "Student engagement and its relationship with early high school dropout." *Journal of adolescence*, 32(3), 651-670.

Astin, A. (1993). "What matters in college? four critical years revisited Jossey-Bass." *Inc., Publishers: San Francisco*.

Astin, A. W. (1977). "Four Critical Years. Effects of College on Beliefs, Attitudes, and Knowledge."

Astin, A. W. (1999). "Student involvement: A developmental theory for higher education."

Banhawi, F., and Ali, N. M. "Measuring user engagement attributes in social networking application." *Proc., 2011 International Conference on Semantic Technology and Information Retrieval*, IEEE, 297-301.

Berger, J. B., and Milem, J. F. (1999). "The role of student involvement and perceptions of integration in a causal model of student persistence." *Research in higher Education*, 40(6), 641-664.

Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., and Sese, F. J. (2013). "Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance." *Computers & Education*, 62, 102-110.

Burch, T. C., and Guarana, C. L. (2014). "The comparative influences of transformational leadership and leader–member exchange on follower engagement." *Journal of leadership studies*, 8(3), 6-25.

Chi, M. T. (2009). "Active‐constructive‐interactive: A conceptual framework for differentiating learning activities." *Topics in cognitive science*, 1(1), 73-105.

Chi, M. T., and Wylie, R. (2014). "The ICAP framework: Linking cognitive engagement to active learning outcomes." *Educational psychologist*, 49(4), 219-243.

Croninger, R. G., and Lee, V. E. (2001). "Social capital and dropping out of high school: Benefits to at-risk students of teachers' support and guidance." *Teachers college record*.

Crumpton, D. J. (2018). "Instructional Behavior and Its Impact on Student Engagement." Walden University.

Del Puerto, C., Guggemos, A., and Shane, J. "Exploration of strategies for attracting and retaining female construction management students." *Proc., 47th ASC annual international conference proceedings*, 6-9.

Di Vincenzo, F., and Mascia, D. (2012). "Social capital in project-based organizations: Its role, structure, and impact on project performance." *International Journal of Project Management*, 30(1), 5-14.

Ellison, N. B., Steinfield, C., and Lampe, C. (2007). "The benefits of Facebook “friends:” Social capital and college students’ use of online social network sites." *Journal of computer-mediated communication*, 12(4), 1143-1168.

Ennett, S. T., and Bauman, K. E. (1993). "Peer group structure and adolescent cigarette smoking: A social network analysis." *Journal of health and social behavior*, 34, 226-226.

Filak, V. F., and Sheldon, K. M. (2008). "Teacher support, student motivation, student need satisfaction, and college teacher course evaluations: Testing a sequential path model." *Educational Psychology*, 28(6), 711-724.

Fredricks, J. A., Blumenfeld, P. C., and Paris, A. H. (2004). "School engagement: Potential of the concept, state of the evidence." *Review of educational research*, 74(1), 59-109.

Freeman, L. C., Roeder, D., and Mulholland, R. R. (1979). "Centrality in social networks: II. Experimental results." *Social networks*, 2(2), 119-141.

Gordon, J., Ludlum, J., and Hoey, J. J. (2008). "Validating NSSE against student outcomes: Are they related?" *Research in Higher Education*, 49(1), 19-39.

Harper, S. R. (2008). "Realizing the intended outcomes of Brown: High-achieving African American male undergraduates and social capital." *American Behavioral Scientist*, 51(7), 1030-1053.

Helms, R., and Buijsrogge, K. "Knowledge Network Analysis: a technique to analyze knowledge management bottlenecks in organizations." *Proc., 16th International Workshop on Database and Expert Systems Applications (DEXA'05)*, IEEE, 410-414.

Hughes, J. N., Luo, W., Kwok, O.-M., and Loyd, L. K. (2008). "Teacher-student support, effortful engagement, and achievement: A 3-year longitudinal study." *Journal of educational psychology*, 100(1), 1.

Hunsu, N., Simmons, D. R., Brown, S. A., and Adesope, O. (2018). "Developing an Instrument of Classroom Social Engagement." *2018 ASEE Annual Conference & Exposition*Salt Lake City, UT.

Jenkins, D. M. (2012). "Exploring Signature Pedagogies in Undergraduate Leadership Education." *Journal of Leadership Education*, 11(1).

Jenkins, D. M. (2013). "Exploring instructional strategies in student leadership development programming." *Journal of leadership studies*, 6(4), 48-62.

Johnson, D., Johnson, R., and Smith, K. (1998a). "Active learning: Cooperation in the College Classroom", Interaction Book Company, Edina, MN."

Johnson, D. W., Johnson, R. T., and Smith, K. A. (1998b). "Cooperative learning returns to college what evidence is there that it works?" *Change: the magazine of higher learning*, 30(4), 26-35.

Jou, K. (2005). "Systems and methods for class designation in a computerized social network application." Google Patents.

Kahu, E. R. (2013). "Framing student engagement in higher education." *Studies in higher education*, 38(5), 758-773.

Kelly, S. (2009). "Social identity theories and educational engagement." *British Journal of Sociology of Education*, 30(4), 449-462.

Kuh, G. D., Kinzie, J., Buckley, J. A., Bridges, B. K., and Hayek, J. C. (2011). *Piecing together the student success puzzle: research, propositions, and recommendations: ASHE Higher Education Report*, John Wiley & Sons.

Ladd, G. W., and Dinella, L. M. (2009). "Continuity and change in early school engagement: Predictive of children's achievement trajectories from first to eighth grade?" *Journal of Educational Psychology*, 101(1), 190.

Lattuca, L., Terenzini, P., Knight, D., and Ro, H. K. (2014). "2020 vision: Progress in preparing the engineer of the future."

Lin, N. (2000). "Inequality in social capital." *Contemporary sociology*, 29(6), 785-795.

Liu, B., Zhou, Q., Ding, R.-X., Palomares, I., and Herrera, F. (2019). "Large-scale group decision making model based on social network analysis: Trust relationship-based conflict detection and elimination." *European Journal of Operational Research*, 275(2), 737-754.

Mansur, A. B. F., and Yusof, N. (2013). "Social learning network analysis model to identify learning patterns using ontology clustering techniques and meaningful learning." *Computers & Education*, 63, 73-86.

Maroulis, S., and Gomez, L. M. (2008). "Does "connectedness" matter? Evidence from a social network analysis within a small-school reform." *Teachers College Record*, 110(9), 1901-1929.

McCulloh, I., Armstrong, H., and Johnson, A. (2013). *Social network analysis with applications*, John Wiley & Sons.

Morrison, J. L., Rha, J., and Helfman, A. (2003). "Learning awareness, student engagement, and change: A transformation in leadership development." *Journal of Education for Business*, 79(1), 11-17.

Ouyang, F., and Scharber, C. (2017). "The influences of an experienced instructor's discussion design and facilitation on an online learning community development: A social network analysis study." *The Internet and Higher Education*, 35, 34-47.

Pascarella, E. T., and Terenzini, P. T. (1991). *How college affects students: Findings and insights from twenty years of research*, ERIC.

Peterson, P. L., and Fennema, E. (1985). "Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics." *American Educational Research Journal*, 22(3), 309-335.

Rabbany, R., Takaffoli, M., and Zaïane, O. R. "Analyzing participation of students in online courses using social network analysis techniques." *Proc., Proceedings of educational data mining*, Citeseer.

Ream, R. K., and Rumberger, R. W. (2008). "Student engagement, peer social capital, and school dropout among Mexican American and non-Latino white students." *Sociology of education*, 81(2), 109-139.

Rienties, B., Héliot, Y., and Jindal-Snape, D. (2013). "Understanding social learning relations of international students in a large classroom using social network analysis." *Higher Education*, 66(4), 489-504.

Rienties, B., and Nolan, E.-M. (2014). "Understanding friendship and learning networks of international and host students using longitudinal Social Network Analysis." *International Journal of Intercultural Relations*, 41, 165-180.

Russo, T. C., and Koesten, J. (2005). "Prestige, centrality, and learning: A social network analysis of an online class." *Communication Education*, 54(3), 254-261.

Saqr, M., Fors, U., Tedre, M., and Nouri, J. (2018). "How social network analysis can be used to monitor online collaborative learning and guide an informed intervention." *PloS one*, 13(3), e0194777.

Scott, J. (1988). "Social network analysis." *Sociology*, 22(1), 109-127.

Shea, P., Hayes, S., Uzuner-Smith, S., Gozza-Cohen, M., Vickers, J., and Bidjerano, T. (2014). "Reconceptualizing the community of inquiry framework: An exploratory analysis." *The Internet and Higher Education*, 23, 9-17.

Tanner, K. D. (2013). "Structure matters: twenty-one teaching strategies to promote student engagement and cultivate classroom equity." *CBE—Life Sciences Education*, 12(3), 322-331.

Taylor, J. E., and Levitt, R. (2007). "Innovation alignment and project network dynamics: An integrative model for change." *Project management journal*, 38(3), 22-35.

Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition*, ERIC.

Wang, M.-T., Willett, J. B., and Eccles, J. S. (2011). "The assessment of school engagement: Examining dimensionality and measurement invariance by gender and race/ethnicity." *Journal of School Psychology*, 49(4), 465-480.

Wolf-Wendel, L., Ward, K., and Kinzie, J. (2009). "A tangled web of terms: The overlap and unique contribution of involvement, engagement, and integration to understanding college student success." *Journal of College Student Development*, 50(4), 407-428.

Xie, K., Di Tosto, G., Lu, L., and Cho, Y. S. (2018). "Detecting leadership in peer-moderated online collaborative learning through text mining and social network analysis." *The Internet and Higher Education*, 38, 9-17.

Yang, K., Yan, X., Fan, J., and Luo, Z. (2017). "Leader-follower congruence in proactive personality and work engagement: A polynomial regression analysis." *Personality and Individual Differences*, 105, 43-46.

Yuan, J., Chen, K., Li, W., Ji, C., Wang, Z., and Skibniewski, M. J. (2018). "Social network analysis for social risks of construction projects in high-density urban areas in China." *Journal of cleaner production*, 198, 940-961.

Zepke, N., Leach, L., and Butler, P. (2010). "Engagement in post‐compulsory education: students' motivation and action." *Research in Post‐Compulsory Education*, 15(1), 1-17.

Zepke, N., Leach, L., and Butler, P. (2011). "Non‐institutional influences and student perceptions of success." *Studies in Higher Education*, 36(2), 227-242.

Zhang, X. (2011). "Social risks for international players in the construction market: A China study." *Habitat International*, 35(3), 514-519.

Zhao, D., Simmons, D. R., and Duva, M. (2019). "Measuring Students' Class-level Sense of Belonging: A Social-network-based Approach." ASEE Conferences, Tampa, Florida.

Zhao, Z.-Y., Zhao, X.-J., Davidson, K., and Zuo, J. (2012). "A corporate social responsibility indicator system for construction enterprises." *Journal of cleaner production*, 29, 277-289.

Zheng, X., Le, Y., Chan, A. P., Hu, Y., and Li, Y. (2016). "Review of the application of social network analysis (SNA) in construction project management research." *International journal of project management*, 34(7), 1214-1225.

Zimmerman, B. J., and Kitsantas, A. (1997). "Developmental phases in self-regulation: Shifting from process goals to outcome goals." *Journal of educational psychology*, 89(1), 29.

Zunzunegui, M.-V., Alvarado, B. E., Del Ser, T., and Otero, A. (2003). "Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 58(2), S93-S100.

Di Vincenzo, F., and Mascia, D. (2012). "Social capital in project-based organizations: Its role, structure, and impact on project performance." *International Journal of Project Management*, 30(1), 5-14.

Ellison, N. B., Steinfield, C., and Lampe, C. (2007). "The benefits of Facebook "friends:" Social capital and college students' use of online social network sites." *Journal of computer-mediated communication*, 12(4), 1143-1168.

Ennett, S. T., and Bauman, K. E. (1993). "Peer group structure and adolescent cigarette smoking: A social network analysis." *Journal of health and social behavior*, 34, 226-226.

Filak, V. F., and Sheldon, K. M. (2008). "Teacher support, student motivation, student need satisfaction, and college teacher course evaluations: Testing a sequential path model." *Educational Psychology*, 28(6), 711-724.

Fredricks, J. A., Blumenfeld, P. C., and Paris, A. H. (2004). "School engagement: Potential of the concept, state of the evidence." *Review of educational research*, 74(1), 59-109.

Freeman, L. C., Roeder, D., and Mulholland, R. R. (1979). "Centrality in social networks: II. Experimental results." *Social networks*, 2(2), 119-141.

Gordon, J., Ludlum, J., and Hoey, J. J. (2008). "Validating NSSE against student outcomes: Are they related?" *Research in Higher Education*, 49(1), 19-39.

Harper, S. R. (2008). "Realizing the intended outcomes of Brown: High-achieving African American male undergraduates and social capital." *American Behavioral Scientist*, 51(7), 1030-1053.

Helms, R., and Buijsrogge, K. "Knowledge Network Analysis: a technique to analyze knowledge management bottlenecks in organizations." *Proc., 16th International Workshop on Database and Expert Systems Applications (DEXA'05)*, IEEE, 410-414.

Hughes, J. N., Luo, W., Kwok, O.-M., and Loyd, L. K. (2008). "Teacher-student support, effortful engagement, and achievement: A 3-year longitudinal study." *Journal of educational psychology*, 100(1), 1.

Johnson, D., Johnson, R., and Smith, K. (1998a). "Active learning: Cooperation in the College Classroom", Interaction Book Company, Edina, MN."

Johnson, D. W., Johnson, R. T., and Smith, K. A. (1998b). "Cooperative learning returns to college what evidence is there that it works?" *Change: the magazine of higher learning*, 30(4), 26-35.

Jou, K. (2005). "Systems and methods for class designation in a computerized social network application." Google Patents.

Kahu, E. R. (2013). "Framing student engagement in higher education." *Studies in higher education*, 38(5), 758-773.

Kelly, S. (2009). "Social identity theories and educational engagement." *British Journal of Sociology of Education*, 30(4), 449-462.

Kuh, G. D., Kinzie, J., Buckley, J. A., Bridges, B. K., and Hayek, J. C. (2011). *Piecing together the student success puzzle: research, propositions, and recommendations: ASHE Higher Education Report*, John Wiley & Sons.

Ladd, G. W., and Dinella, L. M. (2009). "Continuity and change in early school engagement: Predictive of children's achievement trajectories from first to eighth grade?" *Journal of Educational Psychology*, 101(1), 190.

Lattuca, L., Terenzini, P., Knight, D., and Ro, H. K. (2014). "2020 vision: Progress in preparing the engineer of the future."

Lin, N. (2000). "Inequality in social capital." *Contemporary sociology*, 29(6), 785-795.

Liu, B., Zhou, Q., Ding, R.-X., Palomares, I., and Herrera, F. (2019). "Large-scale group decision making model based on social network analysis: Trust relationship-based conflict detection and elimination." *European Journal of Operational Research*, 275(2), 737-754.

Mansur, A. B. F., and Yusof, N. (2013). "Social learning network analysis model to identify learning patterns using ontology clustering techniques and meaningful learning." *Computers & Education*, 63, 73-86.

Maroulis, S., and Gomez, L. M. (2008). "Does “connectedness” matter? Evidence from a social network analysis within a small-school reform." *Teachers College Record*, 110(9), 1901-1929.

McCulloh, I., Armstrong, H., and Johnson, A. (2013). *Social network analysis with applications*, John Wiley & Sons.

Ouyang, F., and Scharber, C. (2017). "The influences of an experienced instructor's discussion design and facilitation on an online learning community development: A social network analysis study." *The Internet and Higher Education*, 35, 34-47.

Pascarella, E. T., and Terenzini, P. T. (1991). *How college affects students: Findings and insights from twenty years of research*, ERIC.

Peterson, P. L., and Fennema, E. (1985). "Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics." *American Educational Research Journal*, 22(3), 309-335.

Rabbany, R., Takaffoli, M., and Zaïane, O. R. "Analyzing participation of students in online courses using social network analysis techniques." *Proc., Proceedings of educational data mining*, Citeseer.

Ream, R. K., and Rumberger, R. W. (2008). "Student engagement, peer social capital, and school dropout among Mexican American and non-Latino white students." *Sociology of education*, 81(2), 109-139.

Rienties, B., Héliot, Y., and Jindal-Snape, D. (2013). "Understanding social learning relations of international students in a large classroom using social network analysis." *Higher Education*, 66(4), 489-504.

Rienties, B., and Nolan, E.-M. (2014). "Understanding friendship and learning networks of international and host students using longitudinal Social Network Analysis." *International Journal of Intercultural Relations*, 41, 165-180.

Russo, T. C., and Koesten, J. (2005). "Prestige, centrality, and learning: A social network analysis of an online class." *Communication Education*, 54(3), 254-261.

Saqr, M., Fors, U., Tedre, M., and Nouri, J. (2018). "How social network analysis can be used to monitor online collaborative learning and guide an informed intervention." *PloS one*, 13(3), e0194777.

Scott, J. (1988). "Social network analysis." *Sociology*, 22(1), 109-127.

Shea, P., Hayes, S., Uzuner-Smith, S., Gozza-Cohen, M., Vickers, J., and Bidjerano, T. (2014). "Reconceptualizing the community of inquiry framework: An exploratory analysis." *The Internet and Higher Education*, 23, 9-17.

Tanner, K. D. (2013). "Structure matters: twenty-one teaching strategies to promote student engagement and cultivate classroom equity." *CBE—Life Sciences Education*, 12(3), 322-331.

Taylor, J. E., and Levitt, R. (2007). "Innovation alignment and project network dynamics: An integrative model for change." *Project management journal*, 38(3), 22-35.

Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition*, ERIC.

Wang, M.-T., Willett, J. B., and Eccles, J. S. (2011). "The assessment of school engagement: Examining dimensionality and measurement invariance by gender and race/ethnicity." *Journal of School Psychology*, 49(4), 465-480.

Wolf-Wendel, L., Ward, K., and Kinzie, J. (2009). "A tangled web of terms: The overlap and unique contribution of involvement, engagement, and integration to understanding college student success." *Journal of College Student Development*, 50(4), 407-428.

Xie, K., Di Tosto, G., Lu, L., and Cho, Y. S. (2018). "Detecting leadership in peer-moderated online collaborative learning through text mining and social network analysis." *The Internet and Higher Education*, 38, 9-17.

Yuan, J., Chen, K., Li, W., Ji, C., Wang, Z., and Skibniewski, M. J. (2018). "Social network analysis for social risks of construction projects in high-density urban areas in China." *Journal of cleaner production*, 198, 940-961.

Zepke, N., Leach, L., and Butler, P. (2010). "Engagement in post-compulsory education: students' motivation and action." *Research in Post-Compulsory Education*, 15(1), 1-17.

Zepke, N., Leach, L., and Butler, P. (2011). "Non-institutional influences and student perceptions of success." *Studies in Higher Education*, 36(2), 227-242.

Zhang, X. (2011). "Social risks for international players in the construction market: A China study." *Habitat International*, 35(3), 514-519.

Zhao, D., Simmons, D. R., and Duva, M. (2019). "Measuring Students' Class-level Sense of Belonging: A Social-network-based Approach." ASEE Conferences, Tampa, Florida.

Zhao, Z. Y., Zhao, X. J., Davidson, K., and Zuo, J. (2012). "A corporate social responsibility indicator system for construction enterprises." *Journal of cleaner production*, 29, 277-289.

Zheng, X., Le, Y., Chan, A. P., Hu, Y., and Li, Y. (2016). "Review of the application of social network analysis (SNA) in construction project management research." *International journal of project management*, 34(7), 1214-1225.

Zimmerman, B. J., and Kitsantas, A. (1997). "Developmental phases in self-regulation: Shifting from process goals to outcome goals." *Journal of educational psychology*, 89(1), 29.

Zunzunegui, M.-V., Alvarado, B. E., Del Ser, T., and Otero, A. (2003). "Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 58(2), S93-S100.