Talking about teaching: Social networks of instructors of undergraduate mathematics

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The RUME community has focused on students' understandings of and experiences with mathematics. This project sheds light on another part of the higher education system – the departmental culture surrounding undergraduate mathematics instruction. This paper reports on the interactions of members of a single mathematics department, centered on their conversations about undergraduate mathematics instruction. Social network analysis of this group sheds important light on the informal structure of the department.

Keywords: *Social networks, instructors, organizational culture, community*

It is widely known that experiences with introductory undergraduate mathematics courses are a significant factor affecting retention rates in STEM majors (Bressoud, Mesa, & Rasmussen, 2015; PCAST, 2012; Seymour & Hewitt, 1997). This has led to increased research and attention to these introductory courses. Very little of that research, however, uses a systems-level approach. In thinking about undergraduate mathematics education, we must consider the entire system at work and the cultures and communities at play at each level. Students and instructors function as individuals embedded in a variety of cultures and communities, each with their own pressures, values, beliefs, assumptions, and practices.

Focusing on the department as a unit of analysis makes particularly good sense when considering introductory mathematics courses. Many institutions offer multiple sections of courses such as Calculus I each term, taught by a range of instructors. The potential variation in experiences at a single institution is remarkable, and so case studies of individual classrooms do not capture the entire picture. This position is supported by the findings of the *Characteristics of Successful Programs in College Calculus* (CSPCC) study, wherein a coordination system was found to be one of the seven key features of successful programs (Bressoud & Rasmussen, 2015). Another reason to take a department-level approach is the potential of the department as a unit of change (e.g., Gibbs, Knapper, & Piccinin, 2008; Wieman, Perkins, & Gilbert, 2010). Work in education and organization science has shown that change is a social construct, best effected and sustained by a group rather than an individual (Corbo et. al., 2015; Daly, 2010).

Methods

Social network surveys were distributed to 61 individuals in the mathematics department at a large research university, one that was identified in the CSPCC study as being relatively more successful at implementing Calculus I. Network questions were used to ascertain the ties that exist between members of the community of calculus instructors, as well as the strength of those ties, and a variety of Likert scale and demographic questions were used to characterize the actors between whom ties do or do not exist (Coburn & Russell, 2008). Five relational networks were measured: advice about teaching (R1); sharing of instructional materials (R2); discussions about teaching (R3); friendship (R4); and influence on instruction (R5). The survey also included Likert scales designed to characterize the individuals, subgroups, and the larger community in terms of trust, innovative climate, professional learning community collaboration and involvement, as well as mathematical affect and beliefs.

Findings

Looking at the different networks, I note differing levels of inclusivity, from a high of 85% included (R3) to a low of 52% (R5). I further note the split, in terms of inclusivity, of the networks into R1, R2, and R5 vs. R3 and R4. This indicates that more actors are involved in discussions about instruction and friendship within the department than the sharing of advice, instructional materials, or influence. One possible interpretation of this is that R3 and R4 are more general relations than the others. Another is that R1, R2, and R5 all seem to involve acknowledging another as "expert" at something, while R3 and R4 may be relations between equals.

Instructors of the Precalculus through Calculus 2 (P2C2) courses are disproportionately active in the networks, especially in R1, R2, and R5. This is gauged by looking at the makeup of the main component of each relationship graph (in each case the only component) and how many of each instructor type are included in that component (Table 1). In R1, R2, and R5, P2C2 instructors account for significantly more of the graph component than their overall representation. In R3 and R4, the distribution of P2C2 and non-P2C2 is close to their overall distribution (within 3 people). The coordination of superficial aspects of P2C2 course structure (e.g., textbook, exams) seems to explain the over-representation of P2C2 instructors in the materials network (R2), but it does not directly explain their over-representation in advice (R1) and influence (R5). These network results seem to indicate that there is more to this coordination system than simply shared course elements.

Table 1: Components of relational networks, including P2C2 instructor breakdown.

Relation	Component (V, E)	Proportion of component that is P2C2 instructors	P2C2 instructors in component (n=23)	Non-P2C2 instructors in component (n=38)
R1	(38, 83)	0.500	0.826	0.500
R2	(36, 65)	0.528	0.826	0.447
R3	(52, 120)	0.385	0.870	0.842
R4	(51, 138)	0.431	0.957	0.763
R5	(32, 55)	0.500	0.696	0.421

Given the network investigations under investigation, it is natural to look for individual actors who are the "most" at something: Who asks for advice the most? Who is asked for advice the most? Who is the most influential? When looking for standout actors, we turn to their degree, the number of ties attached to their node. By asking about *in-degree, out-degree*, and *total degree*, we can begin build a rough picture of important actors. For sake of brevity, this proposal attends only to the advice network (R1) while the presentation will attend to all five. Total degree had mean 2.7 and standard deviation 4.7; in-degree had mean 1.4 and s.d. 3.7, and out-degree had mean 1.4 and s.d. 1.9. There is more variation in actors' out-degrees than in-degrees, which implies that while actors in the network seek different amounts of advice, they seek that advice from a select few. There is a clean break in the in-degree distribution separating three actors from the rest by more than two standard deviations.

Discussion

Since the data collected represents a snapshot of the department in its current state, it is impossible to establish causality between the coordination system in place and the social relations measured in this study. One explanation is that this department is made up of community-minded faculty members, the most communicative of whom are teaching the coordinated P2C2 courses. Another explanation is that the coordination system and the coordinators have developed a sense of community and shared responsibility for teaching these introductory courses, leading to an increase in communication about instruction. The discovery that the coordinators, who are formally in charge of P2C2 instruction, are also informal community leaders confirms Rasmussen and Ellis's (2015) finding that coordinators do more than simply manage the uniform elements of courses – they are central to active communities of instructors engaged in teaching mathematics.

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