THE NORMS AND VALUES OF STEM CULTURE: A FOUNDATION FOR SYSTEMIC CHANGE

Conversation Module 3

Presented by Archie Holmes at the meeting of the
Roundtable on Systemic Change in Undergraduate STEM Education
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WHO IS THIS MODULE FOR?

This module is for leaders of academic units (such as provosts, deans, and department chairs), as well as for faculty and staff in academic units with responsibility for student learning, student affairs and academic advising, and other academic support activities. The module provides guidance and resources to facilitate reflection and discussion about (a) how the culture in STEM academic units relates to student success and (b) ways to enhance or change aspects of the culture in academic units to more effectively support learners.

WHAT ARE THE KEY IDEAS IN THIS MODULE?

STEM innovation and the STEM workforce have produced important advances in scientific understanding and technology that have improved the quality of life for millions of people and that have greatly increased the nation's economic prosperity. Institutions of higher education in general, and STEM academic units in particular, deserve credit for this. For STEM education and research to continue to benefit society as it has in the past, the number of people who understand, appreciate, and work in STEM and STEM-related fields will need to increase (NASEM, 2025). However, many STEM departments and other units do not prioritize teaching (NASEM, 2020), and faculty attitudes and approaches are often based on their own experiences as graduate students and their perceived expectations of their disciplines, rather than on their considerations of the specific needs of their current students (Handelsmann, et al., 2022; Lee, et al., 2023).

This module explains how the nature of STEM culture impacts the extent to which students experience student-ready environments that support their learning. It also offers ideas for shifts that make the culture more supportive. For example, making academic units and institutions more welcoming and supportive of all students—that is, ensuring higher education institutions are "student-ready," as discussed in Module 4—is an important strategy for ensuring that the country, and the STEM workforce specifically, has the well-prepared citizens and employees it needs. Discussions about the goals for student learning and how well current offerings and major requirements match student needs also can shift a unit's culture towards being more student-ready and contribute to increased learning and students' completion of STEM courses and degrees (NASEM, 2025).

WHAT IS STEM ACADEMIC CULTURE?

While it may seem that culture is amorphous and difficult to shape or manage, an important first step is to define explicitly what culture is and how it can affect the experiences of students. Culture is composed of the implicit and explicit norms, values, beliefs, and assumptions that manifest in observable ways, such as behaviors, practices, and policies (Schein, 2016). Academic culture relates to the normative customs, behaviors, values, and beliefs that impact the lives of those who work, study, and interact within a discipline or academic unit of that discipline (Austin, 2011; 1994; Henderson, et al., 2011; Kezar, 2018; Reinholz et al., 2017; Reinholz et al., 2019). As individuals become part of an organization (such as an academic department), they perceive what is valued through the practices and policies they experience. In this chapter, we focus specifically on STEM culture and how it can influence student engagement, performance and persistence (NASEM, 2016).

For many years, STEM academic culture across fields has had some overarching common features: commitment to rigor, emphasis on the value of objectivity, and greater emphasis on research as compared to teaching. While these values historically have created fertile environments for research accomplishments, they have not necessarily fostered productive learning environments for all students. While these values are shared across STEM fields, each department's culture is also uniquely grounded in its own set of values and assumptions that emerge from both the institution and its discipline (Corbo, et al., 2016; Ngai, et al., 2020; Reinholz, et al., 2019). The culture experienced by students in STEM fields may be observed through recruiting and admissions processes, hiring policies and practices, instructional and grading practices, curriculum structure, and the non-academic support available, among many other ways.

HOW CAN KEY ELEMENTS OF STEM CULTURE BE REFRAMED TO BETTER SUPPORT STUDENT LEARNING?

Attracting and retaining students in STEM fields is an important strategy for ensuring a robust workforce and knowledgeable citizens. Yet sometimes aspects of the culture of a STEM discipline and department can undermine the quality of the learning environment. Identifying and modifying aspects of the culture that can undermine student success can help ensure that STEM academic culture supports the learning and success of all students.

Here are some examples of how elements of STEM culture may impact and undermine the ability of students from all backgrounds to thrive. Each example highlights an element of STEM culture that has had a positive impact on some aspects of doing science, but that can also sometimes diminish the quality of the learning environment for students. Each example also suggests a reframing of the STEM value in a way that can enrich the success of all learners:

- **Commitment to Rigor**: Maintaining "rigor" in STEM research and instruction has been a long-standing practice in STEM disciplines. While commitment to rigor may be construed as holding high standards for the quality of work (a laudable goal that contributes to excellence), the value of rigor may also be expressed in ways that could negatively impact students (Riley, 2017). For example, some instructors and programs have interpreted "rigor" to mean "difficult," as indicated by significant numbers of students withdrawing from STEM courses or receiving low grades.
    - An **alternative framing of rigor** would be one where instructors and programs provide clear learning objectives and transparent criteria for what constitutes excellent work– and do not limit the number or proportion of students who can demonstrate success by achieving those criteria. Furthermore, in a learning environment organized around an alternative framing of rigor, teachers would adopt instructional and assessment practices that are aligned with the many methods currently available for assessing high-quality work and critical thinking (NASEM, 2016). Rather than expecting students to do all the work of adjusting to college, recent work has called for changing the culture of STEM and STEM instruction by shifting the focus to "fixing the classrooms" (Handlesman, et al., 2022). In such an environment, informed by a reframed notion of rigor, all students are provided the opportunity to succeed and thrive.
- **The Relative Emphasis on Research compared to Teaching**: Departments, units, and academic programs vary in the value they place on research and instructional activities; each department's particular emphasis on these activities is often related to the overarching mission and culture at the institution where it is situated. Departments that place high value on research productivity typically emphasize research-related activities (more than teaching activities) in annual review processes; advertise research accomplishments (more than teaching efforts) on departmental websites, newsletters, and other official communications; and provide researchers with personnel and resources to secure external research funding and carry out research projects (more than resources to strengthen their teaching). In contexts

where research is highly valued, faculty and staff may see fewer incentives to implement new teaching practices or spend time supporting students outside the classroom or laboratory.
    - An **alternative framing of the relationship between research and teaching** would highlight both kinds of scholarly work as valued and important in an academic department. Departments that place high value on teaching may find ways to offer small classes, provide instructors with professional development activities related to improving teaching, and require robust review of teaching performance for decisions related to career advancement. Such departments may also find ways to encourage the use of pedagogies that are recognized for supporting the learning of all students, such as experienced-based learning, in-classroom student research opportunities, and competency-based assessment (NASEM, 2016; NASEM, 2025). Intentional efforts to assess departmental culture and its impact on student learning and experience can be a helpful step as a department finds ways to strengthen student success.
- **Assumptions about who belongs in STEM fields:** STEM culture can convey various assumptions about who belongs and has the potential to succeed. A related assumption is that all individuals have equivalent abilities (Cech, 2023; Reinholz & Ridgway, 2021), which can lead to behaviors, practices, and policies that interfere with productive learning environments. For example, laboratory spaces are often not designed to be universally accessible, so students who use a wheelchair, have a broken limb, or cannot see certain colors may be unable to safely perform a lab exercise. These circumstances may signal to students powerful messages about who belongs, or not, in STEM fields. Furthermore, departments often place the responsibility on students to share their needs and advocate for themselves, either individually or with the help of others, which communicates to students who require accommodations that their success is not valued or prioritized by staff and faculty–and that they may not belong in STEM.
    - An **alternative framing about belonging** would emphasize ways to help all learners find success in their STEM learning. One example would be to design spaces that support all learners to engage in productive and rewarding STEM work. Another example would be to help learners work on projects that they can see relate to aspects of their daily lives.
- **Commitment to the Value of Objectivity**: A core value in science is the idea of striving to use the greatest objectivity possible in gathering and interpreting data and reaching conclusions about questions. However, this admirable feature of STEM culture may inadvertently lead faculty to hold preferences for quantitative data about the student experience rather than qualitative data, which is sometimes perceived as more subjective. Emphasizing only quantitative data may mean that faculty do not gain the benefit of qualitative research and data that can explain questions of how and why students have various experiences.
    - An **alternative framing of the value of objectivity** as it relates to the student learning experience would emphasize that both kinds of data can provide useful information to illuminate students' learning experiences. Informed by both qualitative and quantitative data, faculty, staff, and administrators have deeper and more extensive information to use to improve the learning environment.

WHAT ARE WAYS TO FOSTER A STEM CULTURE THAT HELPS ALL STUDENTS TO THRIVE?

Changing culture is widely recognized as a challenging goal that requires time and commitment (Kezar, et al., 2023). As explained above, some of the values that have served to advance scientific excellence may also, inadvertently, convey messages that inhibit success in the student learning experience. Furthermore, the existing culture in a STEM unit may lead to resistance to change (Henderson et al., 2011; Kezar et al., 2015; Reinholz & Apkarian, 2018). Thus, academic leaders, instructors, and staff in STEM departments may find that assessing the culture of the unit can help them better understand factors affecting student learning and

success. Reflecting on and assessing the culture in a STEM unit can help identify implicit beliefs and assumptions as well as explicit issues that may undermine student learning. Such reflection may also reveal reasons that efforts to support student success do not always result in the intended outcomes. Analyzing the current culture in a STEM unit can lead to ideas on how to modify practices and policies to ensure that students are able to bring their full intellectual capacity to their academic engagement-- because they feel valued, comfortable, and safe in entering, pursuing, and completing STEM courses and degrees.

Every STEM department is unique, reflecting its particular disciplinary culture, the culture of the institution where it is located, and its own history and traditions as a unit. Thus, analyzing the specific culture of the department is useful. Ways to assess the culture of a department as it relates to student learning include:

- **Examining the current culture in the unit**: A good starting point is often to examine the existing culture and how it affects students' experiences. Examining the existing culture can reveal ways that it already positively impacts students, as well as aspects of the culture that may convey less positive messages. However, it is not always easy to articulate the values and assumptions of one's department. Rather, it can be easier to examine manifestations of culture (e.g., policies, structures, behaviors) and then consider the underlying values and assumptions.
- **Describing the desired culture of the unit**: In some cases, a useful place to start may be to articulate the shared and desired values of a department and then envision what it would look like if those values were to be regularly upheld.
- **Considering the culture from the students' viewpoints**: Another strategy is to reflect critically on how the department's values and culture are understood by the students and influence their experiences as learners. Alternatively, members of the department might consider how proposed cultural values would be received by and impact students.
- **Considering individual as well as collective responsibility for the culture**: Departmental culture emerges from the collective practice of values, norms, and behaviors. But individual faculty, staff, and administrative leaders can benefit from consideration of how their individual actions contribute to the culture experienced by students. Also important to consider is how department members might share responsibility for creating and sustaining a departmental culture that more fully supports student learning.
- I**dentifying and adopting strategies to create more inclusive classrooms**: Instructors can take steps in their classrooms to help students feel more welcome and to foster their interest in and sense of connection with ideas and topics they are studying. Increasing active learning in classes, providing opportunities for students to participate in research, and connecting topics of study to lived experiences of learners are among the practices shown by research to foster interest and motivation among students (Handelsman et al., 2022; NASEM 2025).

WHAT QUESTIONS FOSTER CONSIDERATION OF CULTURE?

Academic leaders who want to foster consideration of the key elements of the culture of their unit and how that culture may relate to student experiences and learning could offer their colleagues these questions for discussion:

- What are our unit's values, assumptions, and beliefs? How do they align with institutional values, assumptions, and beliefs?
- In what ways does our department or unit actively practice its stated values and beliefs? How do these manifest in the type of environment that is desired for students, staff, and faculty?
- How do different groups experience the unit's culture?
- What actions in the classroom, laboratory, or department might help students feel an increased sense of belonging, engagement, and encouragement?

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