Making RUME for Institutional Change

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Overwhelming evidence favors the use of active learning in undergraduate STEM classrooms. Thus, the issue faced by educators is no longer what to do in classrooms, but how to enact what is known to be effective. This poses a challenge, because faculty teaching is embedded in the context of departments, universities, and the broader disciplinary culture. Thus, improving education requires knowledge of how systems work and how to enact systemic change. While organizational change has studied these issues for decades in nonprofit and business settings, the application of this knowledge to higher education is relatively new. Accordingly, this theoretical paper provides an introduction to the organizational change literature in the context of higher education and provides an example of its application through Departmental Action Teams (DATs). By highlighting five principles from organizational change, this paper serves as a reference for change agents wishing to improve undergraduate mathematics education.

There is now considerable evidence for the use of active learning techniques in STEM classrooms. Broadly speaking, active learning aligns with sociocultural and constructivist views, which posit that learning involves constructing meaning through engagement in social practices (Lave & Wenger, 1998; Smith, diSessa, & Roschelle, 1993). As such, active learning courses involve students as active participants in classroom sessions, through activities such as: groupwork, peer instruction, class discussions, and personal response systems. Active learning is generally contrasted with "pure lecture," in which students passively listen to lecture and take notes. While active learning courses often involve some lecture (or mini-lessons), the distinction is that lecture is one of many modes used for instruction, rather than the only one.

A recent meta-analysis of 225 studies demonstrates the benefits of active learning; pure lecture increases failure rates in STEM courses by 55% when compared to active learning (Freeman et al., 2014). This evidence is so strong that the authors of the study described teaching solely through passive lectures as akin to educational malpractice. Moreover, the use of active learning can help reduce existing disparities between students from dominant groups and those historically marginalized in STEM classrooms (President's Council of Advisors on Science and Technology, 2012). Finally, these benefits appear to extend beyond just the courses incorporating active learning, to support students to do better in future courses as well (Kogan & Laursen, 2014). Thus, STEM education research has identified improved instructional techniques (i.e. active learning), scientifically proven to be more beneficial for students than traditional methods. As such, RUME (Research in Undergraduate Mathematics) is confronted with a new challenge: how to foster the use of active learning in undergraduate mathematics classrooms.

Research shows that simply providing faculty with evidence of the value of active learning is insufficient (Foertsch, Millar, Squire, & Gunter, 1997; Reese, 2014). This has been studied extensively in physics, where despite the wealth of instructional advances and widespread awareness of them, they are not widely used (Dancy & Henderson, 2010; Henderson & Dancy, 2007; Lutzer, Rodi, Kirkman, & Maxwell, 2005). Even when new pedagogies are adopted, sustainability is a challenge (Henderson, Dancy, & Niewiadomska-Bugaj, 2012). As such, recent

calls for educational improvement have begun to shift their focus from developing new learning techniques to understanding how to scale and sustain the use of existing techniques (PCAST, 2012). This theoretical paper focuses on exactly this issue: how to enact and sustain educational change. Ultimately, I argue that change efforts should draw on the vast literature of organizational change. I highlight five principles from this literature to support change agents in their own local efforts, and provide an example of their application through Departmental Action Teams (DATs).

Theoretical Framing

Educational improvement requires attention to the university as a holistic system (Corbo, Reinholz, Dancy, Deetz, & Finkelstein, 2016). A recent meta-analysis of 191 STEM education improvement efforts showed that 85.3% of efforts focused on only a small part of the system, and that they were "clearly not effective" (Henderson, Beach, & Finkelstein, 2011). As such, researchers must draw from organizational change, to better understand how to change *systems*. Indeed, if the RUME community seriously considers the seven recommendations of the recent study of college calculus programs (Bressoud, Mesa, & Rasmussen, 2015), the need for systemic change is clear. Thus, change agents must expand their work with individual faculty members to consider how their efforts are embedded in departments, universities, and disciplinary culture. While there are interactions between each of these levels, the academic department itself is often considered the key unit of change, due to its relative coherence as a unit (AACU, 2014).

Given its roots in educational psychology, most educational research is grounded in experimental science. The logic of experimental science is that variations in treatments and contexts can be accounted for statistically, to generalize results across settings. In contrast, organizational change is better understood as an improvement science (Bryk, Gomez, & Grunow, 2011). Given the complexity of organizations, improvement scientists argue that context is too important to be "averaged out" statistically; instead, one must develop a "system of profound knowledge" for how to enact change within a given context (Lewis, 2015). While some educational research aligns with this perspective, such as in action research (Zeichner & Noffke, 2001) and design-based research (Cobb, Confrey, Disessa, Lehrer, & Schauble, 2003), these approaches have not yet been widely adopted.

What follows is a brief description of principles extracted from a synthesis of improvement efforts in higher education (AACU, 2014; Elrod & Kezar, 2015; Henderson et al., 2011), intended to provide undergraduate mathematics educators with powerful ideas that they can use immediately to support their own educational improvement efforts. For a general overview of this literature, consider the book *How Colleges Change* (Kezar, 2013). While it is beyond the scope of this paper, improvement science offers tools for assessing the impact of systemic change efforts, such as: program improvement maps, driver diagrams, and Plan-Do-Study-Act (PDSA) cycles (Bryk et al., 2011). In what follows, I describe five ideas from organizational change and their application to RUME.

Five Good Ideas

These ideas draw the reader's attention to concepts that are often overlooked in educational improvement. The five ideas are: (A) building a shared vision, (B) supporting agency and ownership of a change, (C) promoting the use of evidence, (D) creating opportunities for early

wins, and (E) designing for sustainability. As the authors of a recent effort for systemic change on university campuses note, "almost all of these process – organizational learning, addressing politics, creating a shared vision and unearthing cultural assumptions – were extremely hard for STEM leaders…These processes are often messy and non linear" (Elrod & Kezar, 2015, p. 7). In other words, while these principles are supported by the organizational change literature, they can be difficult to enact, and are not yet widely used.

Building a Shared Vision

Suppose a group of faculty aims to improve student interactions in their department. A common approach is to generate a list of barriers, such as: large class sizes, an overstuffed curriculum, lack of department funds, and many students commuting to campus. Having identified these problems, the group identifies possible solutions (e.g., classroom response systems, curricular change) and debates their relative merits. Yet, this "problems focus" tends to result in a fixation on specific problems and preferred solutions to them. For instance, one group member may fixate on large lecture courses, and the use of classroom response systems as a "solution." Most individuals have such preferred solutions, and this often leads to inflexibility.

Rather than operating in "problem-solving mode," discussions are more effective when they focus on positive outcomes to be achieved (Cooperrider, Whitney, & Stavros, 2008). Suppose the same group of faculty works to generate a shared vision for student interactions in the department. They decide upon the goal: students will feel like a part of a community with their peers and work together productively to succeed as mathematicians. This opens the conversation to many other possibilities, including: improving department culture, running community events, and creating space for student collaborations outside of class. Such an approach builds flexibility, helps reduce conflict, and thus increases collaboration. An "outcomes focus" changes the nature of the conversation, allowing group members to see possibilities (e.g., creating a welcoming departmental culture) where before they saw only obstacles.

Agency

Change is not something that can be "done to others." Yet, very often, educators have a new curriculum or teaching techniques that they would like others to adopt. In other words, the change agents would like to change others. However, as the research on dissemination approaches highlights (Henderson et al., 2011), this is generally not effective. Instead, a change agent should work with others, to help them achieve their goals. This process often begins with developing a shared vision for what the participants want to achieve, affording participants agency in the process. Agency relates to the ability of individuals to influence their circumstances (Bandura, 2006). When individuals have agency over a change effort, they are more invested in the work, as they develop ownership over their change effort. Because of this investment, the individuals are more likely to expend more effort, rather than giving up, when obstacles are inevitably encountered.

Evidence

Psychological research shows that individuals use shortcuts to make decisions (Kahneman, 2011). According to the availability heuristic, individuals usually rely on the most accessible or salient examples to make decisions, regardless of how representative of the larger population they are. Consider a faculty member trying to explain why a student is doing poorly in their

class. The faculty member may notice a student has skipped a few class sessions, and infer that the student is lazy or unmotivated. In general, it is easier to center the locus of control within the student, than to consider systemic factors, such as departmental culture or the student's life circumstances (e.g., working a full-time job to pay for college).

The above explanations are ascriptions of motive, intended to describe the underlying causes of the student's behavior. These ascriptions can be placed on a spectrum from person- to system-focused (Blum & McHugh, 1971; Simpson & Vuchinich, 2000). Person-focused explanations (e.g., laziness) tend to be readily available, so faculty members are more likely to adopt them "by default." Yet, person-focused explanations are also outside of the faculty member's control, so adopting these explanations means that the faculty member has little agency to change the situation. In contrast, systemic factors (e.g., departmental culture) can be changed, so focusing on them increases faculty agency.

When conversations focus on "anecdata," they tend to revolve around person-focused explanations. Thus, to shift conversations towards systemic factors, change agents can use evidence that highlights the systemic nature of issues. In accordance with building a shared vision and promoting agency, change agents should help faculty gather data to answer their questions, rather than presenting data to argue for a preformed agenda.

Early Wins

Change is a time-consuming. For instance, work in teacher professional development shows that effective interventions are longterm and must be holistic (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Wilson & Berne, 1999). Similarly, work at the department or campus level can be expected to take many years (Elrod & Kezar, 2015). Yet, when change work takes years to come to fruition, it is easy for participants to disengage or processes to become stalled. Thus, it is key to build in "early wins" to the process (Kotter, 1996).

The idea of early wins is simple; to begin a change process, a group identifies a vision for what it would like to achieve. Again consider the group that aims to build greater community for its students. While changing the community and the culture of the department is a many-year project, there are also many waypoints or markers of change that would provide evidence of improvement. For example, the group could: survey students about their experiences (collecting data), run community events, run faculty professional-development for inclusive teaching, or seek external funding. By conducting these activities, the group creates concrete "successes" towards the larger goal of building community. This is important internally, for the motivation of the group, and externally, with respect to department and campus politics.

While there may often be early wins on the way to a larger goal, from the perspective of a change agent, they can be strategically built into the change process. For instance, creating early wins is built into the cyclical nature of PDSA cycles in improvement science (Bryk et al., 2011). PDSA cycles are iterative improvement cycles that focus on implementing and analyzing ideas quickly, to enact efforts in a way that is sensitive to the local context. Thus, once a shared vision has been developed, PDSA cycles are one way to identify short-term goals that can be achieved in service of the larger goal, to ensure that the process does not stall.

Sustainability

Change agents often talk about "solving" educational problems, or having courses that are "transformed." This language implies that educational improvement is something that can be "done" and then it will be sustained. Yet, it is difficult to sustain even largely successful change

efforts when external funding is removed (cf. Chasteen et al., 2015). Thus, efforts should focus on continuous learning and sustainability from the offset (Senge, 2006).

One key aspect of sustainability is focusing on culture. Culture is a "pattern of shared basic assumptions learned by a group…which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel" (Schein, 2010, p. 19). As such, a department's culture consists of these beliefs, values, customs, rituals, practices, artifacts, and institutional structures. These various components of culture interact with one another to provide a relatively coherent system. Thus, if one attempts to change only a single component of the cultural system, without addressing other components, it is unlikely that the change will be sustained over time.

As described above, dissemination efforts often do not result in sustained use of new teaching techniques (Henderson et al., 2012). Because these efforts focus only on practices, a single component of culture, there are numerous forces acting in opposition to the use of the new teaching techniques. For example, traditional beliefs about teaching and learning will influence *how* the practices are used, which may limit their efficacy. Or, reward structures may be such that the time required to learn to use the new techniques is not perceived as worthwhile.

Departmental Action Teams

Departmental Action Teams (DATs) were developed as one component of the STEM Institutional Transformation Action Research (SITAR) Project, which fostered and studied systemic change in STEM departments at one research-extensive university (Corbo et al., 2016). A DAT consists of 4-8 participants (primarily faculty) working collaboratively to improve education in a single department. DATs are externally facilitated; facilitators bring expertise in educational research, help coordinate logistics, and draw on principles from organizational change (i.e. the key ideas identified above). In what follows, the process of facilitating a DAT is described in more detail to provide change agents with concrete examples of how to implement organizational change principles in their own educational improvement efforts.

A DAT begins with members developing a shared vision around an issue of common interest in their department (key idea A). Participants have agency to choose an issue that is meaningful to them (key idea B); the role of the facilitators is to help the DAT work on the issue in the most productive way possible, not to tell participants what issue to work on. As the DAT works to achieve its vision, it gathers and analyzes relevant data (key idea C): so it can make informed decisions about potential actions, and so it can build political will from external stakeholders (e.g., a department chair). Along the way, the facilitators and DAT members think strategically about how to build early wins into the process (key idea D) so that progress does not stall. Finally, the types of issues a DAT addresses are crosscutting, and building sustainable structures is a goal from the offset (key idea E).

DATs in SITAR met regularly, typically for an hour every other week for multiple semesters. Between meetings, DAT members assign their own "homework," determining what needs to be done to continue moving the group forward. DAT members may also schedule additional meetings as necessary. Thus, while DATs are externally facilitated, they are departmentally-driven. To date, the DAT model has been used to facilitate 6 working groups through the SITAR project. In what follows, I provide examples of the five key ideas in action. Data are drawn from from four STEM departments: Alchemy, Potions, Prophecy, and Runes (actual department names redacted for confidentiality).

Shared Vision

Once the group has been established, a DAT begins by building a common vision for its work. To help participants build a common vision, the facilitators use a "sticky note" activity (adapted from http://serc.carleton.edu/departments/degree_programs/idealstudent.html). Each DAT member is given a pad of large sticky notes, and asked to write individually their responses to the following prompt:

> Imagine you are writing a letter of recommendation for a student graduating from your department. Ideally, what would you like to be able to say in response to the following questions: (1) what kind of person will they be? (2) what will they be able to do? (3) what will they know? (4) what skills will they have? (5) how will they behave? (6) what will they value?

After writing their responses, the DAT members stick their responses on the wall, the group organizes them looking for common themes, and then they have a whole group discussion about vision. These prompts are designed to help faculty focus on students (not just themselves), and to seek areas of overlap in what all participants value. These prompts appear to work effectively even with DAT participants that have very different views on education.

Agency

While the external facilitators help shape discussions, they do not tell DAT participants what to do. As described above, it is DAT members who determine the vision and direction of the group, not the facilitators. Moreover, the participants determine homework, whether or not to schedule additional meetings, and many other key features of how the work gets done. As a result, DAT members perceive the change effort as theirs. For example, as a participant in the Runes DAT described:

> I really think they did a fabulous job of letting all of us kind of speak our piece and keeping it harmonious and letting us kind of find our own way. I think- Like I said, I think, I'm hoping that everybody's as excited about this as I am, because I think we've struck on something that'll really work for our department.

While this is a quote from just one member of one DAT, it is generally consistent with the perceptions of other DAT members that they "owned" their efforts.

Evidence

Gathering evidence to support decisions was a common thread across DATs. In the Runes and Prophecy DATs, both focused on curricular integration, participants gathered and analyzed institutional data about the course taking patterns and success of their students. In the Potions and Alchemy DATs, both focused on diversity and inclusion in their departments, a wealth of data about the retention, success, and experiences of students from diverse groups were collected and analyzed. These data were used to determine plausible actions for the DATs, and on multiple occasions were used in presentations at faculty meetings or to departmental committees to gather support for the actions of the DATs.

Early Wins

The Potions DAT spent the majority of its first year analyzing data related to diversity in the major, which resulted in a detailed report to the department. Yet, beyond curating data, the DAT also engaged in a number of actions, such as: targeted recruiting of admitted students, building collaborations with other diversity organizations on campus, and leading the department's response to a campus diversity initiative. All of these actions supported the DAT to be seen as a positive force in the department, and ultimately supported it to be institutionalized in the form of a standing committee. Similarly, the Alchemy DAT has begun to focus on concrete actions in parallel to collecting and analyzing data.

Sustainability

Both the Runes and Potions DATs (the only multi-year DATs, to date) have successfully created new departmental structures to sustain their efforts. In Runes, new curriculum coordinator positions have been created (and funded by the department) to revisit curricular integration issues on an ongoing basis. In Potions, the DAT has been formalized as a standing committee. Moreover, the facilitation practices used by the external facilitators have been adopted, and the Potions DAT is continuing to use them in its ongoing work.

Summary

STEM education has identified research-based approaches for improving classroom learning. Yet, actually enacting these approaches remains a challenge. Fortunately, there is a wealth of organizational learning theory, traditionally applied to businesses and nonprofits, that can be adapted to support higher educational change. Accordingly, this paper has two primary aims: (1) broaden the focus of RUME to emphasize systemic change perspectives, and (2) provide practical tools that RUME practitioners can use to increase the impact of their work.

A systemic change perspective provides a new lens for RUME practitioners engaged in improvement efforts. For example, it highlights the systemic nature of educational improvement, operating at multiple levels: students, classrooms, departments, universities, disciplines, and society. As such, improving education requires thinking about these multiple levels. It also highlights the political nature of change, such as the need to develop processes that will effectively engage a variety of stakeholders. Finally, this perspective highlights the need for sustainability. When sustainability is built into a process from the offset, rather than considered as an afterthought, it is much more likely for continuous improvement to result.

This paper provides a number of practical tools that the RUME community can draw upon. For instance, simply organizing improvements around outcomes rather than problems, can result in much more productive conversations. Similarly, building in early wins can help make progress visible, rather than resulting in improvement efforts stalling. By affording participants with agency and the ability to make decisions around evidence, rather than anecdote, it is more likely that innovations in education will be used and sustained. In sum, organizational change provides useful theoretical background to promote systemic change. As researchers adopt this perspective, theory of organizational learning can be adapted and contextualized to RUME.

References

AACU. (2014). *Achieving systemic change: A sourcebook for advancing and funding undergraduate STEM education*. Washington, DC: Association of American Colleges and Universities.

Bandura, A. (2006). Toward a Psychology of Human Agency. *Perspectives on Psychological Science*, *1*(2), 164–180.

Blum, A. F., & McHugh, P. (1971). The Social Ascription of Motives. *American Sociological Review*, *36*(1), 98–109. http://doi.org/10.2307/2093510

Bressoud, D. V., Mesa, V., & Rasmussen, C. (2015). *Insights and Recommendations from the MAA National Study of College Calculus*. MAA Press.

Bryk, A. S., Gomez, L. M., & Grunow, A. (2011). Getting ideas into action: Building networked improvement communities in education. In M. T. Hallinan (Ed.), *Frontiers in sociology of education* (pp. 127–162). New York, NY: Springer.

Chasteen, S. V., Wilcox, B., Caballero, M. D., Perkins, K. K., Pollock, S. J., & Wieman, C. E. (2015). Educational transformation in upper-division physics: The Science Education Initiative model, outcomes, and lessons learned. *Physical Review Special Topics - Physics Education Research*, *11*(2), 020110. http://doi.org/10.1103/PhysRevSTPER.11.020110

Cobb, P., Confrey, J., Disessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9–13. http://doi.org/10.3102/0013189X032001009

Cooperrider, D., Whitney, D., & Stavros, J. M. (2008). *The appreciative inquiry handbook: For leaders of change*. San Francisco, CA: Berrett-Koehler Publishers.

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Framework for transforming departmental culture to support educational innovation. *Physical Review Physics Education Research*, *12*(1), 010113. http://doi.org/10.1103/PhysRevPhysEducRes.12.010113

Dancy, M., & Henderson, C. (2010). Pedagogical practices and instructional change of physics faculty. *American Journal of Physics*, *78*(10), 1056–1063.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). Professional learning in the learning profession. *Washington, DC: National Staff Development Council*.

Elrod, S., & Kezar, A. (2015). *Increasing Student Success in STEM: A Guide to Systemic Institutional Change*. A Keck/PKAL Project at the Association of American Colleges & Universities.

Foertsch, J., Millar, S. B., Squire, L., & Gunter, R. (1997). *Persuading professors: A study of the dissemination of educational reform in research institutions*. Madison, WI: The LEAD Center.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 201319030. http://doi.org/10.1073/pnas.1319030111

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: an analytic review of the literature. *Journal of Research in Science Teaching*, *48*(8), 952–984.

Henderson, C., & Dancy, M. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics - Physics Education Research*, *3*(2), 020102.

Henderson, C., Dancy, M., & Niewiadomska-Bugaj, M. (2012). Use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process? *Physical Review Special Topics - Physics Education Research*, *8*(2), 020104. http://doi.org/10.1103/PhysRevSTPER.8.020104

Kahneman, D. (2011). *Thinking, fast and slow*. New York, NY: Farrar, Straus and Giroux.

Kezar, A. (2013). *How colleges change: Understanding, leading, and enacting change*. New York, NY: Routledge.

Kogan, M., & Laursen, S. L. (2014). Assessing Long-Term Effects of Inquiry-Based Learning: A Case Study from College Mathematics. *Innovative Higher Education*, *39*(3), 183–199. http://doi.org/10.1007/s10755-013-9269-9

Kotter, J. P. (1996). *Leading Change*. Boston, MA: Harvard Business Review Press.

Lave, J., & Wenger, E. (1998). *Communities of practice*. Cambridge, UK: Cambridge University Press.

Lewis, C. (2015). What Is Improvement Science? Do We Need It in Education? *Educational Researcher*, *44*(1), 54–61. http://doi.org/10.3102/0013189X15570388

Lutzer, D., Rodi, S., Kirkman, E., & Maxwell, J. (2005). Statistical abstract of undergraduate programs in the mathematical sciences in the United States: Fall CBMS 2005 Survey. *Providence, RI: American Mathematical Society*.

President's Council of Advisors on Science and Technology. (2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*. Washington, D.C.: Executive Office of the President.

Reese, M. (2014). *Changing course: The influence of social position on college faculty's adoption of educational innovations*.

Schein, E. H. (2010). *Organizational culture and leadership*. San Francisco, CA: Jossey-Bass.

Senge, P. M. (2006). *The fifth discipline: The art and practice of the learning organization*. New York, NY: Random House.

Simpson, C. A., & Vuchinich, R. E. (2000). Temporal Changes in the Value of Objects of Choice: Discounting, Behavior Patterns, and Health Behavior. In W. Bickel & R. E. Vuchinich (Eds.), *Reframing Health Behavior Change with Behavioral Economics*. Lawrence Erlbaum Associates, Inc.

Smith, J., diSessa, A. A., & Roschelle, J. (1993). Misconceptions Reconceived: A Constructivist Analysis of Knowledge in Transition. *Journal of the Learning Sciences*, *3*(2), 115–163.

Wilson, S. M., & Berne, J. (1999). Teacher Learning and the Acquisition of Professional Knowledge: An Examination of Research on Contemporary Professional Development. *Review of Research in Education*, *24*, 173–209. http://doi.org/10.2307/1167270

Zeichner, K. M., & Noffke, S. E. (2001). Practitioner research. *Handbook of Research on Teaching*, *4*, 298–332.