Northeastern
Center for Inclusive Computing

Systematizing Solutions to Attrition in University Computing

Launched in 2019, the Center for Inclusive Computing (CIC) partners with many of the largest computing departments in the country to identify institutional barriers that are preventing women of all races and ethnicities from pursuing computing degrees.

Having worked in-depth with 23 universities and supported detailed data collection and analysis on retention and persistence at 58 universities (representing 25% of US computing graduates), we feel clear on the key structural fixes that computing departments can make to create more inclusive environments and materially increase the representation of women pursuing the major.

Among the eleven Round 1 and Round 2 CIC Implementation Grant Partner Schools that have implemented (some/many of) these solutions, we see an average increase in the representation of women in the second required class ("CS2") from 2018-2019 (Round 1)/ 2019-2020 (Round 2) to 2020-2021 of {7, 6, 4, -1, 4, 3, 7, 2, 6, 0, 3} percentage points.[1] Note that we are currently examining results from 2022. Additionally, when compared with national averages, CIC Partner Schools are, on average, growing faster in terms of the number of computing majors/graduates,[2] while *also* increasing the representation of women persisting through the intro sequence.[3]

In the CIC's view, the minimum list of systemic changes that computing departments should undertake are:

1. Restructure intro computing courses to address the distribution of prior computing experience which is not uniformly distributed with respect to demographic identity,
2. Ensure common assessment (same assignments/exams) in multi-section introductory courses.
3. Restructure and shorten major requirements, moving/removing classes that are not necessary for the majority of computing jobs. Rethink math/science pre-requisites/co-requisites to the intro CS courses to ensure students do not face "impossible semesters"; e.g., a semester in which they take Calculus 2, Physics 2, Data Structures and Discrete Math.
4. "Contextualize" computing curriculum.
5. Implement inclusive practices for recruiting, training, and evaluating teaching assistants.
6. Analyze the DFW rates by course/instructor intersectionally every semester to find problem courses/instructors.
7. And, if logistically possible remove GPA-based enrollment caps.

There may be other best practices (such as peer-mentoring), but what distinguishes the above actions is that they address institutional barriers that CS departments have (often unknowingly) erected that prevents some students from discovering and persisting in computing. If there is strong leadership and a high level of faculty buy-in, interventions 1-6 can be implemented quickly and

---

[1] The school with a net gain of -1% points was because admissions admitted 30% more students to CS to help offset a university-wide budget deficit and the school with 0% gain did not implement any of these changes and is an abject failure – a solid case for why going forward the CIC is stage gating funding.
[2] Defined as those graduating with degrees counted in IPEDS CIP 11
[3] It is still too early in the CIC's work to measure the impact on graduation rates.

affordably, and results can be seen within one term (intervention 7 depends on department resources, budget and ability/permission to hire). In the first half of 2023, the CIC plans to systematize the diagnostic tools and training materials that would allow a university computing program to implement these interventions and eliminate unnecessary and often unrecognized institutional barriers.

Stop trying to fix the student and fix the institution instead

One thing that feels increasingly clear is that retention must be addressed first. Over the past three years, many schools have come to the CIC seeking funding, proposing efforts focused on high school outreach, conference attendance, mentorship, and recruiting while failing to observe the high rates of attrition they are experiencing among women that are *already there*. In other words, schools are choosing not to serve the students they already have. Then, in order to "fix" their diversity problem, schools set out to find new students from historically underrepresented populations, as if these new students will somehow be "better" at surviving their existing dysfunctional system. Indeed, in the 45+ all-day site visits we have done over the past three years, when we ask faculty what they think is going on behind high DFW rates or low enrollment numbers among women, they start by blaming the students for not persisting, for their poor preparation for college, for a lack of interest, and/or for low "mathematical maturity." There is no question that students are coming to college with varying degrees of preparation, as computing is offered in only 50% of public high schools and far more frequently in affluent communities. In addition, of those taking the AP test in 2022, only 31% are women. This means that women and students from under-resourced high schools are less likely to have experience programming. Don't these students deserve a CS1 curriculum that is paced appropriately and with an instructor committed to meeting them at the beginning?

Schools that talk of BPC, and who's faculty apply for NSF funding, should be held accountable for having a handle on their retention and persistence data (disaggregated by demographics and presented intersectionally). They should have identified where they are falling short and created a plan for implementing some, if not all, of the aforementioned changes.

First retention, then attraction

It is only by addressing retention that schools position themselves to work on *attracting* more students from populations historically marginalized in tech. While the CIC is enthusiastic about the results we have obtained (referenced above), we know that working only on retention is not enough to move us towards parity. Indeed, once retention has been addressed, the CIC works with its Partner Schools to implement an array of attraction-focused interventions, including:

1. Building new CS0 courses that attract students from all over the university and allow them to discover computing for the first time; and
2. Making CS0 or CS1 fulfill a general education requirement.
3. Designing interdisciplinary majors pairing computing with other areas of study from biology and chemistry to philosophy and political science;

Northeastern
Center for Inclusive Computing

The CIC is particularly enthusiastic about the transformative power of interdisciplinary computing majors and, increasingly, this is where we are focusing our efforts. If we can scale the implementation of strategies that fix retention, while simultaneously learning which attraction strategies work best in which contexts, the CIC knows that universities can move the needle once and for all.

Opportunities for scale?

On the question of how to scale the retention strategies, we seek the guidance of the National Science Foundation and the Computing Research Association.

- What opportunities are there to connect these practices with BPC funding mechanisms such that those applying for funding see the connection between their individual efforts and the systems in which they operate?
- How might we connect BPC to the CHIPs and Science Act to help increase talent via BPC?
- What would need to happen in terms of additional research, codification, tool development, etc. such that these interventions could be adopted widely across the US?
- *And most importantly, how can CRA's CUE project (if funded) be a convening mechanism to increase buy in by CS departments and learn from others engaged in BPC?*

In asking these questions, we appreciate that there are constraints to scaling the suggested retention-focused interventions within the existing BPC infrastructure at NSF. To name the ones that most quickly come to mind:

1. BPC plans are at the department level, but NSF awards are made to individual PIs and the connection between those two things is still emergent.
2. Unlike DARPA, NSF is not structured to enforce accountability, which is problematic vis a vis the kind of culture change that is necessary for BPC.
3. Dedicated BPC funding is relatively small in relation to research funding, and implementation of the six best practices for the intro sequence is not research.
4. The NSF review process is set up to consider research innovation and not (currently/yet) set up to evaluate the potential for effective implementation of proven, low innovation interventions. Furthermore, reviewers are research experts and, most likely, not BPC experts. Is the BPC part of a proposal evaluated by BPC experts?

We are eager to talk about these questions and tackle associated challenges. Our hope is to build a road map for how to bring this work to scale nationally, closing the accountability gap between talk and action around BPC. Thank you in advance for everyone's ideas, insights, and collaboration.