

Undergraduate Research and Inclusive Excellence: A Strategic Combination

Executive Summary

A most basic tenet of **inclusive excellence** is providing *all* students avenues to excel, regardless of heritage or background. In STEM (science, technology, engineering and mathematics) fields, **undergraduate research** is a proven path to excel, with positive student outcomes that benefit not only an undergraduate's education, but also their post-baccalaureate choices and plans.

An overarching priority of our effort is to increase diversity in STEM. To further inclusive excellence in STEM, it is essential that CU Boulder provide significant support for traditionally underrepresented minority (URM – identified as African American, Black, Native American, Hispanic), first generation and/or community college transfer students to participate in undergraduate research. **Undergraduate research helps recruit, retain and graduate students, particularly URMs.** At CU Boulder, data shows a **Bachelor's completion rate of 95%**, and a **STEM Bachelor's completion rate of 90%**, for URM undergraduates the **Biological Sciences Initiative (BSI) has funded to conduct research.** This contrasts with an overall URM STEM retention, 6-year graduation rate of 43.7%, for students who entered CU Boulder 2006-2010 (Institutional Research, CU Boulder).

Inclusive excellence and undergraduate research are a compelling, strategic combination in helping achieve CU Boulder's strategic imperatives, and so should be supported at the highest level by the University. In this white paper we describe our known strengths in recruitment and retention in STEM through undergraduate research experiences as well as new ways to attract and serve URM, first generation and/or community college transfer students in STEM, thus further advancing STEM fields.

Background

There have been numerous prominent, national calls for participation of undergraduates in research (PCAST 2012; AAAS, 2011; NRC 2003; NRC 2013), calls that resonate with CU

Boulder priorities, as illustrated by the following quote from **Chancellor DiStefano's State of the Campus Address** (Fall, 2017):

“We continue to have one of the highest participation rates of undergraduates conducting research and creative work, exceeding 2,000 students every year. And we are not stopping there. **We feel that exposure of undergraduates to research is fundamental to our mission.** Our long-term goal is to have half of our undergraduates involved in research.”

CU Boulder's **Biological Sciences Initiative** (BSI, <https://www.colorado.edu/bsi/>) has been supporting undergraduate research experiences in STEM in two principal ways:

- 1) Since 1989, BSI has supported **apprentice-based undergraduate research**. This model provides support (including financial) to students to work as part of a faculty-led research team, combined with BSI's professional development programming that builds communication and leadership skills.
- 2) Since 2014, BSI has also supported the development of **course-based undergraduate research experiences (CUREs)**, where students conduct project-based, authentic research based on the work of current faculty as part of their regular course work.

BSI has purposely catalyzed new CURE courses in MCD Biology at the introductory level to increase access to research for *all* students, including those who typically may not be aware of the value of research experience (*e.g.*, first generation and ethnic minority students). Given that these new CURE laboratory courses are serving greater numbers of students earlier in their undergraduate career, and that they fulfill course requirements (for the MCD Biology, Integrative Physiology, Biochemistry and Neuroscience majors, as well as the Arts and Sciences natural sciences core), this greater awareness of research is a crucial first step to increasing participation in apprentice-based undergraduate research. This is especially helpful for traditionally underrepresented students. It is also the reason that BSI has, since 2014, offered an in-depth preparatory course in STEM research methods for entering first generation and minority students.

The beneficial outcomes of undergraduate student participation in research have been well-documented, including by CU Boulder evaluation experts (Laursen, S.L., Hunter, A-B., *et al*, 2010; Seymour, E., Hunter, A-B., *et al*, 2004; and additional publications list at <https://www.colorado.edu/bsi/about/evaluation-and-assessment>). **Research shows that these**

beneficial student outcomes are attained over time, and thus the longevity of an undergraduate's research experience is important, *i.e.*, over multiple semesters (Laursen, S.L., Hunter, A-B., *et al*, 2010). And while participating in apprentice-based research has been shown to have value for all students, very importantly, the **evidence shows that it is particularly valuable for the retention in STEM of underrepresented minority students** (Laursen, S.L., Hunter, A-B., *et al*, 2010, chapter 6).

It is these findings that **compel us to advocate for undergraduate research and inclusive excellence as a powerful combination in advancing CU Boulder's three primary strategic imperatives**, namely to: shape tomorrow's leaders (and we would add "for a diverse world"); be the top university for innovation; and positively impact humanity.

A Strategic Combination

A most basic tenet of **inclusive excellence** is providing *all* students avenues to excel, regardless of their heritage or background. **Undergraduate research**, especially in STEM fields, is a proven and primary avenue to excel, regardless of a student's choice of career or post-baccalaureate endeavor. Participating in research is, in fact, increasingly required for admittance to many graduate and professional programs. *Undergraduate research, done well and robustly, fosters inclusive excellence, for the following reasons:*

1. Undergraduate research **recruits, retains and graduates** students (see BSI specific data below in "Evidence of Success: Outcomes").
2. Undergraduate research can provide **crucial financial support** for students.
3. Undergraduate research provides students a **collaborative community** based on interest; an "**academic home**" within our large university.
4. Vertically-integrated research teams provide **multiple mentors** (faculty PIs, postdocs, graduate students and peer undergraduate researchers).
5. Undergraduate research provides **professional development**, nurturing leadership and communication skills that help students navigate pathways forward.
6. Undergraduate research **engages students** in the fundamental mission of the research university, allowing them to **contribute to discovery and innovation**.

And again, we emphasize that while each of these aspects of undergraduate research have been proven valuable for all students, **evidence shows that they are *particularly significant for underrepresented minority and first generation students*** (Laursen, S.L., Hunter, A-B., *et al*, 2010, chapter 6).

An added value that is key to ensuring the ***high quality*** of undergraduate research, and that helps foster positive experiences for all involved (not solely undergraduates, but also faculty, graduate students, postdocs and other laboratory personnel), is ***professional development programming that augments the research experience itself***. The BSI helps build students' science, communication and leadership skills with professional development opportunities that include scientific proposal writing, research ethics, honors thesis process, and scientific poster preparation. The BSI also facilitates the growth and development of valuable mentoring skills among participating graduate students, post docs and faculty, thus adding to their professional repertoire.

Participating in research, and the associated professional development that BSI provides, is **one of the best investments undergraduates can make, in terms of enriching their coursework, finding community, persevering through graduation and excelling in future endeavors.**

Through our many interactions with undergraduate students, we are keenly aware of the numerous demands on their time. Just as faculty time is a finite resource, so is the time of undergraduates who are doing their best to graduate in four years. Similarly, supporting **undergraduate research is one of the best investments the University can make, in terms of recruiting, retaining and graduating students who are critical thinkers and life-long learners.**

Evidence of Success: Outcomes

The following data specific to CU Boulder illustrates the value of undergraduate research for **Retention and Inclusive Excellence.**

From BSI-funded student statistics* (1989-2017), the:

Bachelor's completion rate is 96%.

STEM Bachelor's completion rate is 92%.

Note, the overall retention of STEM majors, 6-year graduation rate for students who entered CU Boulder 2006-2010 is 59.4% (Institutional Research, CU Boulder)

URM Bachelor's completion rate is 95%.

URM STEM Bachelor's completion rate is 90%.

*Note, the URM STEM retention, 6-year graduation rate for students who entered CU Boulder 2006-2010 is **43.7%** (Institutional Research, CU Boulder)*

*The data above is from BSI's support of 1,881 undergraduates, 1989-2017. This includes 56% female and 12% URM students, who identified as **African American, Black, Native American, Hispanic**. The overall rates include 1699 total graduates, and exclude 116 currently enrolled. The URM rates include 197 total graduates, and exclude 20 currently enrolled.

Additionally, and very importantly in terms of progression to post-baccalaureate opportunities:

**442 BSI-funded students (38 URM) are co-authors
on 562 (61 articles with URM co-authors) peer-reviewed scientific journal articles.**

The following data illustrates how undergraduate research inspires and prepares students for advanced degrees, thus aligning with campus strategic goals:

Progression to Advanced Degrees

Of the 1,699 BSI-funded students who have graduated:

66% have completed Masters or PhDs (or are in progress)

Doctoral degrees:

801 have doctoral degrees (47% of BSI-funded total graduates)

272 Science PhDs, including 13 URM

458 MD or Health-related doctorates, including 66 URM

35 MD/PhDs, including 2 URM

14 DVM, including 1 URM

22 non-science (JD, Ed.D), including 3 URM

11.8% of total doctoral degrees are URM

Advanced terminal degrees (masters, non-doctoral):

323 have masters degrees (19% of BSI-funded total graduates)

123 MS Science, including 13 URM

20 MS Education, including 4 URM

107 MS Medical (MPH, PA, NP, etc.), including 16 URM

73 MS Other(MBA, MFA, MA, etc.), including 16 URM

15% of total masters degrees are URM

Looking to the Future: Increasing Diversity in STEM

Increased participation of traditionally underrepresented minorities in STEM is essential for the continued vibrancy and relevance of STEM research. The greater diversity of those engaged in STEM research, the broader the perspectives and greater possibility of solving any challenge. Diverse perspectives are key to scientific advancement, just as diversity is key to survival in biological systems. Demonstrating leadership at CU Boulder in URM, first generation, and/or community college transfer student STEM recruitment, retention and graduation will thus **benefit humanity**. It will also have a positive impact on research and training grant proposals.

To increase the recruitment, retention and graduation of URM, first generation and/or community college transfer students in STEM, we urge **new and expanded program elements** briefly outlined below, in addition to the substantial, sustained research experience and associated professional development that the BSI currently supports.

First, we urge the expansion of proven strategies that work:

- **More student research grants** – This is needed to more closely achieve the Chancellor's goals. Each year BSI turns away numerous well-deserving students for lack of funding.
- **Larger student research grants** – The research awards need to be large enough to support the students we are most trying to serve, without them working a second job.
- **More CUREs, in more departments, especially at the introductory level** – To provide broader access to research for all students.
- **Conference travel support for undergraduate researchers** – Currently the BSI is able to support few student conference awards, and only if the student is presenting.
- **STEM Research Methods course** – This course prepares entering first generation, URM and community college transfer students for entry into a research lab and expanding it would serve more students.
- **Scholarships** – In addition to research awards, our most deserving students would benefit from increased scholarships to alleviate financial duress.

Second, we would augment these known strategies with new, evidence-based features that will benefit the student research experience:

- **Peer mentoring** – We would pair new and/or community college transfer students with students who are farther along at CU, including as many URM undergraduate and graduate students as possible, so that they may learn from each other.
- **Opportunities for training (of undergraduates and mentors)** – Including mentor training for lab personnel (with participation of faculty, postdocs, graduate students); and inclusivity training opportunities that promote understanding for mentors, peer mentors and students. BSI could provide the infrastructure and training resources to ensure quality, productive research experiences. We strongly urge these professional development training opportunities especially as the volume of undergraduate research is increased.
- **CURE to Apprentice course** – A post-CURE course designed to help students transition to apprentice-based research in a faculty laboratory.
- **Research Advising** – To help undergraduates learn valuable skills in finding research experience(s) best suited to them. Currently this happens for the motivated and/or fortunate student; greater support for more formalized research advising would increase access for all students, and could be particularly helpful to URM, first generation and/or community college transfer students in their first and second years.
- **Honors Advising** - To maximize an undergraduate's research experience with an honors thesis if desired. Many undergraduates do not realize that their research experience can be the basis of an honors thesis, and even for those who do, the realization often comes too late. More formalized honors advising would help students get the most out of their research experience.
- **Support and recognition of research labs** – Including some financial support for faculty research labs that provide this valuable training and teaching of undergraduates.
- **Integration of all program elements** – So that students' needs are met and their professional development in STEM is supported in a comprehensive, successive way from entry to CU Boulder through graduation and beyond.

Conclusion

Undergraduate research is a primary avenue for students to excel, with proven positive outcomes for their education and career trajectories. Done robustly and with commitment to underserved

students, undergraduate research goes hand-in-hand with inclusive excellence. We urge the leaders of CU Boulder's Academic Futures to help us serve students with more and greater opportunities to engage in sustained research, combined with new and additional programming elements designed to specifically support the recruitment, retention and graduation of URM, first generation, and/or community college transfer students.

References

Data from CU Boulder's Office of Institutional Research, Data Analytics:

https://www.colorado.edu/oda/sites/default/files/attached-files/stem_cuboulder_0.pdf

President's Council of Advisors on Science and Technology (2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

American Association for the Advancement of Science (2011). *Vision and Change in Undergraduate Biology Education: A Call to Action*, Washington, DC. <http://visionandchange.org/files/2013/11/aaas-VISchange-web1113.pdf>

DiStefano, P. (2017) State of the campus address at CU Boulder, October 17, 2017. <https://www.colorado.edu/chancellor/2017-state-campus-address>

Laursen, S.L., Hunter, A-B., Seymour, E., Thiry, H., Melton, G. (2010). *Undergraduate Research in the Sciences: Engaging Students in Real Science*, John Wiley & Sons, San Francisco, CA.

Seymour, E., Hunter, A-B., Laursen, S.L., DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education* 88(4), 493– 534.