

Understanding Centrality: Investigating Student Outcomes within a Classroom Social Network

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What is centrality?

- Centrality is a concept from Network Analysis¹
- In a classroom, centrality describes how “connected” or “embedded” or “central” a person is in the class network²
 - Student → “node”
 - Interaction between two students → “edge”
- Centrality is a family of measures³. We look at 4 types:
 - Degree:** the number of interactions a student is involved in (*both self-reported and reported by others*)
 - Outdegree:** the number of interactions reported by a student (*self-reported only*)
 - Indegree:** the number of interactions a student is involved in, as reported by others (*reported by others only*)
 - PageRank:** a more sophisticated version of indegree that depends not only on the interactions coming into a given node, but also the indegree of all adjacent nodes. (For example, when a popular website like BuzzFeed links to a lesser-known website, the indegree of the lesser-known website increases.)

Methods

- Physics Modeling Instruction students at FIU responded to a network survey five times during the Fall 2014 semester, asking them to list individuals with whom they had a “meaningful classroom interaction” (instructors were listed due to open-ended format)
- The Force-Motion Concept Evaluation⁴ (FMCE) was administered pre- and post-instruction, then matched
- Demographic data was downloaded from the online course roster

Data Analysis

- Each network survey was compiled into an edge list
- Edge lists were aggregated together into a master edge list (N=84); the fifth collection was omitted in order to maintain uniformity of response rates
- Student centrality measures were calculated using the *igraph* package in R; demographic data and FMCE data were incorporated as node attributes⁵
- Linear regression was used to determine:
 - Which initial factors centrality is predicted by
 - Which final outcomes centrality predicts

What is centrality predicted by?

Initial Factors to test:

- Sex
- Ethnicity
- Incoming GPA
- FMCE pre-score

Linear Model	Estimate
Degree ~ SexM	-3.31 *
Outdegree ~ SexM	-4.07 ***
Indegree ~ SexM	0.763
PageRank ~ SexM	0.000788

* p<.05, **p<.01, ***p<.001

Table 1. Summary of linear regressions for one-factor models of centrality as predicted by sex (using male as the base model). This shows that male students reported fewer interactions as meaningful than did female students.

Linear Model	Estimate
Degree ~ GPA	2.80 ***
Outdegree ~ GPA	1.37 **
Indegree ~ GPA	1.42 ***
PageRank ~ GPA	0.00120 ***

* p<.05, **p<.01, ***p<.001

Table 2. Summary of linear regressions for one-factor models of centrality as predicted by incoming GPA. This shows that all four measures of centrality are significantly predicted by incoming GPA.

Results

- Some centrality measures (Degree, Outdegree) are predicted by sex
- No centrality measures are predicted by ethnicity → **inclusive environment**
- Four centrality measures are predicted by incoming GPA
- No centrality measures are predicted by FMCE pre-score

Network of Physics I Modeling Instruction Classroom, Fall 2014

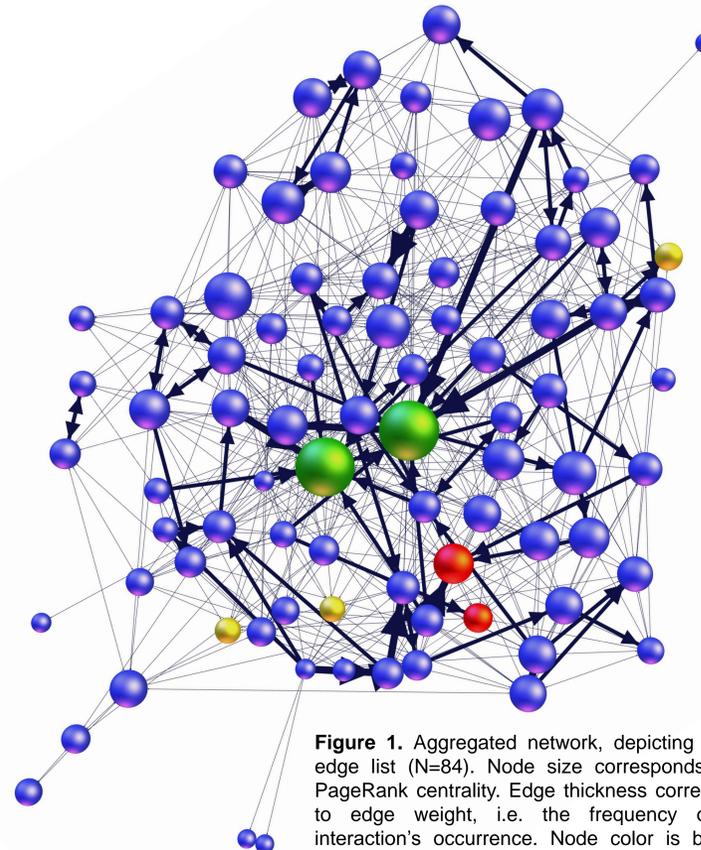


Figure 1. Aggregated network, depicting master edge list (N=84). Node size corresponds to its PageRank centrality. Edge thickness corresponds to edge weight, i.e. the frequency of that interaction's occurrence. Node color is blue for students, red for instructors, green for teaching assistants, and gold for Learning Assistants.

What does centrality predict?

Final Outcomes to test:

- Final grade in course
- FMCE gain

Linear Model	Estimate: Coeff 1	Estimate: Coeff 2
Grade ~ Degree	1.099 ***	-
Grade ~ Outdegree	1.309 **	-
Grade ~ Indegree	1.968 ***	-
Grade ~ PageRank	1426.34 **	-
Grade ~ Degree + GPA	0.155	11.82 ***
Grade ~ Indegree + GPA	0.272	11.86 ***
Grade ~ Outdegree + GPA	0.163	12.03 ***
Grade ~ PageRank + GPA	47.1	12.19 ***

* p<.05, **p<.01, ***p<.001

Table 3. Summary of linear regressions for one- and two-factor models of grade as predicted by centrality and incoming GPA. The one-factor model shows that all four centrality measures significantly predict final grade. However, the two-factor model indicates that the predictive power of centrality disappears when incoming GPA is controlled for. Taken together, these two models mean that students who have achieved highly in the past (high incoming GPA) continue to achieve highly (high Grade), *while interacting very much in the classroom*. We believe this means centrality plays a mediating, if not predictive, role in pre- to post-course performance shifts.

Linear Model	Estimate
FMCE gain ~ PageRank	1643.95 *

* p<.05, **p<.01, ***p<.001

Table 4. Summary of linear regressions for one-factor models of centrality as predicted by incoming GPA. This shows that a student's pre-post gain on the FMCE is significantly predicted by their PageRank centrality.

Conclusions

- Male students report fewer interactions than females
- Minority students interact just as much as majority students
- High-GPA students interact more than lower-GPA students
- Interactions do not depend on incoming physics knowledge
- Final grade is mediated by centrality
- FMCE gain is predicted by PageRank**

Results

- Grade is significantly predicted by all four centrality measures, *but not when incoming GPA is controlled for*
- FMCE raw gain is predicted by PageRank**

References:

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