The Power of Networks as an Engineering Sophomore

Janet Y. Tsai, Daria A. Kotys-Schwartz and Daniel W. Knight
University of Colorado Boulder, Department of Mechanical Engineering
Janet.tsai@colorado.edu

Abstract: Sophomore year for engineering undergraduates is competitive, high-stakes, and where many students choose to leave engineering for alternate majors. Through the lens of Actor-Network Theory, this paper explains the existence and significance of networks of power within the engineering sophomore class as observed ethnographically, with specific attention to the implications of power differentials for engineering persistence and retention.

Overview

The 4-year engineering undergraduate curriculum is characterized by a rigid sequence of technical courses. Applied math and physics courses taken during the 1st and 2nd years are prerequisite requirements for subsequent technical engineering courses necessary for specialized engineering majors. Students who have difficulty with or fail a fundamental class during their first two years can seriously delay their graduation date or be discouraged from finishing the degree. Such experiences are known to discourage students and have been correlated with early departure from engineering majors (e.g., Seymour & Hewitt, 1997). Nationally, 82% of engineering students return for the second year, while only about 65% continue into the third year; there is a much smaller attrition rate between the third and fourth years (Fortenberry, Sullivan, Jordan, & Knight, 2007).

Engineering educators have focused on curricular interventions to improve the first-year experience (e.g., Sheppard & Jenison, 2007). However, little attention has been given to understanding the environmental or structural barriers that engineering students face during the second year of their education. The courses of the sophomore year mark the descent into "the valley of despair" as students are confronted with a seemingly endless march of technical requirements chained together with little wiggle room for electives or failure (Kotys-Schwartz, Knight, & Pawlas, 2010). The second year features gateway courses that eventually lead to the practice of engineering, courses that initiate students into greater levels of abstraction and analytical engineering problem solving. At the large public university we studied, the traditional engineering math sequence is Calculus 1 and Calculus 2 in the first year, Calculus 3 and Differential Equations in the second year. As our focal instructor told students on the first day of class in Calculus 3:

> [This class is] somewhere between Calc 1, where everything is perfectly defined, and the 4-year end where nothing is defined and you don't know all the answers… it [uncertainty] has to start somewhere and that is *here* [emphasis added].

Within this challenging and uncertain environment, students must develop methods to survive the competition, including forming alliances and participating in networks like study groups, fraternities, and extracurricular programs. Students who successfully navigate the sophomore engineering terrain gain power in the form of higher grades, greater confidence in their abilities, and privileged access to material and human resources.

Theoretical Orientation

Actor-Network Theory or ANT (Nespor, 2007) provides one means of examining the processes wherein students act in networks that place them on distinct educational trajectories in space and time. Network resources, including fraternity exam archives, residential engineering honors programs, and tutoring programs, all operate in distinct space-time locations with restricted access. ANT describes learning as changes in the organization (both temporal and spatial) of actors and networks, thus this theory offers a useful framework for studying the organization of students and emergent power dynamics within the competitive environment of the second year of engineering school. In line with ANT, we seek to uncover and describe the "ongoing social activities" that shape actor-networks and learning among students (Nespor, p. 12).

Using Actor-Network Theory, this study adopts an ethnographic approach in examining local classroom contexts and associated course activities to understand how sophomore student participation in university practices of engineering leads to power differentials. Differences in power among students can result in differential access to actor-network resources and impact important educational outcomes such as retention.

Methodology

We observe two Calculus 3 classrooms: one, a large lecture-style with over 130 students, the second a smaller honors section of only 30 students, both taught by the same Instructor of the Applied Math department at our study site, a large public university. By first observing standard classroom practice, student actors and networks

of interest were identified for further detailed study through in-person open-ended interviews. Observational fieldnotes provided the backbone, primary record of events to be analyzed by the qualitative research team. Passages of interest were flagged, subsequently coded, and used for initial reconstructive analysis (Carspecken, 1996). Course artifacts including the syllabus, textbook, homework, exams, and projects, were collected to further inform the network analysis, though were secondary to our main focus on human actors.

Reconstructive analyses were compared and coded with the observations, artifacts, and interviews to reveal network connections as perceived by the students and as performed publicly during class. Salient student groupings, as discussed below, were identified through initial coding of observational, interview, and reconstructive data.

Preliminary Findings

Preliminary analysis of the data indicates several emergent trends. First, in both classes, the Instructor is a major power player who guides the organization of the classroom culture, maintaining the framework within which students establish their own power hierarchies and actor-networks. The Instructor appears to be in charge, not only governing grades, homework assignments, projects, and exams, but also controlling how lecture periods flow, which students get their questions answered and which students get special attention.

The students, meanwhile, group themselves according to different strategies they use to negotiate the pre-established power hierarchy (the curriculum and supporting infrastructures). This includes those who follow stereotypical practices of good students like getting to class early and sitting in the front rows, as well as students who choose unorthodox strategies like playing games on their phones and ignoring most lectures. These student groups, or actor-networks, have distinctive characteristics, working styles, and methods of positioning themselves within the power hierarchy of the classroom. They not only have different positions within the power hierarchy, but they also have different levels of access to resources including Instructor help, previous exams, senior students to help with homework, and more. This power hierarchy is based on both valid and non-valid indicators of academic power, as some students incorrectly prioritize the ability to write code in Mathematica (a computer program) above conceptual understanding and communication of mathematical concepts, while other students eagerly share their test scores with their peers and know exactly where they stand with regard to the class's normal distribution and bell curve.

Conclusions and Significance

Understanding how sophomore students organize themselves within actor-networks of power is essential for understanding how to support students within the competitive environment of engineering. Feeling empowered or disempowered within one's educational context affects not only student performance but also how much one feels like one belongs and desires to remain in that context (Marra, Rodgers, Shen, & Bogue, 2012). This study takes a new and novel look at what is happening in the second year of engineering school by analyzing the social currents of the process of becoming an engineer. This study breaks from traditional engineering education research by incorporating methods from the learning sciences and observing the development of student culture ethnographically (Johri & Olds, 2011). Because engineering education occurs within the larger context of societal power differentials, it is necessary to study and understand these processes in order to give more engineering students better chances at success.

References

Carspecken, P. F. (1996). Critical ethnography in educational research: a theoretical and practical guide. New York: Routledge.

Fortenberry, N. L., Sullivan, J. F., Jordan, P. N., & Knight, D. W. (2007). Engineering Education Research Aids Instruction. *Science,* 317(5842), 1175–1176. doi:10.1126/science.1143834

Johri, A. and Olds, B. M. (2011), Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences. *Journal of Engineering Education*, 100: 151–185.

Kotys-Schwartz, D., Knight, D. W., & Pawlas, G. (2010). First-year and capstone design projects: Is the bookend curriculum approach effective for skill gain? *In Proceedings of the American Society for Engineering Education Annual Conference and Exposition.* Louisville, KY.

Marra, R. M., Rodgers, K. A., Shen, D. and Bogue, B. (2012), Leaving Engineering: A Multi-Year Single Institution Study. *Journal of Engineering Education,* 101: 6–27.

Nespor, J. (1994). Knowledge in motion: space, time, and curriculum in undergraduate physics and management. London; Washington, D.C: Falmer Press.

Seymour, E., & Hewitt, N. (1997). Talking About Leaving: Why Undergraduates Leave The Sciences. Westview Press.

Sheppard, S., & Jenison, R. (1997). Examples of Freshman Design Education. *International Journal of Engineering Education,* 13(4), 248–261.