Considering the Evolution of the STEM Mathematical Pathway at the University of Oklahoma using Organizational Development and Change Theory

Calculus serves as an entry course for many STEM majors (Bressoud, Mesa, & Rasmussen, 2015); for that reason, secondary students often try to move quickly through mathematics courses in high school to get to a calculus course (Bressoud, 2015). Despite enrollment in high school calculus more than doubling from 1990 to 2009 (Sadler & Sonnet, 2018), students often go on to enroll in prerequisite or remedial mathematics classes in college (Bressoud, Camp & Teague, 2012). This means post-secondary students in algebra, precalculus and calculus courses have often already been introduced to the key topics in previous courses on their "rush to calculus" (Bressoud, 2015).

"Failure in calculus is akin to an exit from STEM" (Voigt, Apkarian & Rasmussen, 2017, p. 34); yet, many incoming freshmen with STEM majors fail, or never reach, calculus. These students often finished high school believing they had a head start in mathematics even though their mathematical foundations were lacking (Reamer, Ivy, Vila-Parrish & Young, 2015) and focused on procedures rather than understanding the meaning and coherence of fundamental mathematical concepts (Thompson, 2013). While there have been variations in the reports of failure rates in calculus (Apkarian et al., 2016, Schraeder, Pyzdrowski & Miller, 2019; Wieschenberg, 1994), numerous members in the mathematics education community have put great effort into studying and improving students' calculus experiences. To help STEM students achieve mathematical success, many course variations are seen in the precalculus and calculus sequence. Some involve stretching out the course sequence over additional semesters; incorporating prerequisite material, often in a just-in-time manner; and increasing contact hours in a semester past the credit-hour designation for a course (Voigt, Apkarian & Rasmussen, 2017). For successful changes in undergraduate mathematics instructional practices to occur, efforts should involve policy creation that takes local needs and operational norms of the department into account. However, there must also be a recognition of the complexity of the issue that involves coordinated efforts lasting over an extended period of time, incorporation of evaluation and feedback for instructors, and a support structure that facilitates instructional growth and reflection (Henderson, Beach & Finkelstein, 2011).

Following others who have studied their own institutions (Apkarian, Bowers, O'Sullivan & Rasmussen, 2018), in this case study, we look at how the University of Oklahoma (OU) has attended to the mathematical pathway leading to STEM fields, often dealing with issues that arise when students enter postsecondary studies with inadequate mathematical foundations. We[1] use multiple sources of information to provide the particular context of the situation and in-depth picture of the campus response, including ongoing challenges. For OU, this has impacted hiring, course structure, course coordination, TA training, and support systems.

Theoretical Framing

Kurt Lewin's (1943, 1946, 1947a, 1947b) change theory provides a simple, yet poignant, way to look at organizational evolution (as displayed in Figure 1). Lewin

[1] Following Apkarian, Bowers, O'Sullivan, and Rasmussen (2018), *we* and *our* refer to the four authors; *we+* and *our+* refer to some nonempty subset of the four authors and others, typically mathematics department members, working at OU.

suggested that organizations in status quo must have some motivation for change. In order to "unfreeze" the status quo, there is a need to build recognition for change, a realization that the status quo is not beneficial, and a need to build trust to establish support to back the change. This leads to a movement stage where plans are carried out through a series of change actions that target a new systemic equilibrium. During this period, frequent communication between and the involvement of multiple individuals are necessary. The stabilization stage allows the sustainability of the new equilibrium. This stage, also referred to as "refreezing," involves finding mechanisms that ensure the new values and practices remain by anchoring the change in the culture and providing support or training as needed.

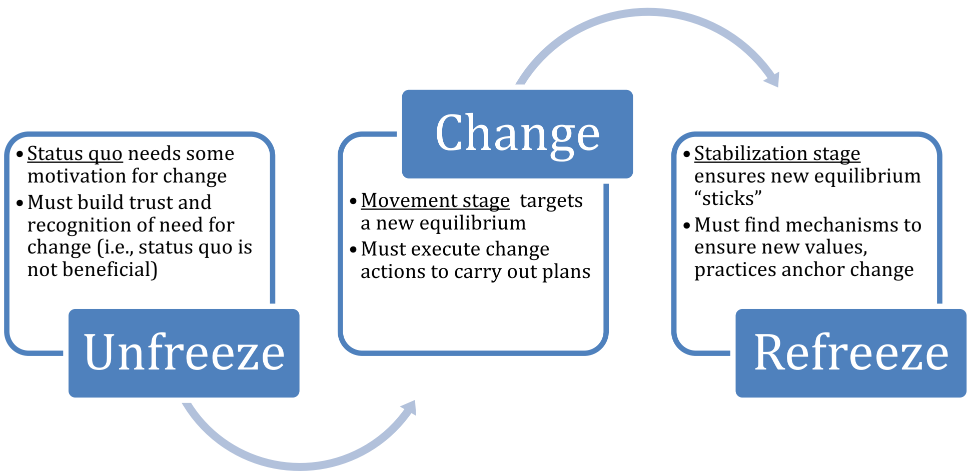

Figure 1. Lewin's Three Stages of Organizational Evolution.

Throughout the entire process, Lewin points out the needs for reflection, both in the short and long term. He also put forth that there are often restraining forces that will try to keep the status quo and driving forces to the desired state. Lewin's ideas are still well respected (Burnes, 2004), and similar ideas have been used in the context of change of pedagogy for instructors (Heyward, Kogan & Laursen, 2016).

We also frame our process within the six-box model of Weisbord (1976) that assesses how organizations function. We now introduce each of Weisbord's six "boxes" briefly, in light of the current study. The first is *purpose*; in this area, primary goals are considered. For OU, a unifying goal was to improve teaching and learning in the STEM math pathway. The second is *structure*; in this case study this means focusing on how the work to achieve the goal of increased student mathematical success is divided. The third is *relationships*; this area deals with interpersonal interactions and how conflict is managed. The fourth is *rewards*, which may be formal incentives (e.g., pay raises) but they also include informal incentives that motivate individuals (e.g., peer approval, feeling one's work is valued). The fifth is *mechanisms*, and this considers the "procedures, policies, meetings, systems, committees, …that facilitate concerted efforts" (Weisbord, 1976, p. 443). In light of Lewin's change theory, both existing systems and processes may undergo or allow for change as well as new systems and processes that are created as driving forces leading to the desired equilibrium. The sixth, and final area is *leadership*, which should coordinate with the other five areas, and it involves understanding the environment to make sure the other five areas are kept in sync.

Methods

In order to understand change in post-secondary education, it is vital to view the university as a complex system and to recognize that effective change strategies must be designed so they are compatible with this interconnected, multileveled system (Henderson, Beach & Finkelstein, 2011). In line with this and with case study methodology that involves setting bounds on what is to be studied, this study specifically looks at the STEM math pathway three-course sequence (i.e., College Algebra, Precalculus & Trigonometry, Calculus 1) at the University of Oklahoma over the period from Fall 2014 to Spring 2019 (present) using multiple data sources that represent pertinent student, faculty, department, and administrative actions and interactions.

As is recommended for qualitative research, this study is based on "prolonged engagement and persistent observation" (Cresswell, 2007, p. 207) occurring over a two-year period (Fall 2017 to Spring 2019) to understand changes that took place since Fall 2014. Using multiple sources to corroborate evidence that involved member checking (Lincoln & Guba, 1985) where the first two authors engaged in the majority of the writing and the last two authors gave extensive feedback on the accuracy of the account.

The lead author had numerous meetings in understanding and carrying out her role as the newly hired First-Year Mathematics Director. Her notes from meetings with many administrators and advisors in the College of Arts and Sciences, the College of Engineering, and University College (the college all incoming OU freshman are first assigned to upon entry into the university), the agendas and notes from her regular meetings with the mathematics department Chair, the course coordinators, and the Math (Tutoring) Center Director were used. The difference in the perspectives of the lead author and the co-authors is that the lead author not only has a different role, but she was relatively new to the university, joining in 2017. The co-authors were all part of OU's Department of Mathematics during the period under study, and each played different, integral roles in the evolution that is described. The three coauthors often had overlapping roles that included serving as course instructor, course coordinator, principal investigator on funding aimed at reforming courses in STEM pathway, member of the First-Year Mathematics committee, administrative position in the College of Arts and Sciences, and departmental liaison for mathematics placement. The narrative that follows is a compilation of the notes and the lived experiences of the four authors of the paper.

In addition, the first two authors conducted a review of many different types of records. This included examining sources directly related to the courses under study: grades (i.e., pass rates, failure rates, and withdrawals), materials (i.e., syllabi, textbooks and active learning workbooks), and enrollments. This also involved a review of other sources that impacted the number and types of students and their experiences in the course under study: admissions and placement systems, numbers of incoming freshmen, and Math Center attendance. Finally, there was also a review of other pertinent documents, including academic program reviews for the department and grant progress reports (related to internal and external funding that impacted the courses) filed by the principal investigators and the external evaluation reports filed after site visits by those not associated with the university.

Narrative of the Findings

A holistic analysis of the case (Cresswell, 1998) was used in order to structure the findings that follow into a narrative describing: a) the problem and context, b) how key issues were addressed, and c) the lessons learned. Weisbord's six-box model is also interwoven throughout the narrative in italics, highlighting the "boxes" of organization and change at OU.

Unfreezing: Problem and Context

Context. OU is a public research university. In Fall 2018 the main campus had almost 24,000 students, of which almost 20,000 were undergraduates. Each year OU historically accepts around 4,000 first-time, full-time freshmen, over half coming from schools in Oklahoma and over a quarter from schools in Texas. About 58% of the student body identify as white, 33% identify as a minority group, and 7% are international.

There are four math pathways at OU; STEM students typically enroll in College Algebra (CA), Precalculus and Trigonometry (PC) or Calculus 1 (C1) courses since arts, business, humanities, social science, and other majors are served by different math courses. About 25% of the incoming cohort of freshmen enroll in CA, PC and or C1 courses in the fall of their first semester. Over 67% of the students in C1 are engineering majors, 22% are other science majors, and 1% are mathematics majors.

Problem. While many of the motivating factors relate to all first-year mathematics classes at OU, for this study we primarily focus on the CA-PC- C1 three-course sequence that comprises the STEM math pathway. Some of the factors, such as ongoing challenges with the Oklahoma K-12 educational system (OSSBA, 2016), were outside the control of OU personnel. However, a number of factors deemed within our+ control helped those in *leadership* (i.e., departmental administration and upper administration) as well as those teaching these courses see the need for "unfreezing" the situation. For upper administration, one problem was the low pass rates, since success in a freshman math course had been deemed vital to OU student retention. For those teaching more advanced mathematics classes and classes outside of the department for which CA, PC and C1 were prerequisites, problems arose when students entered their courses without the requisite, expected mathematical knowledge. For the department Chair, one significant problem was dealing with student frustration when they had wildly varying experiences based on their assigned instructors. Two problems cited by instructors were having disengaged students who felt they had already covered the material and having wide variability in the mathematical understanding of the students enrolled in their courses. Each problem listed was related, and, as a whole, all could be tied to a single *purpose*: to improve the teaching and learning in the STEM math pathway. This dovetailed with the upper administration's desire to have fewer D/F/W grades.

Looking at the *mechanisms* in place, the department deemed there was a need for: a) a system that allowed more time, resources, and effort to prioritize first-year mathematics classes, b) course offerings that take students' previous experiences and current needs into account, c) improved teaching in the CA, PC and C1 courses, and d) redesigning key courses to positively impact students' experiences, learning, and preparation for future STEM courses.

Changing: Addressing Key Issues

The *structure* for accomplishing the purpose of improved student success in the STEM (CA-PC-C1) track involved a number of key activities, largely motivated by our+ perceived gaps when reading the recommendations from (Bressoud et al., 2015). Seven key efforts are now outlined in more detail.

Creating a First-Year Math program. In 2015, the department, under pressure from upper administration, proposed new *leadership* over the courses primarily taken by first-year students. The creation of the First-Year Mathematics (FYM) program required the approval and funding *mechanisms* from upper administration to hold a successful external search. A primary component of the proposal for the FYM program detailed a Director who would be a tenured faculty member with administrative experience. These criteria were motivated by the necessary *relationships* required within and outside the department. The Director would report to and work very closely with the department Chair, as well as serve as a contact person for other OU administrators on issues related to FYM courses and instruction. The Director's *leadership* role would involve serving as the FYM point person, including assessing and improving the courses that many tenured and tenure-track (T/TT) faculty typically overlook. The Director, by virtue of being a tenured professor would have status among T/TT faculty.

Since the directorship was a top-down *mechanism*, some faculty members were initially resistant to the entire FYM idea, and thus the *relationship* between those in FYM program and the rest of the department was crucial. The Director's position as a tenured, full professor has been fundamental to her status in the department. Initial concern about FYM disproportionately acquiring resources has subsided substantially as T/TT faculty see that the FYM program is not trying to act as a separate entity, but rather as a subset of the department. Through FYM efforts and deliberately open communication, mathematics faculty have come to recognize that the FYM program allows the mathematics department to better accomplish, monitor, document, and disseminate the department's many achievements, including carrying a heavy service burden.

Creating Renewable Term Faculty positions. A second part of the FYM proposal was to convert and *reward* five highly-valued long-time contingent instructors to longer-term, teaching-focused positions called Renewable Term Faculty (RTF) lines. These positions are not ranked, but have contract terms from 3-5 years. In the new *structure*, the RTF would report to the FYM director. This too required approval from upper administration who were enthusiastic supporters. One obstacle from the T/TT faculty involved concerns about whether such positions would reduce the chance for tenure lines. We+ found a *structural* compromise that the RTF would only teach FYM courses. The creation of RTF *mechanism* gave those individuals work stability, which allowed them to focus more on their own teaching and service within the department.

These positions also facilitated a *leadership structure* that includes a dedicated coordinator for each FYM course and more cohesive coordination in CA and PC. RTF attend department faculty meetings, serve on departmental committees, and have their own leadership council for coordinators. Thus, they develop *relationships* between themselves and T/TT faculty. As of Spring 2019, we+ have 9 RTF members. Given that these positions are fairly unusual at OU, there is remaining work to be done on related *mechanisms* (e.g., RTF evaluation criteria and voting privileges at department meetings).

Incorporating active learning in the PC and C1 courses. The move toward active learning (AL) required a funding *mechanism*, as well as administrative support, to unfreeze status quo instructional methods. In May 2015, the department was awarded a competitive internal grant from OU's Course Innovation Program. The proposal was to revamp the PC course using evidence-based research to guide the approach. A team of T/TT faculty and RTF spent the 2015-16 academic year clarifying the goals and developing the intervention. The team studied research articles, consulted with the OU Center for Teaching Excellence, examined course content, visited peer institutions undergoing similar reforms, and invited guests to visit OU. Strongly motivated by the University of Michigan, the University of Nebraska, and Arizona State University, we+ developed a pilot course that relied heavily on students working in groups on a uniform workbook, with very short lectures interspersed during the class time. We+ included undergraduate Learning Assistants (LAs) as part of the *structure*, to assist the instructor (TA, RTF, or contingent faculty member) in guiding the groups.

One crucial *relationship* in designing this project was the connection with T/TT faculty. The PC course is not taught by tenure-stream faculty members; yet, any lasting change must have their proactive support. The design team therefore included five T/TT faculty members. Funds from the grant were used to *reward* team members with summer-participation salary and travel funds.

The AL initiative expanded in 2018 with funding from an Association of Public and Land Grant Universities' SEMINAL, which stands for *Student Engagement in Mathematics through an Institutional Network for Active Learning*, Phase 2 grant. This funding and networking has been the *mechanism* for extending AL to the C1 course. A team of 14 T/TT faculty, RTF, and graduate students gathered for a one-week work session in Summer 2018 to create AL modules for each section of our C1 textbook (Stewart, 2016). These modules were piloted in several courses during the 2018-19 academic year. A second work session will occur in Summer 2019 to fill in some gaps and begin creating modules for Calculus 2. Given the different pool of instructors (which for this course often includes T/TT faculty), their varying *relationships* with the FYM program, and only loose coordination of the course (to have a common final), we+ will face the challenge of encouraging, but not mandating, the use of these modules. As we+ shift toward full coordination in C1, we+ envision the use of the AL modules becoming the default *structure* in CA while full coordination and use of AL modules eventually becoming part of the Calculus 2 course *structure*.

Extending TA training. A second component of the internal Course Innovation Program grant was the *structural* enhancement of our+ graduate Teaching Assistant (TA) training. The training primarily focuses on TAs serving as course instructors and discussion leaders, but also includes sessions on tutoring, exam proctoring, and grading. We+ developed training offered to incoming TAs in Fall 2015. Over the following four years, we+ gradually added sessions involving collaborative learning, active learning, growth mindset, and working with diverse groups for the more experienced graduate instructors scheduled to teach PC. The training, which is held during the two weeks before each fall term, now consists of two partially overlapping streams of sessions for the: a) new cohort of incoming TAs and b) the graduate student instructors and undergraduate Learning Assistants (LAs) involved in courses with AL components. This effort was supported by the administration as a step to improve student success rates, while the department approved the effort to help our+ TAs become proficient instructors. The bonds formed by the TAs during the first year benefit them throughout their graduate careers. So, in addition to the two-week training, the new cohort of incoming TAs share a communal office adjacent to the department's offices to help foster peer *relationships*.

Another *structural* change is that all incoming language-qualified TAs are assigned as C1 discussion leaders and serve as tutors in the calculus area of the Math Center. The TAs meet biweekly with the FYM Director and the C1 coordinator to discuss the C1 course and other issues; they also have Math Center training to refresh their content knowledge across the coursework covered by the Math Center. Once TAs have completed a semester as a discussion leader, each TA discusses with the C1 coordinator and the FYM Director whether he or she should spend another semester as a discussion leader or move on to become an instructor of record, typically in the CA course.

Improving mathematics placement. As observed in the MAA Calculus study, student success in the first college-level mathematics course is closely tied to the *mechanism* of placement into an appropriate first mathematics course (Bressoud et al., 2015). In response to the administration's focus on retention, the departmental Undergraduate Committee requested that OU switch from using the ACT-Math subscore for initial placement and the COMPASS test for those desiring alternate placement. We+ recommended the nationally vetted (McGraw-Hill, 2015; Reddy & Harper, 2013) and research-based (Doignon & Falmagne, 1999) system ALEKS-PPL; use of this system began at OU in Spring 2016. After three semesters, we+ discovered students were increasingly using inappropriate resources when completing the unproctored assessment. In Fall 2018, we+ switched to a proctored format. Our+ data demonstrate increased student success using ALEKS-PPL, particularly with the proctored assessment. The added effort of proctoring, however, put strain on OU's admissions and advising *structures*. The central administration made the decision to switch to a multiple measures model that uses existing measures for the initial placement, with proctored ALEKS-PPL for those desiring alternate placement. The availability of the secondary option was greatly influenced by the *relationships* that had been forged between the math department and the admissions/advising units. We+ will continue to collect data on student success, both in student's original placement and in subsequent courses.

Accessing information for data-driven decisions. With so many changes happening in the department, keeping track of relevant data was crucial. In the FYM proposal, the department emphasized the need for continuous access to institutional data regarding students in mathematics courses. Without this *mechanism*, we+ would be unable to assess the changes proposed or to report our+ findings to the administration. This request was met by allowing direct departmental access to the College of Arts and Sciences staff member who holds the access license. The first two authors meet regularly with this staff member to obtain and analyze relevant data; this *relationship* is one of the crucial driving forces to making change in the FYM program. Each summer, we+ compile a document called the "Fact Book," holding enrollment, grade distributions, and major distribution for all math courses. The book also reports on success between sequential courses (e.g., C1 success of "A" students from PC as compared to "B" or "C" students). Other projects include tracking results as we+ modify the math placement system, quantifying the influence of the Math Center, and collaborating with the College of Engineering to track student success in courses outside of mathematics. Overall, the access to data allows us to articulate *purpose* for future requests, gather information for grant proposals, and use data in making curricular and *structural* decisions.

Piloting successful fast-track and corequisite courses. A newer initiative that has grown out of the FYM *leadership*, *relationships*, and data accumulated over the last five years is the development of courses in response to the *purpose* and needs of our+ client disciplines and the administration. In Fall 2018, when an increased number of students were placed in developmental (non-credit-bearing, remedial) mathematics courses, we+ created CA sections for students near the placement cutoff score that included two hours per week of supplemental instruction lead by undergraduate LAs. Students in these corequisite CA courses performed as well or better than students in the traditional sections. In Spring 2019, we+ piloted "fast-track" sequences that meet five days a week and, thereby, allow students to take two consecutive required math courses in the same semester. This allows students in STEM to catch up with their peers if they were placed below C1 or had an unsuccessful first attempt. For example, an engineering major could take PC during the first half of the term and C1 in the second half, and then be on track with the recommended schedule for the major. We+ have piloted two such sequences with extremely positive results for the PC-C1 track and will continue pilots in Fall 2019. These courses enhance our+ *relationships* with other science and engineering units and with the administration *leadership*, while also providing greater *structural* variety in the ways students fulfill math requirements. The courses were developed and piloted by the FYM Director and the appropriate course coordinators. Our+ access to data enabled us to identify the best courses to include in pilots and to readily assess student success.

Framing changes in light of national recommendations. Table 1 provides a snapshot of some of the changes in CA, PC and C1 over the last five years. The seven recommendations for calculus courses (Bressoud, Mesa & Rasmussen, 2015) are used to highlight just some of the changes that have occurred in OU's STEM pathway.

Table 1.
Overview of changes in initial mathematics courses in STEM pathway at OU

7 recommendations	2014	2019 (Present)
1. Regular collection, use of local data	Some by administration with limited communication to department	• Monthly data meetings with members of College of Arts and Sciences, College of Engineering and Department of Mathematics • Access to dedicated statistics expert in the College of Arts and Sciences • Creation of an annual department fact book (with statistics for all classes) for upper administration
2. Effective placement system	ACT score used with COMPASS multiple choice tool for students dissatisfied with initial placement	• Multiple measure math placement with ALEKS testing and instructional modules available for students dissatisfied with initial placement

3. Effective course coordination	Loose coordination (common textbook, general syllabus outline, problem sets, exams) in CA and PC. No coordination in C1.	• Full coordination of CA, PC and full coordination to start in C1 in Fall 2019 involving: common textbook, common syllabus, weekly instructor meetings, common exams, sequence of observations for new instructors
4. Challenging courses that engage students mathematically	No method to monitor this	• Consideration of student pass rates in STEM courses for which CA, PC and C1 serve as prerequisites (to track rigor of courses)
5. Student-centered instructional methods	No method to monitor this	• Active-learning tasks and instructional guidebooks used in CA, PC • Piloting Active Learning tasks and workbooks in C1
6. Robust TA development program	1.5-day orientation and 1-credit instructional development course in fall semester	• 2-week training session for new cohort of graduate students • Cohort teaching model • Biweekly, content-specific meetings with new cohort for entire first semester (reducing student course fees)
7. Proactive student support services (e.g., tutoring centers, services for first-generation students) that foster students' academic and social integration	Math Center offered tutoring to students in courses through the calculus sequence, small room and limited hours, staffed only by graduate students working as tutors with department secretary loosely overseeing the space.	• Math Center open to many math courses and all FYM • Math Center Director hired • 1-hour/week Math Center requirement for all CA and PC students with less than B average • OU efforts for social integration outside of mathematics department including "camp" for incoming students, gateway courses and bridge programs for at-risk students, and more holistic mentoring programs

Refreezing (and still Changing): Lessons Learned

Looking at the above changes, one could reasonably state that the department is still changing, with many aspects still in flux, including the new placement system and inclusion of AL tasks for C1. However, there are aspects that have been refrozen and have had influence and consequences beyond our+ changes. The inclusion of AL in the PC course has TAs, RTF and T/TT faculty considering how they can incorporate AL in their assigned courses. The TA training is refrozen into two weeks, which is a drastic improvement over the 1.5 days previously allocated. This timeline allows us to change and be flexible about certain training modules inside the two weeks.

There are some difficulties and lessons learned from what has been accomplished and is still in the works at OU that can be of benefit to other mathematics departments. Data-informed decisions only happen if data are collected, analyzed, and communicated in a timely fashion with the right leadership. However, this is often a time-intensive task, and changes in admissions/placement systems make it difficult to do cross-year analyses.

Increasing first-time, full-time incoming freshmen enrollments from 3,724 to 4,473 between the 2010-11 and 2018-2019 academic years, but having static or decreasing human and financial resources led to departmental shifts towards larger-enrollment courses. For example, using AL instructional methods and holding course enrollment in the AL classes to around 30 students has created tension between these smaller courses and those courses not implementing AL that have been forced to larger lecture formats. When financial and human resources are scarce, communication and transparency of efforts across all those impacted, both within the department (e.g., T/TT faculty, TAs, RTF) and outside (e.g., College of Engineering, admissions/placement units) is of utmost importance to maintain trusting relationships.

Conclusions

The mathematics department at OU has gone through several different changes that required unfreezing, change actions, and refreezing the most effective efforts. The *purpose* was to improve student experience and retention, but to do it in a way that was both research-based and mathematically rigorous. Some of those changes required considering the existing departmental *structure*, including creating renewable-term faculty positions and committing to active learning in the Precalculus and Trigonometry course. These changes could not have happened without *mechanisms* like the internal and external funding received. The *relationships* within and outside of the department have strengthened; tenured and tenure-track faculty were involved with efforts (some with *rewards* given), and the First-Year Math Director, along with renewable-term faculty, have continued to study the impact of changes in different courses. This happened with departmental *leadership* and upper administration committing to and continuing to pursue a common *purpose*: student success in the STEM mathematics pathway. OU's changes are one example of a department willing to unfreeze in order to better serve the university as a whole.

References

Ahlgren Reddy, A., & Harper, M. (2013) Mathematics placement at the University of Illinois, *PRIMUS*, 23(8), 683-702.

Apkarian, N., Bressoud, D., Rasmussen, C., Ellis, J., Larsen, S., Braddy, L., & Johnson, E. (2016). Progress through Calculus: National survey summary. Retrieved May 28, 2019 from http://www.maa.org/sites/default/files/pdf/PtC%20Survey%20Report.pdf

Apkarian, N., Bowers, J., O'Sullivan, M. E., & Rasmussen, C. (2018). A case study of change in the teaching and learning of precalculus to calculus 2: What we are doing with what we have. *PRIMUS*, *28*(6), 528-549.

Bressoud, D. (2015). Insights from the MAA national study of college calculus. *Mathematics Teacher*, *109*(3), 178-185.

Bressoud, D., Camp, D., & Teague, D. (2013). *Background to the MAA/NCTM statement on calculus*. Washington, DC: MAA Press.

Bressoud, D., Mesa, V., & Rasmussen, C. (Eds.). (2015). *Insights and recommendations from the MAA national study of college calculus*. Washington, DC: MAA Press.

Burnes, B. (2004). Kurt Lewin and the planned approach to change: A re-appraisal. *Journal of Management studies*, *41*(6), 977-1002.

Cresswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five traditions, 2nd ed*. Thousand Oaks, CA: Sage.

Doignon, J.-P. & Falmagne, J.-C. (1999). *Knowledge spaces.* Berlin, Germany: Springer-Verlag.

Hayward, C. N., Kogan, M., & Laursen, S. L. (2016). Facilitating instructor adoption of inquiry-based learning in college mathematics. *International Journal of Research in Undergraduate Mathematics Education*, *2*(1), 59-82.

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.

Lewin, K. (1943). Problems of research in social psychology. In Cartwright, D. (Ed.) *Field Theory in Social Science* (pp. 155-169). London: Social Science Paperbacks.

Lewin, K. (1946). Action research and minority problems*. Journal of Social issues*, *2*(4), 34-46.

Lewin, K. (1947a). Frontiers in group dynamics: Concept, method and reality in social science; social equilibria and social change*. Human Relations*, 1(1), 5-41.

Lewin, K. (1947b). Group decision and social change. *Readings in Social Psychology*, *3*(1), 197-211.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

McGraw-Hill Education. (n.d.) *ALEKS, Case studies and research highlights*. Retrieved June 9, 2019 from https://www.aleks.com/highered/ppl/research_and_case_studies.

Oklahoma State School Boards Association. (n.d.). *Oklahoma schools struggle with teacher shortage despite cutbacks*. Retrieved June 9, 2019 from https://www.ossba.org/2016/08/22/oklahoma-schools-struggle-with-teacher-shortage-despite-cutbacks/.

Reamer, A. C., Ivy, J. S., Vila-Parrish, A. R., & Young, R. E. (2015). Understanding the evolution of mathematics performance in primary education and the implications for STEM learning: A Markovian approach. *Computers in Human Behavior*, *47*, 4-17.

Sadler, P., & Sonnert, G. (2018). The path to college calculus: The impact of high school mathematics coursework. *Journal for Research in Mathematics Education*, *49*(3), 292-329.

Schraeder, M. R., Pyzdrowski, L. J., & Miller, D. A. (2019). The impact of prior exposure to calculus. *American Journal of Educational Research*, *7*(3), 237-243.

Stewart, J. (2016). *Calculus., 8th Edition*. Boston, MA: Cengage Learning.

Thompson, P. W. (2013). In the absence of meaning…. In *Vital directions for mathematics education research* (pp. 57-93). Springer, New York, NY.

Voight, M., Apkarian, N., & Rasmussen, C. (2017). Diverging from the standard fare: Variations in the calculus curriculum. *MAA Focus*, *37*(1), 32-34.

Weisbord, M. R. (1976). Organizational diagnosis: Six places to look for trouble with or without a theory. *Group & Organization Studies, 1*(4), 430-447.

Wieschenberg, A. A. (1994). Overcoming conditioned helplessness in mathematics. *College Teaching*, *42*(2), 51-54.