The High School Research Initiative:

Engaging Teachers and Students in a Dual-Enrollment Research Course

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Abstract

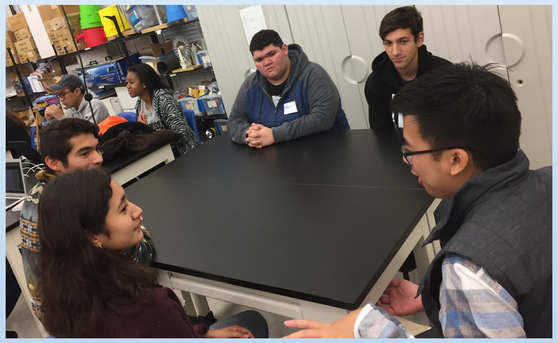
The High School Research Initiative (HRI) is an inquiry training resource center, providing teacher training, dual-enrollment research courses, and supportive resources to lead scientific inquiry in the classroom. At the forefront of the HRI program is the "Scientific Inquiry and Collaboration" dual-enrollment course, which offers high school students experiences in open-inquiry research and university-collaborative research. This course is taught at high school campuses by teachers, who have completed the 3-wk training program. Teachers and students receive teaching, curriculum, and research support in-person and virtually, as well as program evaluation feedback throughout the yearlong course.

Introduction

At UT-Austin's College of Natural Sciences, undergraduate students dive into scientific research right from the start through the Freshman Research Initiative (FRI). Now high school students can do the same. The pioneering HRI program provides high schools students the opportunity to initiate and engage in real-world research experience with faculty at The University of Texas at Austin. The HRI offers a dual-enrollment course, which is part open-inquiry and part University-collaborative research for high school students. The resulting course provides high school students both college credit for the HRI-Research Methods course (NSC 309) and high school credit for Scientific Research and Design or Project Based Learning.

The SEPA-funded HRI program is the result of partnerships between nationally recognized UT programs: UTeach, FRI, and OnRamps. UTeach specializes in STEM teacher preparation, while the FRI specializes in undergraduate research experiences and OnRamps offers infrastructure and experience in hosting dual-enrollment courses throughout Texas.

The HRI seeks to leverage the benefits of these partnerships, obtaining similar outcomes in the FRI and UTeach. That is - FRI students are more likely to earn a STEM degrees, graduate within 6 years (Rodenbush, et al., CBE Life Sci Educ., 2016), earn an estimated 16% more in lifetime earnings (Walcott, *et* al., CBE Life Sci Educ., 2018), and (we believe) graduate better prepared to pursue advanced degrees or jobs in industry. Similarly, UTeach is a model for outreach, professional development, and science education. UTeach-prepared teachers provide an advantage of 5-9 months of schooling over other teachers (Marder, UTeach blog, https://uteach.utexas.edu/sites/default/files/student-gains-by-pathway-working-paper-2017jan10.pdf).



How does it work?

Summer: Teacher Professional Training

High school teachers, who have partnered with the HRI, complete an intensive 3-week professional training over the summer. Led by HRI and UTeach master teacher, the training offers the course curriculum, a first-hand experience to the inquired-based approach, and instructor guidance. Additionally, the HRI provides equipment and materials support (i.e. access to equipment inventory and financial support), ongoing professional training and support, UT campus events and opportunities to present research findings to a broader audience, as well as other means of research and education support.

Fall Semester: Student Inquiry Research

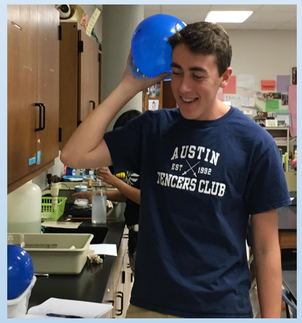
- High school teachers lead their high school students in the completion of two inquiry-based research projects, providing an opportunity for students to ask and answer questions in a scientific way.
- The latter of these two inquiry-based projects is entered into the high school and/or regional science fair in the spring.
- High school teachers receive a number of follow-up training sessions on the high school campus and UT campus.
- High school students interact with UT instructors through the course management system (i.e. Canvas); this includes evaluation of work, announcement of assignments, and feedback for their work.
- High school classes visit the UT-Austin campus, sitting in UT courses, visiting UT professors, talking with students, and visiting labs.
- High school students are assessed for their readiness for the dual-enrollment/college credit option. Students satisfying the requirements will be given the option to enroll in the college course, as well.

Spring Semester: Student-UT Collaborative Research

- High school students conduct research in collaboration with their partnered UT-Austin lab in the Freshman Research Initiative (FRI).
- High school students complete technical reports, present their findings, and present at the UT College of Natural Sciences Undergraduate Research Forum (April), as well as at the high school and/or regional science fair.
- High school students and teacher host an HRI Student Showcase event at their campuses (May, late). HRI students present their research findings in the form of an oral presentation with slides to their fellow students, parents, and school administrators.
- Enrolled high school students may receive the dual-enrollment course credit: college credit course HRI-Research Methods (NSC 309) and high school credit course in Scientific Research and Design [SRD, PEIMS: 8724.H900.Y (fall) and 8724.NC10.Y (spring)] or Project-based Learning in Project Lead the Way. However, students may withdraw from the University course at any point during the semester.

Summer: Student Fellowship Research

Over the summer, research fellowships are awarded to fund one student from each course section to conduct research at the partnered FRI lab.



Results

Current Evaluation Phase: Formative

Table 1: Five years of the High School Research Initiative (HRI)

Year 1 2016-17	Year 2 2017-18	Year 3: 2018-19	Year 4: projected	Year 5: projected
1 high school, 1 class section, 2 UT faculty collaborators, 3 UT peer mentors, 1 teacher, 10 students	4 high schools, 4 class sections, 4 UT faculty collaborators, 5 UT peer mentors, 4 teachers, 36 students	7 high schools, 9 class sections, 5 UT faculty collaborators, 9 UT peer mentors, 7 teachers, 104 students	9 high schools 12 class sections, 7 UT faculty collaborators, 11 UT peer mentors, 9 teachers, 180 students	9 high schools, 13 class sections, 7 UT faculty collaborators, 12 UT peer mentors 9 teachers, 195 students

Table 2: HRI Year 2

High School	No. of Students	Diversity	UT FRI Collaborator	Description of UT Collaborative Research Project
Austin High School (public)	14	50% Hispanic, 7% African American	Dr. Josh Beckham	Virtual Drug Screening lab -- HRI students develop a drug efficacy assay. This work involves expressing drug targeted proteins and using PyMol to visual potential drug docking sites. Discipline(s): biochemistry, molecular biology, and computational chemistry.
Travis High School (public)	7	71% Hispanic, 29% African American	Dr. Mary Ramsey	Fish Behavior lab -- HRI students study and predict fish behavios, such as social interactions and learning behaviors. Discipline(s): biology
St. Michael's Catholic Academy (private)	8	13% Hispanic, 13% African American	Dr. Tim Riedel	DIY Diagnostics lab -- HRI students study water quality. This work involves DNA amplification techniques (such as LAMP or qPCR) and some field biology work in the area of water collection. Discipline(s): biology, chemistry, and computer science
St. Dominic Savio Catholic High School (private)	10	30% Hispanic, 10% Native HI Pacific	Dr. Elizabeth Ilardi	Bioactive Molecules lab -- HRI students synthesize small-molecule drug candidates. This research includes compound purification and analytical analysis. Discipline(s): biochemistry and chemistry

It was one of the best PDs I've had as a science educator, because this is what I've been wanting to do with my students, but didn't know how to approach it, especially while teaching content.
Jennifer Giannou-Moore, teacher, Austin High School, 2016-18

Quotes from 2016-17 Austin High School HRI students:
It's a class unlike any other class you've taken and it sets you up to know … what you want to do in college. And it's still going to be a fun class …

When reporting the similarities between the HRI and other courses, one student said: *"Well, I mean it's in a classroom. There aren't a whole lot of similarities after that."*

Select Results from HRI, year 2:
Professional development was again highly-rated. *"[The teachers] were the students, it helped me to see how they might think about it".*

Students' value of science as an endeavor and confidence in their abilities seems to have been bolstered by HRI, increasing the students' interest in taking more science courses. Additionally, HRI teachers report that student interest and participation in science fair has increased as a result of participating in HRI.

Select Results from HRI, year 3:
~1/3 of HRI students will be the first generation in their families to attend college. These students are nearly all attending the public schools in the program with the largest percentages of these students centered in three of the four public schools (Akins, Del Valle and Travis).

Evaluation Plan

Summative Phase: Years 3-5

To determine the extent program participation affects:

1. Students' knowledge and skills, including their scientific literacy skills (Gormally et al., 2012), knowledge about experimental design, complexity of scientific reasoning, and scientific communication skills (program developed rubric for examining student knowledge and skills);
2. Students' attitudes, including their science motivation and as well as their scientific self-efficacy, science identity, and scientific values orientation (Estrada et al., 2011; Brussard and Carlson, 2014);
3. Students' educational pursuits, including their enrollment in higher education immediately after high school and their persistence in science majors;
4. Teachers', research collaborators', and near-peer mentors' abilities to mentor students in scientific inquiry (focus groups and interviews); and
5. Teachers' self-efficacy in using active learning and facilitative pedagogical techniques (Watson and Calligham, 2014).

Example: Question 1. What impact does participating in HRI have on students' knowledge and skills?

Sub-questions	Study Design	Data Collection Tool(s)
To what extent do students show improvement in their scientific literacy skills?	Pre and post with comparison group	Test of scientific literacy skills (Gormally et al., 2012)
To what extent do students show improvements in their scientific self-efficacy, interest in persisting in STEM majors in college?	Pre and post with comparison group	Survey of student attitudes (Estrada, et.al, 2011) and study developed survey items.
To what extent do students engage in complex reasoning about their scientific inquiries/research?	Post-hoc analysis of student work (research proposals, end-of-course presentations)	Rubric for evaluating complexity of reasoning during scientific inquiry
To what extent can students effectively communication about their research?	Post-hoc analysis of student work (research proposals, end-of-course presentations)	Rubric for measuring the effectiveness of scientific explanations (HRI developed)

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