Advances in Engineering Education

SUMMER 2020 VOLUME 8 ISSUE 2

Thinking in Systems to Uncover Faculty Mental Models Situated in Curricular Change

DAVID REEPING

AND

LISA MCNAIR
Virginia Tech
Blacksburg, VA

Key words: instructional change; mental models; systems thinking

BACKGROUND

The Department of Electrical and Computer Engineering (ECE) at Virginia Tech is in the fourth year of a large-scale change project called "Revolutionizing Engineering Departments" (NSF RED) (Lord et al., 2018). Our project has three interrelated goals: (1) broaden the range of students entering the department, (2) expand the boundaries on what careers are possible, and (3) provide greater student choice in curricular decisions (Reeping, McNair, Martin, & Ozkan, 2019). We finished phase one of curriculum development last year, the resulting new courses are being taught, and we are collecting baseline data. We expected and experienced resistance, as with any change effort (Hoey IV & Nault, 2008). However, a specific theme of resistance from faculty cut across the project goals during curriculum development: a suspicion that the new program would lack rigor. To better understand how faculty perspectives on rigor might influence change efforts and to identify productive ways to move forward together, we used a systems modeling technique– Causal Loop Diagrams (CLD) – designed to reveal connections in themes across large projects.

We adopted CLDs to better understand concerns about the loss of rigor based upon comments by faculty about students we hoped to attract into the department – that some did not fit "under the ECE tent" or were "not serious" about the program – and about the curriculum, which the faculty did not want to "water down" (Ozkan et al., 2019, p. 5). Rigor has been defined as "creating an environment in which each student is expected to learn at high levels, each student is supported so he or she can learn at high levels, and each student demonstrates learning at high levels" (Blackburn, 2017, p. 13). Yet, rigor, in this case, had been seemingly perverted from a paradigm about challenging

students with the appropriate scaffolding for success to associating rigor with a rite of passage or academic natural selection (see Riley, 2017).

Our analysis examines perceptions of rigor in relation to resistance during the early curriculum development phase – resistance associated with the goals of broadening participation and using student-centered pedagogies. We sought to uncover how these faculty mental models impacted the RED change effort as situated in the broader system – that is, thinking about how emerging goals of the department intersect with faculty priorities like research and teaching practices. We focus on the application of the technique, our next steps as a result of the technique, and ways it can be used in other contexts.

METHODS

We approached the task of making the latent system of interlocking project goals and departmental processes apparent by drawing from systems thinking literature in the third year of the project (Meadows, 2008). We reviewed recordings and notes selected from the past three years of curriculum development-focused meetings, program experience meetings about the student experience throughout the entire program beyond the curriculum, and weekly administrative meetings that focused on broader issues pertaining to the grant project – such as how tenure expectations could be changed (n = 21 faculty, n = 3 graduate students, n = 2 advisors). These meetings were chosen because the three goals of the projects were discussed continuously as a form of backward design in curriculum development (McTighe & Wiggins, 2004). The participants of the meetings included a mix of the administrative team of principal investigators, the department head, graduate research assistants, faculty represented across ranks in the department, and two department advisors.

We coded the data thematically (Gibbs, 2007) to uncover influential variables in what was stymieing our change processes. We then used a CLD to connect the variables together. CLDs describe the positive and negative relationships between variables in a system, forming loops across different processes (Sterman, 2000). CLDs have two types of loops, reinforcing and balancing. A reinforcing loop produces an increase or decrease in a variable of interest while a balancing loop moves the variable to a specific target value, then maintains it.

We used a "small models" approach (Ghaffarzadegan et al., 2011) to maintain a comprehensible model size. The loops were backdropped with the literature on rigor (e.g., Blackburn, 2017; Riley, 2017; Slaton, 2010), prestige (e.g., Readings, 1996) and relevant work on broadening participation in engineering. The diagram was reviewed by multiple members of the principal investigator team as a form of peer debriefing (Spall, 1998).

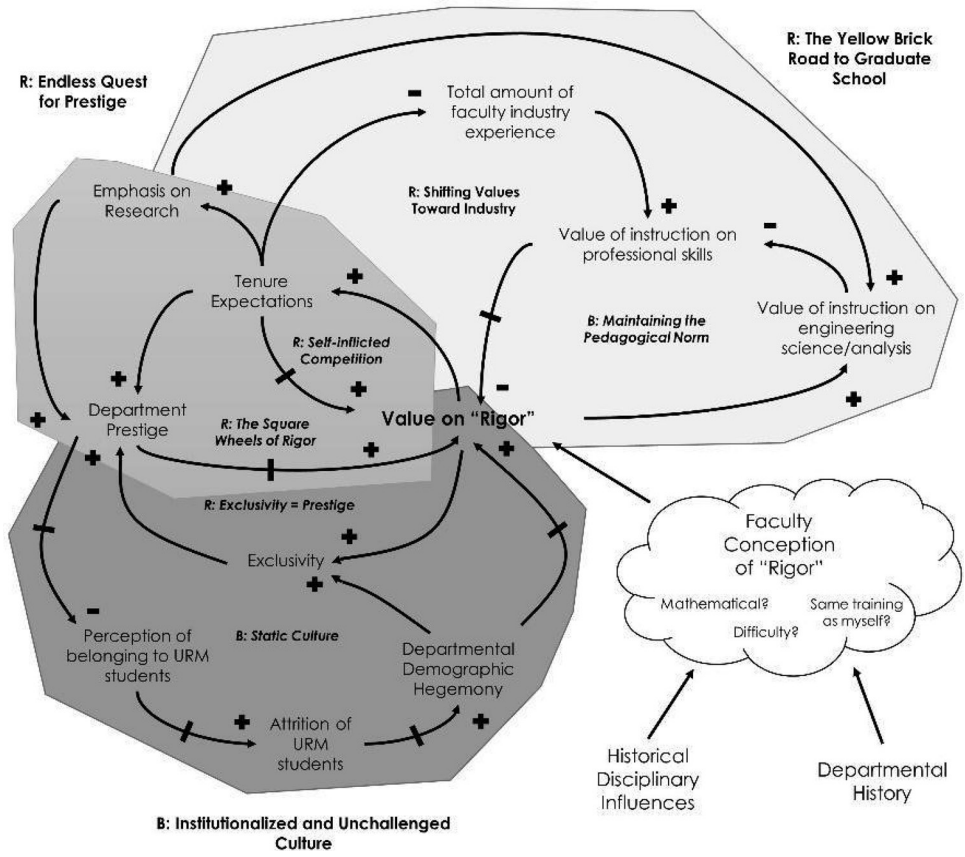

Figure 1. CLD of influence on rigor in RED site progress. The relations X → Y with "+" means X increases Y and "–" indicates X decreases Y. A dash on → represents a delay in X. Each main loop is highlighted by a shade of gray. Reproduced from Reeping, McNair, Martin, and Ozkan (2019), ©2019 IEEE.

PRELIMINARY RESULTS

In creating the diagram shown in Figure 1, we found three main loops – two reinforcing and one balancing. The first reinforcing loop, *Endless Quest for Prestige*, captures how the culture of "rigor" fuels a cycle of increased research activity to fulfill tenure expectations and fund labs and graduate students, breeding internal competition (see Readings, 1996). This loop competes with the goal of fostering a wide range of careers because success has been established as producing a specific type of student and research profile (see Edwards & Roy, 2016).

The second reinforcing loop, *The Yellow Brick Road to Graduate School,* captures how faculty value rigorous engineering science and place less emphasis on professional skills (see Seely, 1999), influenced

by continually increasing research expectations (Schimanski & Alperin, 2018; Edwards & Roy, 2016). *The Yellow Brick Road to Graduate School* can be thought of as the faculty's focus on paving a clear trajectory for students toward advanced research and hence graduate school – thus, this loop competes with the goal of expanding student choice. Faculty with industry experience could mitigate the culture of rigor by integrating perspectives from engineering practice (Fairweather & Paulson, 1996).

The balancing loop, *Institutionalized and Unchallenged Culture*, reveals how the department's curriculum is implicitly designed for the typical student persona termed "Brad," a white male from northern Virginia interested in working for a defense contractor (Ozkan et al., 2019). This current version of prestige could signal to underrepresented students they may not belong. The loop is delayed, since attrition and assessing one's fit in a particular culture occurs over time (see Tinto, 1987). Because of the focus on retention, the loop competes with the goal of attracting a broader range of students. We detail our model further in Reeping, McNair, Ozkan, & Martin (2019).

NEXT STEPS

As a result of the CLD modeling, we are implementing shifts in our change process through departmental leadership and staff from the Center for Excellence in Teaching and Learning to disrupt loops sustaining research-philic and teaching-phobic models of rigor in the institutional culture – focusing on the *Institutionalized and Unchanged Culture* and *The Yellow Brick Road to Graduate School* loops:

1. Advisors are now recognized as significant sources of knowledge about students, their experiences in the 'rigorous' classrooms, and why students make course withdrawal decisions that delay their academic progress (*Static Culture* loop). We have included advisors in more central roles in the project. To assemble the different knowledge bases in the department, we invited the advisors and a mix of tenure-track faculty and professional track ranks responsible for developing new courses to the weekly project meetings to collaborate on the change process holistically – beyond curriculum development.
2. Faculty are receptive to evidence-based evaluation data but reluctant to sacrifice content (*Maintaining the Pedagogical Norm* loop) or the privacy of their classrooms. We are implementing pilots of minimally invasive techniques to collect measures of student understanding and confidence and faculty input on concepts covered in their courses.
3. As a result of working together to develop curricula, faculty have begun to communicate more across sections and courses. We are encouraging this communication via monthly curriculum meetings in which project-based pedagogies and their connections to ECE concepts are discussed. In

fact, faculty are starting to experiment with publishing in educational venues, which opens up new avenues of scholarship in the department (*Endless Question for Prestige*). One conference paper has been published co-authored with a faculty member in the department (Ball, Baum, & McNair, 2019), another faculty member is engaging in a narrative analysis of her teaching experiences in the face of increasing class sizes, and three faculty of the introductory course are collaborating on a weekly muddiest point project to identify common sticking points in the new course. Moreover, the position announcements for the new Director of the Undergraduate Program and an associated collegiate, i.e., teaching-focused, position explicitly listed engineering education research as a possible area of research. Although these positions are not tenured, the openness to such scholarship is a promising start. It might be too early to tell how faculty perceive this shift in the context of rigor. Still, the willingness to participate in publishing scholarship on teaching and learning can be an early marker of shifting to less stringent views on rigor. This growing acceptance of diverse forms of scholarship could help disrupt the *Endless Quest for Prestige Loop.*

4. To investigate the smaller *Static Culture* loop, we are surveying the interests of students longitudinally to monitor the extent to which our goal of bringing in a broader range of students is succeeding in the presence of rigor's traditional influence. We just collected the first sample of baseline data in sections of the first course.

Our model can be used by others as an enabler and informer in the context of faculty development or coaching efforts in the face of promoting curricular change. Conceptualizing how themes connect can help change agents identify process-oriented themes and means of monitoring how they change over time. Specifically, locating leverage points or critical loops – what Lattuca and Stark (2011) would call "decision points" – in the system provides a framework to situate assessments and professional development in hopes of mitigating troublesome processes (see Meadows, 2008). In addition, models can be developed independently – whether through CLDs or other techniques like systemigrams (Boardman & Sauser, 2008). In our setting, we plan to engage faculty in diagramming their mental models of the project using a shared model building exercise (Vennix, 1996) as a faculty coaching and professional development approach that may be useful for encouraging the adoption of instructional innovations (Cruz, 2019) and overall project acceptance.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1623067. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

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AUTHORS

David Reeping is a Postdoctoral Associate in the Bradley Department of Electrical and Computer Engineering at Virginia Tech. He earned his Ph.D. in Engineering Education at Virginia Tech and was a National Science Foundation Graduate Research Fellow. He received his B.S. in Engineering Education with a Mathematics minor from Ohio Northern University. His main research interests include transfer student information asymmetries, agent-based modeling of educational systems, and advancing quantitative and fully integrated mixed methods.

Lisa D. McNair develops integrative education projects that transverse perspectives within and beyond the university. Her currently funded NSF projects include revolutionizing the VT ECE department, identifying practices in intentionally inclusive Maker spaces, and exploring professional identity development in Civil Engineering students with disabilities. She is also a co-PI on two grants – Vibrant Virginia and 4-VA – focused on building networks across Virginia to support PK12 teaching and learning. At Virginia Tech she led a cross-college team in creating the interdisciplinary undergraduate Pathways Innovation Minor, and she teaches graduate courses in educational theory, assessment and research methods. Her work in CRSE focuses on building networks between the University and multiple community sectors and supporting engagement in science, engineering, arts, and design.