

**CULTURALLY RESPONSIVE
STRATEGIES FOR REFORMING
STEM HIGHER EDUCATION**

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CULTURALLY RESPONSIVE STRATEGIES FOR REFORMING STEM HIGHER EDUCATION: TURNING THE TIDES ON INEQUITY

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INVESTOR IN PEOPLE

This book is dedicated to all of the undergraduate computer/information science students who were ever made to feel as if they didn't belong. You do.

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Foreword

What you are about to embark on in reading this book is a grantmaking team's dream scenario.

After months of dialogue and analysis, strategy, and negotiation, a foundation places a big bet on a recognized champion of higher education to tackle a complex challenge facing our country. That champion takes the bet but does not simply carry out a project or initiative. Instead, she initiates something much bolder — something akin to a *movement* — a new and different community that has the potential to grow and sustain in the lives of college communities to the point where it becomes a kind of *new normal*.

This book is a further step in the building of that *new normal*. It was not conceived of in any grant proposal — it arose from the work organically. And as with any potential movement that has sustaining power, it has been carried out as a true collaborative effort, built from the field by the field for the field of higher education.

If you have picked up this book, you may already know the United States is no longer positioned to be the long-term global leader in science, technology, engineering, and mathematics (STEM). This is in part because the United States has more or less stood in place, encouraging only our so-called “best and brightest” to proceed into these professions, while other countries have been racing to catch up. If this story is news to you, not to worry, you will be caught up by the end of the first chapter.

Given the power of technology, this stagnation cannot be allowed to stand if our country is to remain competitive in the global economy. More importantly, as has become readily apparent with our recent politics, this stagnation cannot stand because nothing less than our democracy is at stake. To foster a more equitable world, it is our collective responsibility to provide opportunity to all learners no matter their racial or ethnic background, gender, sexual orientation, or place of birth, so that those who will lead us into the next frontiers of science and technology will be representative of the population they are serving.

So what to do? Well, there are many steps to be taken, but among them is catalyzing a focus on creating a more inclusive and equitable culture on our campuses. TIDES chose to begin in introductory computer science classrooms across a diverse group of colleges and universities. Why computer science? Because at the time this work was initiated, it was *the one* discipline shown to be getting *less* diverse (particularly in terms of gender) at our colleges despite our school admissions seeing a surge in diversity. And its faculty are also among the least diverse of any field. So the determination was to start where the problem was particularly acute and connect to other disciplines through faculty collaboration.

The idea of collaboration was included intentionally because faculty are at the center of the change we seek in higher education. Together, they create the

culture on our college campuses, and to use a computer science metaphor, faculty are our primary *interface* with our future: the students. And as you will come to learn, the future is bright because the vast majority of faculty are committed to student success.

This work takes place against the backdrop of important developments in US higher education. College quality, affordability, and worth becomes even more critical as a postsecondary credential becomes indispensable for upward social mobility and a career that will exist well into the future. Inclusivity, representation, and belonging of diverse people, backgrounds, needs, and philosophies are actively negotiated as a new college-going demographic arrives to class. Other shifts are manifesting in more invisible ways, in the hearts and minds of college faculty and staff, as they examine their responsibilities as educators of the citizens, innovators, and leaders of tomorrow.

The accounts in this book will demonstrate how faculty can, indeed, lead our institutions of higher education into a more inclusive and promising future for all. You will read about departments examining and changing their teaching to better attract students from underrepresented groups. There are models for discussing personal identities among colleagues and students so that our differences can be positioned as classroom assets. These chapters also reveal what it took for some colleges to integrate new elements into existing infrastructure at the classroom, department, and institution levels. This book is rich with examples of good teaching in the computational sciences, including uses of project-based learning, classroom participation tools, peer mentors, and learning communities. Lastly, the authors offer deeply personal reflections on how they came to recognize their considerable impact on individual student achievement, and as a result, how they have changed as faculty.

Because these faculty persisted over several years through courageous conversations, reflected on their identities as teachers, mentors and collaborators, and changed their approach to teaching – and then importantly – shared their experiences with others on their campuses, the work of TIDES will impact thousands of students year after year for decades.

This approach to sustained change is consequential because it is only with a diverse STEM workforce that we can hope to achieve breakthroughs that will lead us to a more equitable world. And it is only a representative STEM workforce that can be counted on to ensure that technology contributes to leveling the playing field rather than continuing to exacerbate our differences.

As grantmakers, our aim was to create the conditions for change by providing space and time for tough conversations, to respect the people and institutions who choose to do this work, and to cheer them on through the wins and struggles alike. Whether you work in academia or are an external stakeholder, we hope that these lessons can inspire you, as they have for us, to play a role in the *movement* that has begun. It has been a privilege to witness the journey of TIDES and its champions. For that, we are grateful as grantmakers, but more so as citizens of our interconnected, colorful, and hopeful world.

Ryan Kelsey & Sue Cui

Chapter 1

That None Shall Perish

Kelly M. Mack and Kate Winter

*Don't try to fix the students.
Fix ourselves first.*

— Marva Collins, circa 1975

Reflection

There were only eight of us in the class. Being so few in number meant that we all sat in the front row of the classroom. An upper level, honors class for Biology majors. Of this elite eight, only one of us was white, the rest were African American like me. Not an odd situation for a Historically Black Institution. Our professor was white. Also not odd for an institution like this.

Every other day of the week — Monday, Wednesday, and Friday — for 50 minutes at a time, we pored over our notebooks to write down as much of what he said as we possibly could. He talked fast. And because it was the 1980s, there were no natural breaks or pauses between sentences for him to change slides or, Heaven forbid, write on the chalkboard (as most professors did back then). He just talked.

At the surface, this would have appeared to be “normal.” But, if you looked just a bit more closely, you would have noticed one ever-so-slight subtlety that would forever change how I viewed students of color in STEM classrooms. You would have noticed that even though he was teaching, he was only teaching to one of us, for the entire 50 minutes. Guess which one. For 50 minutes, with feet planted firmly on the floor and pointed in our direction, his upper body was contorted in such a way that everything from the waist up faced in the direction of the one white student in the room, who sat at the far left end of our row. The rest of us were invisible; our learning was insignificant. There was essentially no way for him to know by the looks on our faces if we were puzzled about the

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material. There was no way for him to sense – as all good educators do – whether or not we were connecting with the lesson, drawing the right conclusions, or mastering the concepts being discussed at us. There was practically no way for him to know when any of us even raised our hands to ask a question. In those 50 minutes on every Monday, Wednesday, and Friday of the semester, the learning experience of one white student was generalized to an entire class of students of color. And, for him (and maybe that one white student), that was alright. But, for us, there was an undeniable and unspoken element of stolen opportunity in that class that, even today, is painful to explain.

It has been decades since I completed that course. I earned an A, but I suspect it was despite the way I was taught, not because of it. It is unfortunate that while much has changed in US undergraduate STEM classrooms since then, much has also remained the same. Students of color continue to report feelings of isolation, lack of belongingness, marginalization, and invisibility. And we, as educators, continue to search for new ways of ameliorating these feelings – many of which are focused on “fixing” the student. For the life of me, though, I cannot understand what about the me back then would have needed to be fixed in an Honors Biology class that I had earned the right (and privilege) to be in. I had a strong GPA. I was thriving in the discipline. I felt like I belonged at the institution. I had a community of friends. I was fully assimilated into the culture of the institution. I was applying to graduate schools, and getting acceptances. I had not one, but several summer research internships under my belt. According to modern STEM higher education beliefs, I was “fixed.” But, was he?

Organizational Context

The Association of American Colleges and Universities (AAC&U), founded in 1915, has long been recognized and respected as a national leader in promoting liberal education at the postsecondary level. Contemporary views about liberal education, though, have been fueled by common misunderstandings that: (1) far-too-narrowly limit it to the arts and humanities only; (2) selectively dismiss the medieval origins of the liberal arts, which included both mathematics and the sciences; or (3) both. The result is a contemporary interpretation of education – liberal or not – that, as Steve Jobs noted, does not “make our hearts sing.”

Through its dual, century-old commitments to liberal education and inclusive excellence, AAC&U is uniquely positioned to not only correct these misperceptions, but also ensure that all students – regardless of gender, race, socioeconomic status, or sexual orientation – have equitable access to a liberal education that affords them opportunities to meaningfully contribute to the US STEM workforce in ways that will position them for decision-making authority and maximal impact.

However, according to Chris Carter, “the teaching of any science, for purposes of liberal education, without linking it with social progress and teaching

its social significance, is a crime against the student mind.” Indeed, if we are to prepare a generation of scientists who are both competitively trained *and* liberally educated to solve the most complex problems of our day, our teaching strategies cannot rely so heavily upon the one I endured or any facsimile thereof. Nor can they rely upon our merely gaining a deeper understanding of “what works” in undergraduate STEM teaching and learning. In other words, the teaching of the sciences must extend far beyond teaching core scientific principles. Today, our teaching must also demonstrate both the practicality of applying those principles to real-world problems as they unfold in real time and the necessity of including diverse worldviews for prioritization of those problems and their solutions.

To better position itself for impact in the sciences, in 2010, AAC&U expanded its mission-level commitments to liberal education and inclusive excellence through a strategic merger with Project Kaleidoscope (PKAL) – a leading national alliance for the reform of STEM higher education. Since its founding in 1989, PKAL has provided high-impact professional development opportunities for STEM faculty to gain mastery in implementing advanced pedagogies, transformative leadership strategies, and interdisciplinary analyses of educational outcomes. Today, PKAL exists as both a vibrant network of nearly 10,000 STEM academicians and an epicenter for promoting the deeper understanding of not only “what works” in undergraduate STEM education, but also “for whom it works” and “under what conditions it works best.”

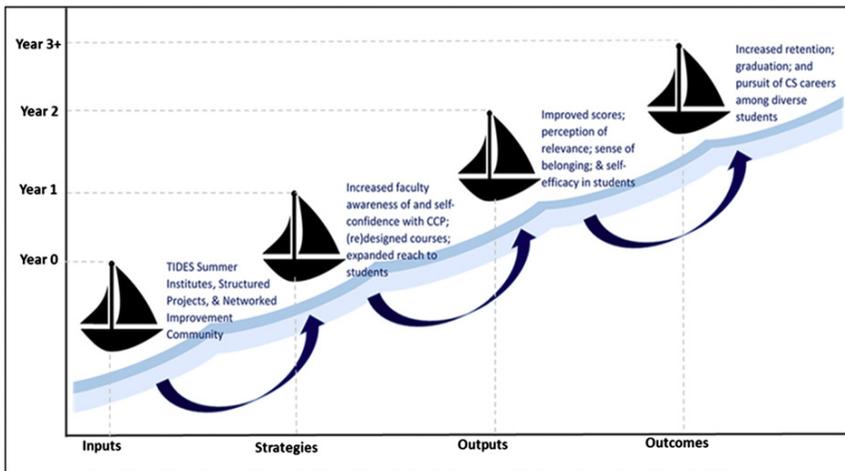
Background and Significance

Arguably, not since World War II has there been a greater clarion call for scientific discovery and innovation than now, especially in the computer/information science disciplines. In fact, by the end of this decade, the US economy will annually create over 120,000 new jobs requiring at least a bachelor’s degree in computer science to satisfy the workforce demand for emerging fields like cloud architecture, forensic investigation, and geospatial technology (Evans, Mckenna, & Schulte, 2013). However, currently, only approximately 56,000 computer science baccalaureates are produced each year (NSF, 2017). This dilemma is further complicated by a shifting sociopolitical landscape that has created and now perpetuates the systemic marginalization of the “new majority” of undergraduates in US higher education – women, students of color, and those from low socioeconomic backgrounds (Schneider, 2014) – who represent not only rich sources of untapped talent, but also the diversity of perspectives and worldviews that are essential for addressing the most vexing computer/information science problems of our day.

For decades, much attention to and support for broadening the participation of new majority students in STEM oftentimes has amounted to no more than vigorously addressing perceived academic and social deficiencies within undergraduate students themselves (Valencia, 2010). On the other hand, others – with whom we wholeheartedly agree – have identified comprehensive pedagogical reform as

one of the most advanced mechanisms for redressing the systemic marginalization of new majority students in STEM disciplines (Tsui, 2007). However, mastery of the pedagogy – *particularly culturally responsive pedagogy* – commonly poses a substantial challenge for STEM faculty who oftentimes lack the substantive knowledge of and proficiency in teaching strategies that would enable *all* students to master STEM content (Froyd, Fowler, Layne, & Simpson, 2005). Further, the traditional approaches to faculty professional development, far too often either: (1) overlook the collective wisdom of faculty (Wolff, 2016); (2) fail to holistically consider the root causes of faculty indifference to pedagogical reform (Fairweather, 2008); (3) are designed primarily as isolated attempts that are nearly impossible to export, adapt, or bring to scale (Kania & Kramer, 2011); or (4) pay far too little attention to the racial and structural inequities that persist within the culture of higher education, at large, and the computer/information sciences, more specifically (Williams & Marxer, 2014).

To that end, the AAC&U Teaching to Increase Diversity and Equity in STEM (TIDES) was introduced to the US undergraduate STEM reform community in 2014 as a different approach to professional development for STEM faculty – one that could eliminate the deficiencies named above and, ultimately, turn the tide on inequity. Its goal was to touch, either directly or indirectly, at least 100,000 students, primarily those from historically under-represented groups.



At its core, TIDES offered a re-conceptualization of the STEM faculty professional development domain in ways that reject conformity to centuries-old beliefs about the sovereignty of the STEM professoriate in deciding who deserves to thrive in the undergraduate STEM classroom. It also represented a strong pivot toward equity and justice as core essential elements for immediate and widespread change in undergraduate STEM teaching.

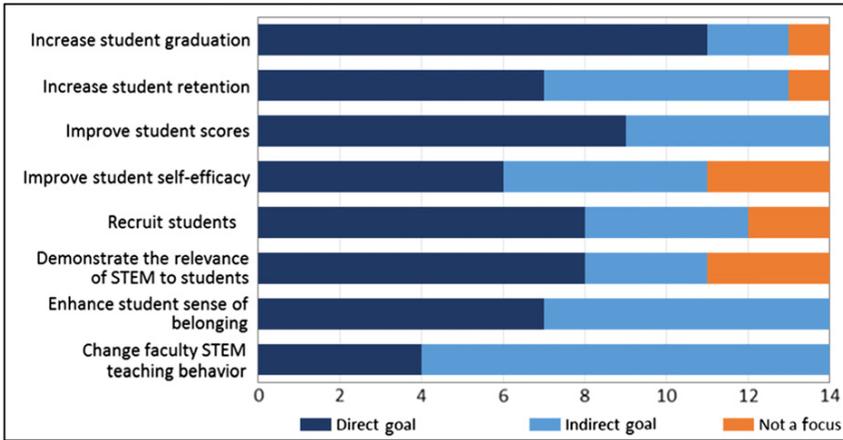


Figure 2: TIDES Institution-level Objectives Mapped to TIDES Program-level Objectives.

students' scores in STEM and demonstrating its relevance to their career aspirations and daily lives (an indirect goal).

Professional Development Program

At the outset, it is important to note that in every aspect of the TIDES professional development program, representatives from all institutions were exposed to the same intervention, regardless of whether they were fully funded finalists or honorably mentioned. As a result, what we discovered was something that we had suspected all along. There is not always a direct correlation between the degree to which an institution can change and the level of investment made in changing that institution. In some striking cases, our honorable mention institutions were equally, if not more, successful than our fully funded institutions. This is not to say that investment is not important. Rather, it is to note that careful attention must be paid to determining the level of readiness that an institution presents at the time of proposal submission. It cannot be emphasized enough that even more careful attention must be paid to the institutional environment to which a level of readiness is attributed. Indeed, no two college campuses are alike. What appears as a lack of readiness in one institution can, and sometimes is, readiness for another. Thus, it is more than the combination of institutional readiness and institutional context that is needed for predicting impact. It is also the ability to discern whether the level or type of readiness is appropriate for any given institutional context.

TIDES is rooted in an understanding that a key component of institutional readiness includes deep and critical introspection of ourselves as educators. Therefore, superimposed upon the objectives of individual TIDES institutions was a three-year-long professional development program, which, from the very

beginning, sought to unmask the complexities of our personal implicit biases. Coupled with this reflection was an intentional focus on increasing our self-efficacy in implementing culturally responsive teaching strategies in the classroom. Many scholars have noted that self-efficacy is a strong determinant of behavioral change (Bandura, 1977; DeChenne, Enochs, & Needham, 2012; Mohamadi & Asadzadeh, 2012). Indeed, infusion of its core elements – performance accomplishment, vicarious experiences, verbal persuasions, and psychological states – into the professional development activities of STEM faculty not only promotes the kind of sustained behavioral changes required for culturally responsive teaching, but also positively impacts undergraduate STEM student learning even in the face of institutional barriers (DeChenne et al., 2012; Mohamadi & Asadzadeh, 2012).

Year 1 | Journey Into the Unknown

In every year of our TIDES professional development program, three representatives from each of the nineteen TIDES institutions were recruited as a team to participate in annual institutes and workshops. In many cases, the same representatives participated in professional development activities for the duration of the program. In other cases, the institution made the decision to rotate representatives as institutional needs and faculty schedules dictated. These interdisciplinary teams included one computer/information scientist, one administrator with decision-making authority over STEM curricular changes, and another faculty member from any other academic discipline engaged in the campus' TIDES-related activities.

In Year 1, these TIDES institution teams were immersed in the social science literature that undergirds cultural responsiveness, including elements of implicit bias, the intersections between gender and other social identities such as race and socioeconomic class, and the need for self-reflection regarding assumptions about students' abilities based on their appearances or backgrounds. It cannot be overlooked that immersion in the literature, alone, was insufficient to guarantee our success.

As a community, there were three agreements to which we had to be fully committed. The first agreement was based on a private conviction and public assertion that new majority students cannot and should not be blamed for their underrepresentation in STEM. The second agreement was grounded in our declaration that the power and privilege afforded to every STEM faculty member plays a critical role in the academic success of underrepresented students – both in and outside of the classroom.

Reaching these first two agreements was, of course, no easy task. The ease and speed with which we arrived at them was facilitated by the presence of “credible experts” (Gass & Seiter, 2016; Hovland, Janis, & Kelley, 1953) who were responsible for exposing TIDES faculty to the foundational theories and literature underpinning the underrepresentation of women and students of color in STEM. For our carefully designed institutes and workshops, our “experts” served as facilitators, plenary presenters, small-group discussion leaders, and

informal advisors. Beyond their disciplinary expertise, each adroitly displayed extreme patience in responding to characteristic scientific skepticism, as well as compassion for our resistance to the intense emotions that are often evoked with difficult dialogues and a congenial disposition that fostered open and candid conversation. Collectively, this combination of expertise and empathy displayed by our credible experts contributed to an overall climate that was non-threatening – maximizing the likelihood their messages would be not only heard, but also internalized.

Beyond the didactic components of the TIDES institutes and workshops, institution teams utilized the rest of their time together engaged in meaningful small-group interactions where personal and professional tensions around cultural diversity could be more fully explored and resolutions made more relevant to a specific institutional context. To avoid having faculty revert to their default behaviors and beliefs associated with culture-less undergraduate STEM teaching strategies, all TIDES participants were paired with an institution coach. In keeping with Kotter's model (2012) for organizational change, our institution coaches served as a formidable guiding coalition. Kotter notes that individuals most ideal to comprise this body are those with strong position and broad expertise (Kotter, 2012). To that end, institution coaches were carefully selected and paired with TIDES institution teams based on the potential for full alignment between their expertise and the project's focus, and their appreciation for what more the project could accomplish if pushed to do so.

The nature of pushing a TIDES institution team toward bigger accomplishment, admittedly, meant that the relationship between institution coach and team was, at times, strained. Specifically, it was our institution coaches who were responsible for reinforcing messages gleaned from the didactic programming of TIDES Institutes, preventing faculty from reverting to old habits of mind, and challenging them to embrace completely new mindsets that could foster innovation – all while holding them accountable for operationalizing cultural responsiveness into core STEM course design and delivery. Thus, our third, and the most significant, agreement was to remain fully present and in community with each other, no matter the difficulty or uncomfortableness. With this third agreement established, together, institution coaches and their assigned TIDES institution teams powered through their work in interpreting, understanding, *and* integrating the key concepts, lessons, and motivations for culturally responsive pedagogical reform that addressed unique institutional contexts and dictated how STEM, especially computer/information science, courses were to be designed or redesigned as part of their TIDES projects.

Undoubtedly, the careful infusion of external influences – be it through credible experts or institution coaches – contributed to the development of a “safe, brave space” (Ali, 2017) for TIDES faculty. However, the penultimate influence on this environment stemmed from the community of TIDES faculty themselves. In many Institute and Workshop settings, it is often the case that there are moments of clarity – when that which was confusing to one becomes clear, or when that which was held to be true by one is proven false. It is also often the case that these moments are done privately within our own thoughts. For