

Transcending Industrial Era Paradigms: Exploring Together the Meaning of Academic Leadership for Diversity

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Transcending industrial era paradigms: Learning together for diversity

Abstract

This poster describes findings from a transdisciplinary freshman learning initiative involving four cohorts from 2012 to 2015 with over 200 freshmen students from 59 different majors in partnership with over 30 community agencies and 20 faculty members from 5 colleges at California Polytechnic State University, San Luis Obispo. Although the outcomes of the initiative indicated success, the activities proved difficult for our university to support. The stated reasons included assertions of lack of efficiency and suspicion of the pedagogical methods. We have come to believe that this systemic intolerance for differences is the same dynamic that produces the persistent lack of diversity in STEM (traditionally defined as the physical sciences, technology, engineering, and math). We know other STEM change agents are struggling with these same forces that preserve past methods, approaches, and values. The common view in STEM education is that the systemic lack of diversity is a problem that needs to be fixed, rather than a predictable, normal outcome of the current system's functioning. But from the point of view of systems thinking, the symptoms and patterns of exclusion in STEM education are rooted in the assumed and unexamined values and paradigms of the system's architects. We, the administrators, faculty, staff and participants, create and uphold the structures, policies, and practices that produce inequity. Instead of leading for diversity, we lead by the exertion of force and control in order to achieve "efficiency" and maintain a specifically non-diverse institutional identity in service to preserving "market advantage." We value and develop "economies of scale", which require homogeneous thinking, action, and results—none of which support diversity of structure, thinking, action, and outcomes. To realize diversity, our paradigm must shift from an imbalanced prioritization of traditional capitalist values, such as economy of scale (one-dimensional thinking and efficiency) to economies of scope, inherently diverse in structure, thought, and action. Diversity almost certainly means a great deal of tolerance and cooperative capacity. This includes embracing conflict, ambiguity, uncertainty, and paradox, all of which are more or less antithetical to economies of scale, the academic currency of expertise, legacy definitions of efficiency, and the objectivism foundational to STEM epistemologies. Transcending these industrial era paradigms and values is required to foster diversity in higher education institutions.

Introduction

The National Science Foundation calls for reform in science, technology, engineering and math (STEM) higher education ask researchers to address two persistent, apparent problems (AP):

AP:Scale. The failure for STEM learning innovations to be adopted at large scale;

AP:Diversity. The failure of STEM education to achieve outcomes of diversity.

Within AP:Scale the granting agencies are asking why aren't research-based practices in STEM education being adopted across the higher education system? Why aren't faculty more often using evidence-based practices such as active learning in the classroom? Why aren't proven artifacts for learning shared more widely? STEM outcomes of diversity are understood as graduating cohorts that duplicate the societal population distribution of individuals who identify in categories of racial, ethnic and gender identity. Questions in this realm include why are a

disproportionate amount of Latinos dropping out of engineering schools? Why are women still a relatively small percentage of the STEM population? Another way to state these apparent problem is that AP:Scale is the inability of the STEM higher educational system to learn from itself, and AP:Diversity is the STEM higher education system producing stable homogeneous outcomes over time.

Embedded in these two apparent problems is the understanding that “STEM” refers exclusively to disciplines that share common assumptions: the nature of reality; what constitutes verifiable knowledge; and legitimate methods for deriving verifiable knowledge. In short, “STEM” includes only the epistemic assumptions of what is called objectivist science.

Decades of research have brought the STEM community to some common views about these apparent problems. Current theories of AP:Scale are that it could be solved if innovation developers’ had sufficient understanding about the nature of organizational change¹, or if changes were radical enough, “transformative,” then change could be sustained. Regarding AP:Diversity, a commonly-held belief is that underrepresented groups enter college deficient in their preparation². Remedial programs seek to “fix” this apparent problem. Another model advocates diversity in STEM faculty hires. These models share the assumption that the apparent problem beneath AP:Diversity can be remedied by changing the numbers of individuals from underrepresented groups. Culturally-responsive teaching, advocated by Gay³ shows promise as a systemic solution, yet ironically AP:Scale undermines the possibility of systemic uptake of this potentially promising practice.

We propose an alternative explanation for apparent problems of “Diversity” and “Scale” that is based on the premise that the STEM higher education is a dynamic system. Explicitly, a dynamic system is a socially-constructed concept defined by the recursive interaction between what one might call the “parts” of the system; in this case, they are historical events, society, institutions, families, students, staff, and faculty. One sorts out what is “in” or “out” of the system, i.e., the “boundary”, by a shared set of goals. For example, a stated goal around both AP:Scale and AP:Diversity is in preparing an informed citizenship in a technological world⁴ or in addressing societal challenges⁵.

Hypothesis: AP:Scale and AP:Diversity are unintentional consequences of a STEM education *system* perfectly functioning as designed by the system’s architects. That is, the STEM education *system* is socially constructed; preserving this STEM *system* from within the shared paradigms of STEM causes the apparent problems.

In order to realize different systemic outcomes, it is required that we, the architects and guardians of STEM disciplines, transcend our invisibly-held and unexamined STEM paradigms to make conscious, alternative choices. We derived this insight through action research⁶, rather than through the use of the reductionist science methods typical of STEM. In this paper, we describe the context of these insights, the insights and their theoretical basis, and the implications for faculty.

Context for our inquiry: Institutional exclusive excellence

The institutional context of this action research was a comprehensive undergraduate institution in the Western United States, California Polytechnic State University, San Luis Obispo (Cal Poly). Cal Poly's many successes have created a traditional culture of exclusive excellence. Like many "successful" universities, entry and graduation highly favor those who have a wealth of historical advantages--this is particularly true for what is traditionally called "STEM"--Science, Technology, Engineering, and Math. These exclusive dynamics show up as gaps in access (Figure 1) as well as an apparent "achievement gap" with respect to students who are traditionally underrepresented in STEM and other majors (Figure 2). At Cal Poly, this picture looks as shown in Figures 1 and 2, where the gaps are largest in engineering: underrepresented groups (URGs) make up less than 20% of the freshman class and graduate at rates 12% less than their non-UGR peers.

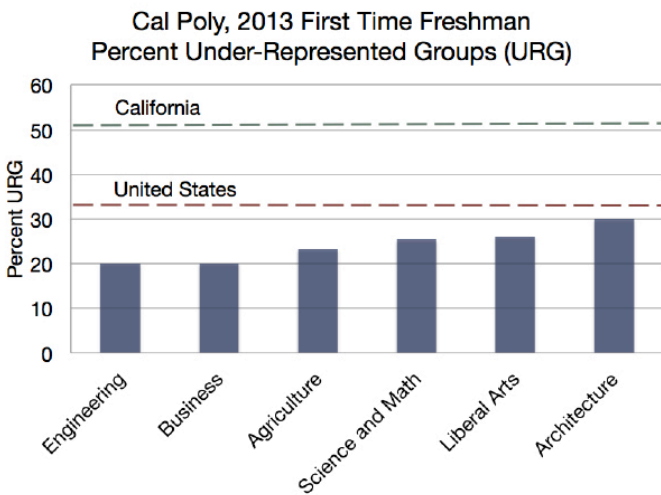


Figure 1: Access gap at Cal Poly. Underrepresented groups (URG) include Hispanic/Latinos, African American, Hawaiian/Pacific Islanders, Native Americans, and Multiple Races. URG comprise a disproportionately low fraction of the freshman classes relative to their population in California and the United States. Access gap is largest for engineering (Sources: Cal Poly's Fall 2013 Factbook and 2010 US census)

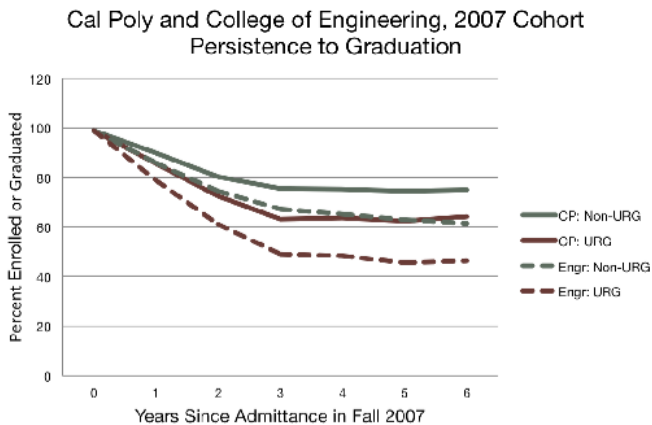


Figure 2: Achievement gap. The so-called "achievement gap" is illustrated through gaps in the rates of persistence to graduation. The 2007 freshman cohort shows a typical trend where the URG persistence rate is less than the non-URG rate by 12-15%. (Source: CP institutional Research data on persistence in Zimbra Briefcase, December 2013)

Within this context, we began an integrated freshman experience, SUSTAIN, in 2012. The initiative spanned two quarters where students took general education courses together, worked on community-based projects and had weekly dialogues. In addition, the faculty who were teaching the courses met together for at least two hours per week. This time together allowed us, the faculty, to increase our capacity to purposefully choose actions and dispositions in the classroom. The support provided in these

meetings was invaluable as we transitioned to more integrated self-direct learning for students and faculty. Through this learning initiative, the faculty built the capacity to reflect and examine assumptions. We also believe that an important part of this experiment was the availability of the student community voice as feedback to the faculty.

Students took between half and three-quarters of their course load with faculty who taught pre-existing general education courses. The difference for the students was that they took courses with a cohort and that faculty attempted to integrate content across disciplines. Courses included English, communications, humanities (ethnic studies, history, sociology), STEM (physics, biology, and engineering). Students also worked with a community partner on a project in San Luis Obispo County. The projects were sometimes integrated into the course topics but existed outside the traditional education system.

There were four cohorts of students and, to date, they are achieving institutional outcomes at the same level as a matching cohort of students (Table 1). In addition, the students report “1) increased capacity for personal reflection, 2) a new sense of ownership in education, 3) a discovery of internal motivation and the joy of learning, and 4) deepened friendships that led to an increased capacity for collaboration and risk taking and an increased sense of support and resilience.”⁷

Below is data for the four cohorts of SUSTAIN and a cohort of matching students (matched on gender, year, and major) as of June 2015. For the most part, the institutional measures indicate that SUSTAIN students are the same as the matching cohort of students. There are several exceptions:

- 2013, 2014 and 2015 SUSTAIN cohorts have higher grades than the matching cohort.
- The 2012 cohort students had almost twice as many students with minors than the matching cohort.
- The students in the 2014 cohort of SUSTAIN changed majors at a greater rate than the matching cohort.

Cohort		2012 (n=43)	2013 (n=41)	2014 (n=61)	2015 (n=62)
Years completed June 2015		4	3	2	1
GPA	SUSTAIN	3.056	3.136	3.171	3.213
	Matching	3.002	2.896	2.931	2.979
	Difference	0.054	0.240*	0.240*	0.234*
Units completed	SUSTAIN	187	143	116	75
	Matching	192	149	106	75
	Difference	-5	-6	10	0
Percent of students with a minor	SUSTAIN	40%	29%	15%	2%
	Matching	19%	21%	10%	2%
	Difference	21%*	8%	5%	0%
Percent of students changing majors	SUSTAIN	30%	26%	31%	21%
	Matching	26%	31%	16%	17%
	Difference	4%	-5%	14%*	4%

Table 1: Institutional measure of student success: SUSTAIN and matching cohorts. Students who self-selected into the SUSTAIN learning initiative show very similar levels of achievement when measured on traditional institutional outcomes
* Significant at p=0.05

As we inquired together in the SUSTAIN learning initiative we endeavored to use participatory action research (PAR) methodology as this disposition can accommodate all scientific frames. PAR is essentially a community-based and practice-based inquiry that involves practitioners as both subjects and co-researchers; it holistically includes all ways of knowing (positivist, constructivist and emancipatory). Like action research, PAR is grounded in a practice of collaborative, on-going inquiry, experimentation, and change⁶. Its primary intent is achieving the intended positive social change. PAR represents the core capacity for resilience and adaptation. Additionally, without a disposition of co-learning, faculty only consider what students should learn and neglect their own learning development; co-learning puts faculty in solidarity with students as learners. An added benefit of student-faculty co-learning relationships is that they foster a culture of inclusiveness⁸. Many of the insights gained were possible because of this open, emergent method.

Findings: Iceberg analogy of the STEM education system

While the data on persistence and graduation rates of URG is undeniable, focusing on the “student” trends displaces attention from these deeper systemic issues that produce these trends. For example, a side effect of a “traditional” culture is the predominance of the time-honored lecture modality of teaching, particularly in STEM disciplines at Cal Poly^{9, 10}. How might the problematic “student” trends in STEM (AP:Diversity) be intertwined with the persistence of traditional STEM teaching (AP:Scale)? Might it be that URG are disproportionately disadvantaged in this traditional system? As we conceptualized the STEM higher education system as a complex, dynamic sociopolitical system it gave us insight toward the source and disruption of apparent problems of “Scale” and “Diversity”.

A dynamic system is one in which there is a recursive interaction over time between the “parts” of the system; the process of identifying the “parts” consists of grouping elements by a set of shared goals. In STEM, a commonly-held goal of addressing apparent problems of “Scale” and “Diversity” is that we must maintain a perceived national (U.S.) economic advantage in a technologically and ethnically diverse world. In systems theory, the problematized phenomena of a dynamic system result from the collective action of the system over time. That is, the apparent problems of lack of learning and lack of diversity are outcomes of a system functioning as designed rather than something “going wrong.” Specifically, the interactions of individuals and groups of people who share the same goals, aggregate to produce the systems’ culture. This culture functions to maintain itself over time. Stated hyperbolically, we in STEM are maintaining the status quo by rejecting advances in learning and eliminating diversity.

The anthropologist Edward Hall^{11, 12} asserted that cultures are produced by the systemic actions derived from shared beliefs, values, and interests. He compared culture to the dynamic interaction between an iceberg and the water in which it is floating. This dynamic interaction produces what we call “the tip of the iceberg”—a metaphor that indicates that one is seeing a small portion of something much larger. As depicted in Figure 3, the visible tip is like the systemic outcomes and represents about 10% of the iceberg; the 90% that lies beneath the surface contains the structure that interacts with the surrounding water to produce the “problem” of the tip. In the case of ice, the structure of a water molecule is such that, upon freezing from

the liquid state, the molecules align so that the volume of the solid (ice) is larger by about 10% than the volume of the water that created the ice. As a result, the 10% additional volume (“the tip”) emerges from the water surface. Because the structure of the molecule is consistent from molecule to molecule, we can replace all the water molecules of a particular iceberg and get the same phenomenon of the tip. We could even physically remove the 10% of volume above the water’s surface and the tip would be recreated through the dynamic interaction of the remaining ice and the surrounding water; the tip is “cooked into” the invisible structure. That is, the invisible structure determines systemic behavior.

In a similar way, thought structures within a culture--beliefs, values, and paradigms--are invisibly held by those within the system and determine the behavior of the system. The STEM system’s agents create the institutional structures, policies, and practices consistent with their existing beliefs, values, and paradigms, which occur as “given.” As illustrated in Figure 3, these socially-constructed institutional structures then create patterns of behavior which lead to the visible outcomes, analogous to the “tip” of the iceberg.

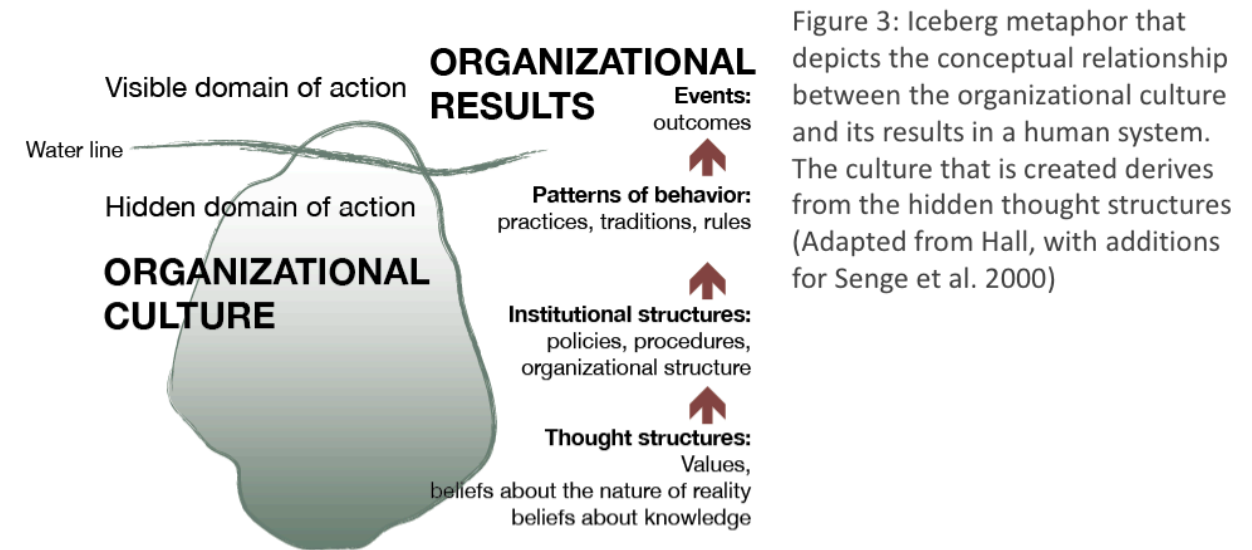


Figure 3: Iceberg metaphor that depicts the conceptual relationship between the organizational culture and its results in a human system. The culture that is created derives from the hidden thought structures (Adapted from Hall, with additions for Senge et al. 2000)

As a small example of the persistence of the structure from the SUSTAIN learning initiative, we removed any requirement for attendance from our weekly dialogues and predictably not everyone showed up. There was no credit associated with the dialogues and we were explicit about each participant’s autonomy. This became a consistent point of discussion for those who did attend. These discussions began with methods of “fixing” the attendance problem often in the form of rewards (food) or punishments (exclusion from the group). This dynamic, from undefined expectation to problem to extrinsic motivation for participation, is the persistent structure of the education system even though we were explicitly attempting to behave differently. As we, the faculty and students, began to recognize the structure we could let go of the problem and the solutions. However, this “letting go” had to occur repeatedly (almost weekly) as the issue continued to be bothersome to many of us.

What are the cultural beliefs, values, and paradigms that are causing the problems of intransigent STEM pedagogies that result in STEM cultures that are exclusive? We first note that “S” refers

to the physical, or equivalently, the natural sciences; it excludes all other organized ways of thinking, or “sciences.” Implicitly, natural sciences are prioritized over other “sciences.”

The natural sciences derive knowledge through what are believed to be objective observations and measurements. In this process, the observed is believed to be held separate from the observer (an “object”) such that observations are distinct and unaffected by the observer; observations are also presumed to represent the observable, “universal truth,” rather than acknowledging anything about the observer’s choice of what to observe, how to observe it, or the socially constructed assumptions within the “scientific” frames of reference. Simply put, the natural sciences often hold a right/wrong (simple) worldview, which is fit for limited yet important purposes.

The “laws” of natural science create STEM paradigms that are part of the thought structure that conditions the system and culture. For example, it is generally accepted that an object at rest or in motion will stay at rest or in motion unless acted upon by an external force. Simply put: change requires the use of force. The world is otherwise static. While this law produces useful, self-consistent mathematical models for manipulating physical objects, it is not really true in any literal sense; all of matter as we know it is in a constant state of flux, rather than stasis. However, holding this as a “law” has the consequence of limiting the solution set for social change to solutions that require external force. Some examples of these force based structures are that students will not learn without grades, faculty will not engage in professional development without a system of punishment and rewards, or to reach a goal one must lay out a step by step action plan. It is often impossible within this epistemology to entertain alternatives like the joy of learning, the internal desire to master a topic, or attending to an outcome manifests it.

This basic assumption of the necessity of force creates a set of methods. In objectivist science, the purpose is to understand natural mechanisms so that these can be generalized to like systems and manipulated for predictable outcomes, scalability. Because understanding comes through quantifying indicators, measurements and techniques must first be devised to enable quantification. These measurements are presumed to be accurate indicators of some naturally occurring parameter even though the parameter itself, along with the measurement techniques, are not naturally occurring but socially-constructed. Statistically sound measurements require that one eliminate all known sources of variation so that one can mathematically verify correlations between variables that can be manipulated and the response to those variables (lack of diversity). In other words, objectivist science seeks to reduce variation to a set of controllable conditions. What is often overlooked in reductionist, objectivist science is that the state of nature rarely mimics laboratory conditions, where all influential sources of variation are eliminated. This is particularly true when one is working in a complex, dynamic social system that includes human beings.

Within STEM cultures, these invisible thought structures (90% of the iceberg) are the basis for all visible actions (tip of the iceberg). The tendency to reduce and prioritize these quantitative parts of the “whole,”--natural science, engineering, math and technology--over the arts, humanities and social sciences is a cultural norm that is enacted in a myriad of ways: national policies to increase the number of “STEM” graduates (where S means “natural sciences” only); higher normative salaries for those in STEM-derived fields as seen in comparisons such as PayScale.com; STEM faculty and student cultural attitudes that “general education” is simply

something to get through, rather than an integral part of one’s education. Admittedly the trend to incorporate the “Arts” into STEM (“STEAM”) takes a step toward removing the socially-constructed separation of “STEM” and “non-STEM” fields.

In our transdisciplinary learning initiative, we began to see that connection between the two apparent problems and the STEM thought structure that was causal to the APs. These symptoms and their apparent STEM thought structures are summarized in Table 2. It’s important to note that we are not arguing that STEM is inherently bad or wrong, only that it is limiting the view of the world and the solution space for the problems of our time. We note that the positive intent of the STEM thought structures is to accurately preserve and advance the canons of science.

Table 2. Cal Poly systemic problems and their root causes.

Problems (symptoms)	Causal systemic STEM thought structures (hidden beliefs, values and paradigms)
STEM cultures that are <i>exclusive</i>	<ul style="list-style-type: none"> • The definition of Science in STEM excludes all organized studies (e.g., cultural sciences, critical sciences) but the natural sciences; • What counts as knowledge excludes all ways of knowing except what is believed to be objective measurement;
Intransigent STEM pedagogies	<ul style="list-style-type: none"> • The accurate preservation of STEM “laws,” methods and content knowledge is imperative; • Lecture is the most efficient way to deliver this content accurately and at scale; • Alternative approaches to learning STEM risk conceptual misunderstandings; • Delivery of authorized content by experts ensures the accurate transfer of scientific understanding.

What are the unintended consequences of prioritizing quantitative disciplines over qualitative? In the learning initiative, the tendency to prioritize the quantitative over the qualitative showed up repeatedly in faculty and student behavior around the value of teaching and learning STEM course content (Physics) over content that was apparently outside that (e.g., History, Women and Gender Studies, English, Communication Studies). Our dialogues together enabled us to see that we, the faculty and students, were socially constructing this hierarchy. What we noticed when we honored a greater balance across these fields, or when we began to question our actions together is that the qualitative social and critical sciences enable one to reflectively understand one’s self and values, to set goals and pursue passions. That is, the qualitative social and critical sciences provide the human development necessary to make meaning of learning the quantitative disciplines. The tendency to prioritize the natural sciences (and Technology, engineering, and Math) at the expense of these qualitative social and critical sciences drains the relevancy from learning what is traditionally called “STEM”. By excluding qualitative social and critical sciences from ones’ full developmental aims, we diminish the interest and ability to learn “STEM.” We also repel those who have interests beyond the traditional STEM foci; this well-known pattern in engineering causes students with broader human interests to leave engineering majors¹³. The system is structured to eliminate diversity of thought which, we believe, is also reflected in the elimination of diversity in gender, ethnicity and race.

Additionally, we encountered strong institutional efforts to conserve past practice and knowledge to the extent of creating institutional barriers to learning and teaching innovation. Our innovations were seen as so threatening, particularly to Engineering college colleagues, that the engineering faculty involved in these innovations became direct targets for adverse employment actions by a few institutional actors within the college. This is a pattern that we saw repeated not only at our institution but at others as well. When innovations attempt to include a totality of thinking and being, the rigor is questioned or the actions are vilified. This occurred even in the face of academic freedom and the supposed protections of the tenure system. In addition, several of the faculty in the learning initiative at Cal Poly were adjuncts and their vulnerability within the system was more pronounced.

Considering the problems in STEM education through this iceberg metaphor, no influx of students in STEM or implementation of “better” STEM pedagogical practices is likely to close the alleged achievement gap or result in scaled transformations in STEM pedagogies. These solutions address the symptoms; the problems are rooted in the systemic thought structures. Consequently, interventions that do not address the deep, underlying thought structures held by faculty and students are similar to removing the tip—they create a temporary apparent fix, but the “problem” will be reproduced through dynamic systemic forces. A classic example that we have seen repeatedly is when an instructor adopts a new teaching technique in the absence of considering his hidden assumptions, only to experience a “worse” outcome; the typical conclusion is that there is something wrong with the technique and which therefore deepens the instructor’s inability to make effective change. It is more likely that the structure and rules of his class, created from his unexamined thought structures, functioned to undermine the benefits of the new technique, rather than support it. In the end, these symptoms of intransigence in pedagogy and diversity are rooted in the invisibly held thought structures within STEM cultures. Therefore, in order to get a different result, one must address the STEM beliefs, values, and paradigms, a very difficult task indeed.

Implications for STEM faculty

If the STEM community desires to overcome apparent problems of diversity and scale in teaching and outcomes, we must address STEM beliefs, values, and paradigms. This requires a set of conditions that enables we, the STEM system participants, to see “ourselves.” Conceptually, seeing oneself requires a simple act of reflection and inquiry. However, self-reflection is vulnerable to distortions and limitations of the reflector’s existing thought structures; that is, an eye cannot see itself. The transdisciplinary context of our research functioned to extend individuals’ ability to see their thought structures. We often referred to this process as “capacity building”. This result follows Einstein’s principle that one cannot solve problems at the same level of thinking that created the problem. In this case, we must expand the boundaries of thinking beyond the traditional disciplines of STEM. This means broadening the “S” in STEM to include all the sciences. We included faculty and students from across the university which created a true diversity of thought.

Alternative sciences include complex worldviews that vitally complement the natural sciences. The term “science,” from Latin *scientia*, implies knowing; it refers to an organized inquiry. There are many sciences that approach the process of deriving knowledge with sets of

assumptions about the nature of reality that differ from those in STEM. Mingers¹⁴ provides a look at the range of sciences as indicated in the table below, where the natural sciences are contrasted with the critical sciences and social sciences (or, “the arts and humanities”). While some may argue with the accuracy or completeness of Mingers’ categorizations (e.g., some social sciences hold positivistic frames) it illustrates that each type of science has a use orientation and a set of assumptions about reality. We aim to value all perspectives.

Table 3: Types of science and their frames. After Mingers (1992)

Type of Science:	Natural	Social	Critical
Frame and habits of mind	Positivist	Hermeneutic, Constructivist	Emancipatory, Deconstructivist
Use orientation or interest	<i>Posits universal truths</i>	<i>Constructs meaning from patterns</i>	<i>Examines and evaluates latent assumptions</i>
Assumptions about reality (ontology)	<i>Technical:</i> Predictable outcome of practical skills for employment	<i>Practical/Meaning:</i> Intellectual development and practical skills for understanding	<i>Liberation*:</i> Enlightenment to enact conscious choices
Some practices derived from the science	Engineering, Western medicine	Education, counseling	Performing arts, spirituality

*Liberation indicates the process by which models and paradigms are revealed as such, introducing both consciousness and choice into aspects of the system where they were previously missing or artificially constrained.

An important quality of the positivist scientific frames (STEM) is that while they include scientific inquiry, they primarily extend the existing set of assumptions through instruction. In contrast, the critical sciences deconstruct.

In the context of our learning initiative we planned for two years before the first cohort launch in Winter of 2102. Part of this planning including developing principles by which we could weigh actions and decisions. Our first principle was an antidote to reductionism and all its unintended consequences: honor the whole. For us the whole included diverse ways of thinking, it also includes the needs of the institution for student success and fiscal responsibility.

Principle 1: Antidote to reductionism = holism

S in STEM holistically redefined:

Science = organized inquiry of emancipatory, constructivist or positivist frames (the arts, humanities, social and natural sciences).

whole-STEM = the arts, humanities, social and natural sciences, engineering, technology and math

To honor the whole in STEM education, we must also include the arts, humanities, and social sciences in an egalitarian way--we refer to this holistic frame as “whole STEM” (w-STEM). The w-STEM learning context makes transformative learning possible because it goes beyond instruction of skills and methods (positivist); learning dialogues that include the emancipatory frame of science interrogate hidden assumptions in ways not otherwise possible; additionally, constructivist learning contexts cultivate habits of creativity that are not emphasized in solely positivist approaches. This leads to our second strategic principle: the antidote to institutional inertia in STEM pedagogy is resilience.

Principle 2: Antidote to intransigence = resilience

resilience redefined:

Resilience = the capacity to foster well-being through continuous adaptation to change.

Resilience is the capacity to foster well-being through continuous adaptation. The distinguishing attribute of resilience is a state of innovation¹⁵: being able to conceive of change, collaboratively act on intentions, reflectively consider results and adapt. These attributes critically draw on holistic human development not often present in positivist science approaches.

The challenge of growing a culture of resilience in traditional STEM cultures is their prioritization on preserving time-honored (positivist) methods. This is not bad in itself, in fact, these methods are quite useful in some contexts, but emphasizing adherence to past methods does not foster the capacity to create and test methods that draw on constructivist and deconstructivist approaches. That is, STEM institutional inertia is cooked into the culture of STEM. This circular problem within STEM education can only be interrupted by “stepping out” of the STEM circle, so to speak, into w-STEM. This includes expanding ways of knowing to accommodate learning, diversity, and resilience.

However, in the absence of developing a capacity for resilience, faculty members from disciplines with varying epistemological traditions commonly talk past one another¹⁶. One might argue, e.g., that all STEM curricula “include” general education that includes “other” sciences. However, most institutions of higher education in the U.S. are optimized for “efficiency,” where disciplines are separate from one another in departments. These departments provide courses solely distinct from other disciplines, taught by faculty members who have been educated in traditional disciplinary systems.

The use of participatory action research was a critical component of this resilience. When we could set forth a theory and a plan for intervention while being sensitive to our own participation, we were able to recognize feedback in the system and adjust accordingly. We attempted to embrace flexibility and we could notice when this was not present in our instructional methods or even in the students. We found that these skillful means can only be developed in community. Through engaging in a shared community, assumptions and thinking can be revealed through a dialectic process in a safe and reflective environment that includes all points of view.

We have learned from SUSTAIN¹⁷ and our work with PAC, that there are three components that need to be in place in order to safely build resilience using high-impact practices: 1. A diverse

community of student learners who have autonomously chosen an alternative learning experience; 2. A developmental process for widely-interdisciplinary faculty teams to build the capacity to collaboratively teach and co-learn with the students; and 3. An institutional “place” for students and faculty to safely learn with high-impact practices.

Summary

We have framed two persistent apparent problems with STEM higher education as systemically produced through the shared worldviews within STEM cultures. These thought structures invisibly act to produce the STEM cultures that preserve and reproduce past practices and mindsets. The unintended consequence of such a replication is a systemic lack of diversity in all its forms. No amount of interventions using the same level of thinking that created the problems is likely to result in a sustained change in outcomes. Therefore, leading for diversity involves transcending our STEM thinking; disrupting these industrial era STEM paradigms. We argue that our attention has to be changed from economy of scale (one-dimensional thinking and efficiency) to economies of scope, inherently diverse in structure, thought, and action. Our transdisciplinary learning community setting proved to enable all participants to see their habituated thinking by providing a safe place to reflect and deconstruct invisibly-held assumptions.

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