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The High School Research Initiative Prepares and Supports Texas Science Teachers Doing Research in Their Classrooms

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ABSTRACT

Many Texas science teachers, especially in rural areas, lack access to content specific, inquiry-based professional development. To address this, UTeach and the Freshman Research Initiative partnered to create the High School Research Initiative (HRI), offering research-based curricula, training, and classroom support. The HRI leads teachers in a two-week research methods course and provides standard-aligned training in biomedical and behavioral research modules—Fish Behavior, Caffeinated Coli, Habitat Scouts, and Virtual Drug Screening—informed by active university research. Teachers receive lesson plans, activities, and materials to implement the modules in their classrooms. A mixed-methods evaluation revealed increased teacher preparedness, strong community support, and successful classroom integration. This paper outlines the HRIs' model, highlights its impact, and offers strategies for preparing in-service science teachers.

Keywords: high school teacher professional development, high school research, rural STEM education, science inquiry training

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INTRODUCTION: OVERVIEW OF THE HRI AND THE UTEACH CONNECTION

Many Texas science teachers are underprepared due to a lack of science-specific professional training. When they experience low pay, excessive workload, dissatisfaction with administrative support, and a lack of personal autonomy, teachers leave the profession (Pressley, et al., 2025), and minimal training further stacks the odds against them. These shortcomings are exacerbated by the rise of alternative certification programs that fail to include science inquiry training and the decrease in the number of certified STEM teachers overall (Marder, M., 2025). Since 2010, a lack of training and support has resulted in secondary science teachers in Texas leaving the field at higher rates than in any other subject area (Horn, et al., 2021). Teacher preparedness issues are particularly acute in rural and small-town schools, where nearly 75% of new teachers hired last year are uncertified (Van Overshelde, et al., 2024; Marder, 2024). In addition, rural teachers often lack access to nearby universities, have multiple daily class preparations, and may be the sole science instructor for all four high school grades. Limited funding for science materials, lower salaries, fewer mentors, and higher poverty rates within the community further challenge success in rural settings (Sacharczyk, 2014).

However, there is hope to improve teacher preparedness. High-quality professional training, such as that provided by the University of Texas UTeach program, significantly improves teaching quality and student learning outcomes in science (Backes, et al., 2018). The UTeach program prepares undergraduate students to pursue careers in math, science, and computer science. By combining subject-specific coursework with hands-on teaching experience, these preservice teachers gain practical teaching skills while completing their undergraduate degrees. According to data from 2011--2016, secondary school students taught by UTeach Austin trained teachers perform significantly better in math and science, achieving 4--6 months more learning over a nine-month school year than do those taught by non-UT graduates (Backes, et al., 2018). However, UTeach Austin currently produces fewer than 20 science teachers a year of more than 100,000 science teachers who are employed in Texas.

Given this need to improve access to high-quality teacher preparation experiences in Texas on a broader scale, UTeach sought to expand its reach to serve in-service Texas teachers. The expanded effort was achieved through a partnership with the UT Freshman Research Initiative (FRI), an organization with over 30 undergraduate research groups and almost 20 years of experience developing course-based

research experiences that build science efficacy and interest in STEM fields for undergraduate students (Rodenbusch, et al., 2016). Given that positive attitudinal gains can also be applied to high school students carrying out research (reviewed in Al-Thani and Ahmad, 2025), UTeach and the FRI joined forces, creating the High School Research Initiative (HRI). Broadly, the specific aims of HRIs are to provide in-service teacher training, curricula based on ongoing FRI research, and a supportive community consisting of university faculty, undergraduate near-peer mentors, high school teachers, and students.

To meet program goals and support teacher participants, the HRI integrates key components from UTeach's highly successful teacher certification program. The HRI professional development, led by UTeach Master Teacher Deanna Buckley, a veteran educator with 40 years of classroom experience, mirrors UTeach's research methods course by fostering open inquiry and building in-service teachers' confidence to guide students in their own inquiries. Additionally, this training emphasizes project management, formulating testable questions, and conducting safe inquiries via UTeach's project-based instruction curriculum. Notably, UTeach's Classroom Interactions course, which helps preservice teachers use technology for classroom management and accommodates diverse learners, is also embedded into HRI teacher training. Beyond HRI teacher training, UTeach principles extend into HRI lesson plans, which follow the 5E learning cycle format used in UTeach's Step 1 and 2 field courses, further integrating research-based practices to improve both student and teacher outcomes.

In an interest in bettering teacher preparedness, this manuscript details the essential features of the HRI, which is funded by the NIH NIGMS Science Education Partnership Award (SEPA) and serves to improve science teacher readiness and teaching quality. This manuscript describes the goals of HRI teachers, provides details of teacher professional development, shares information about the curricular modules, includes how the teachers implemented the modules, contains information on how others might implement a similar program, reports major outcomes, and provides lessons learned with the next steps.

METHODOLOGY

Goals for the HRI Teachers

The primary objectives of the HRI program are to empower high school teachers; provide them with the necessary skills, knowledge, and resources; support their research experience in the classroom; and facilitate the desired attitudinal outcomes for their students. The goals for the teachers include the following:

- High school students' scientific motivation, efficacy, and identity should be cultivated while their interest in pursuing educational and research goals in biomedical and behavioral sciences should be encouraged.
- Build a foundational understanding of STEM content in key areas, including biology, molecular biology, microbiology, ecology, and/or environmental science, to lead the classroom research experience.
- Technical skills for scientific research, such as maintaining lab safety practices, recording observations, designing experiments, using micropipettes, culturing and quantifying bacteria, collecting and organizing data in spreadsheets, applying statistical tests to analyze groups, and interpreting findings, should be developed.
- The 5E Learning Cycle (Engage, Explore, Explain, Elaborate, Evaluate) is applied to create and deliver effective project-based instruction.
- Collaborate actively within a community of high school teachers, students, university faculty, and undergraduate students to share knowledge, resources, and mutual support.

Teacher Professional Development

The High School Research Initiative (HRI) leads annual multiweek summer professional development (PD) and provides monthly training sessions throughout the year for teachers to facilitate inquiry-based teaching in their classrooms. Inquiry-based teaching has been shown to improve job satisfaction, increase teacher retention, and improve student learning (Pongsophon, 2017; Toropova, 2021). The engaging, discussion-based virtual summer professional development is led by university faculty and a UTeach master teacher. The summer training includes a two-week UTeach Research Methods experience and Research Module training. These PD sessions focus on experimental design, lab techniques and procedures, lab safety, scientific writing, statistics, mathematical modeling, research content, etc.etc. Sessions are recorded and accompanied by editable presentation slide decks for flexible, asynchronous review. Ongoing teacher support and training are provided via regular check-ins, mentoring, monthly training sessions, and one-on-one office hours with faculty and near-peer undergraduate mentors.

The monthly training sessions are based on teacher-suggested topics, such as teaching chi-square data analysis, finding data resources, learning from mistakes, and walking through examples of student-generated data. This multilayered approach helps teachers develop and share knowledge, practice authentic scientific methods, and connect high school students with current science research.

Overview of Research Modules

To provide teachers with authentic research experience that builds students' scientific motivation, efficacy, and identity, the High School Research Initiative (HRI), in collaboration with the Freshman Research Initiative, developed research modules rooted in ongoing biomedical and behavioral research at the University of Texas. Each module includes 5E lesson plans detailing data collection and statistical analysis, lecture slides, classroom activities, module timelines, alignment with 2024 Texas high school TEKS teaching standards and Next Generation Science Standards (NGSS), and protocols created by UT faculty and undergraduate peer mentors. The HRI student learning outcomes align with those in the UTeach Research Methods course and include critical thinking and research design skills, as students execute research projects and communicate findings through written, oral, and visual modalities. During summer professional development, teachers work directly with HRI faculty and undergraduate peer mentors for a given module to provide project-specific training. This professional development is designed to be interactive and dynamic so that teachers can master the research material, ask questions, and develop strategies for integrating it into their classroom.

The HRI field-tested four Research Modules from 2023--24 from FRI research collaborations: Fish Behavior, Habitat Scouts, Caffeinated Coli, and Virtual Drug Screening (VDS). These research modules are described below.

The HRI Fish Behavior module is an outgrowth of the [FRI Fish Behavior Lab](#). It condenses the FRI curriculum into three core units via prerecorded behavior trials and includes the option of having live fish observations and behavior assays in the classroom. Each unit contains a mini-research project presentation and reflection opportunity to assess student understanding of the material and an option for a larger-scale research presentation at the conclusion of the module. The first lesson introduces fish behavior, featuring elements of experimental design and basic research methods as students learn to recognize and quantify social interactions (such as mating and aggression) in community tanks. The next two lessons utilize the basic skills acquired in lesson one to develop hypotheses and predictions via controlled behavior experiments. HRI students explore sex and species differences in anxiety/exploration tendencies and problem-solving/cognitive abilities. All aspects of the curriculum are designed to be incredibly relevant to high school students. For example, as students learn to test and quantify anxiety-related behaviors in fish, teachers can broach topics related to mental health, anxiety, and wellness in the classroom.

The Habitat Scouts module involves collaboration with the FRI Urban [Ecosystems Lab](#)) and includes the collection of data near greenspaces in the participants' local area. The larger research question for this HRI module concerns how different greenspaces impact the environment and how human activities impact greenspaces (e.g., urbanization on soil health or insect life). Using the provided guidelines, classes choose greenspaces in their local area to study, typically near the school, visiting each site a few times per week over five weeks. No previous experience or special equipment is needed. The data collected included interviews with community members, site mapping, GIS measures of land use, quantification of human impact, surveys of insect biodiversity, soil profiling, and investigations of soil microbe health. In the end, students upload the data onto an online database and create figures with a subset of their data, providing valuable data that allows analyses across greenspaces.

The Caffeinated Coli module was developed by the FRI [Microbe Hackers Lab](#) which focuses on education and synthetic biology research (for an overview of research, see Quandt, et al., 2013). The HRI Caffeinated Coli module utilizes *E. coli* strains that have been genetically engineered to rely on caffeine or other methylxanthines (e.g., theophylline or theobromine) to develop a bioassay to test caffeine concentrations in everyday items. In this module, students learn that this modified *E. coli* strain was created through two steps: first, removing one of the key guanine biosynthesis genes in *E. coli*, and second, adding a plasmid that allows the bacteria to use an alternative, synthetic pathway to make guanine from caffeine. The module introduces how these bacteria can be used to accurately detect the amount of caffeine in a beverage at a level comparable to that of an HPLC instrument (Gutierrez, et al., 2019). Students then conducted this bacterial bioassay using the Caffeinated Coli strain provided with the module and known caffeine standards. After completing this first attempt, students then engage in an inquiry where they investigate the caffeine content of a liquid of their choosing, again using the bioassay and analyzing the data from their experiment.

The Virtual Drug Screening module is based on the similarly named FRI research lab, Virtual Cures, which seeks to identify new chemical compounds that may serve as drugs against infectious diseases caused by bacteria (e.g., tuberculosis, staph infections, *E. coli*, bubonic plague; Ghanem, et al., 2018). The HRI portion of this work focuses on the TEM-1 protein, which is involved in antibiotic resistance. *E. coli* bacteria that harbor this protein are more drug resistant. In this project, HRI students use recombinantly engineered bacteria that carry a DNA plasmid containing the genetic sequence to produce the TEM-1 protein. Students then grow the bacteria on agar plates and determine if a certain

drug inhibits growth via antibiotic disc diffusion assays. Students explore which chemical compounds—known drugs and novel chemicals they choose to test—inhibit the function of the TEM-1 protein in particular or act as antibiotics through other mechanisms. Students also use an online molecular visualization program (iCn3D) to view what the TEM-1 protein looks like and the potential binding interactions between the drugs and the protein to better understand the molecular basis for drug action in a ‘hands-on’ way, as they manipulate the molecular representation. Students develop skills in molecular and microbiological lab techniques, troubleshoot experiments, and data collection with analysis of results.

Participants: Teacher Recruitment and Module Implementation

Teachers are the central focus of the High School Research Initiative (HRI), which plays a crucial role in integrating the various components of the program. Teachers are empowered to shape the Research Modules and their implementation in the classroom. Veteran teachers mentor new teachers, share the results of their work at conferences, and even assist with recruiting efforts, encouraging new teachers to participate.

In the program’s first six years, the HRI primarily recruited central Texas teachers, many of whom had completed UTeach preservice courses. Currently, in the program's ninth year, the HRI prioritizes rural Texas teachers. While the program accepts all teachers who have completed the application materials, the HRI will prioritize rural, uncertified/alternatively certified Texas teachers without UTeach experience as the program continues to grow.

Many teachers learn about HRIs through word-of-mouth, the Science Teachers Association of Texas CAST conference, or the [HRI website](#). To better reach rural educators, the HRI plans to begin advertising in local newspapers. Advertising and teacher recruitment materials emphasize the program’s offerings, including the UTeach master teacher-led training, standard-aligned curriculum, 5E lesson plans, financial support, consumables and equipment, CPE and G/T credits, and connection to the HRI faculty and undergraduate mentors.

Once accepted, the HRI teachers are matched with a research module of their choice, participate in annual multiweek online summer professional development (as described above), and implement the research module in their classrooms. In the first years of the HRI program, teachers were invited to attend the summer professional development for any or all of the research modules that interested them. Based on teacher feedback, we now offer the selection of one primary research module, with the option to add the Habitat Scouts Research Module, requiring minimal equipment and preparation. All former HRI teachers are invited to

participate in annual summer professional development, allowing them to refresh their training in a previous research module or explore a new one.

Table 1: Description of the 2023–24 HRI teacher participants.

Teacher	District Type	Private / Public School	Module(s) Implemented	Course(s)	Grade Level
A	Rural	Public	Caffeinated <i>Coli</i> , Habitat Scouts, Fish Behavior, VDS	Scientific Research and Design	12 th
B	Rural	Public	Habitat Scouts, Fish Behavior	Environmental Systems, Aquatic Science	11 th - 12 th
C	Rural	Public	Habitat Scouts	Environmental Systems	11 th - 12 th
D*	Urban	Private	Caffeinated <i>Coli</i> , VDS	n/a	NA
E	Urban	Private	Fish Behavior	Research Course	12 th
F	Urban	Private	Habitat Scouts, Fish Behavior, Caffeinated <i>Coli</i> , VDS	7th grade science, 8th grade science, Biology, Chemistry	7 th - 11 th
G	Urban	Public	Caffeinated <i>Coli</i>	Medical Microbiology	12 th
H	Urban	Public	Caffeinated <i>Coli</i>	n/a	Unknown

Teacher D (*) attended the HRI summer professional training asynchronously, viewed the videos afterward, and then elected to synchronously attend the HRI PD the following summer. Teacher H did not respond to inquiries about the grade level and course containing the HRI curriculum.

How Others Might Implement Something Similar

The High School Research Initiative (HRI) is committed to disseminating details important for program replication. This section offers guidance on how others might establish a similar teacher preparation program. For example, critical programmatic roles include the director for program oversight, the UTeach Master Teacher for teacher and mentor training, and the program coordinator for daily operations and curriculum development.

To prepare participants for the HRI program, several safety and administrative steps are implemented. A human research plan undergoes Institutional Review Board (IRB) review to ensure participant privacy protection during program evaluation, whereas biosafety protocols approved by the Institutional Biosafety Committee (IBC) address laboratory hazards and safe material disposal. Faculty and staff complete Youth Protection Training to work with minors. Teachers complete a short HRI application requiring a brief letter of support from their principal and accept that participants sign a memorandum of understanding (MOU) detailing responsibilities. During the summer training, teachers complete the Texas Education Agency (TEA), general laboratory and module-specific safety training. Before classroom implementation, teachers conduct a risk assessment with their students, and the HRI director handles material transfer agreements to transfer biological materials to the classroom.

RESULTS

Building on the UTeach model, the High School Research Initiative (HRI) provides in-service teacher training led by a UT Master Teacher, equipping high school teachers to facilitate inquiry-driven science experiences in their classrooms. Since 2016, the HRI has hosted eight multiweek summer professional development sessions, partnering with over 27 teachers from 25 schools and impacting over 400 high school students.

This section presents the results of 2023--2024, during which the program shifted to prioritize rural teachers while continuing to welcome all interested teacher participants. During this timeframe, the HRI partnered with eight teachers: three from rural public schools and five from urban/suburban schools (three private and two public schools; see Table 1). Only one of these teachers had previous UTeach training prior to joining the HRI. Teacher preparation and certification status were not selection criteria during this time; however, three or more teachers in this cohort were either alternatively certified or not certified.

In 2023--24, eight HRI teachers implemented the following research modules: five implemented caffeinated coli, four implemented habitat scouts, four implemented fish behavior, and three implemented virtual drug screening (see Table 1). These Research Modules were implemented in dedicated research courses, such as Environment Systems, Aquatic Science, Biology, Chemistry, Medical Microbiology, or a general science course (see Table 1). In alignment with the flexibility of the research modules, HRI teachers often adapt the modules to fit their

schedules and customized implementation on the basis of their students' needs and course requirements.

To further evaluate the impact of this recent iteration, two focus groups were conducted: the first after the summer professional development sessions and the second after implementation of the module(s) in the classroom. The teacher participants felt that professional development workshops were well facilitated, appreciating the number of strategies used, such as interactive slides, breakout discussions, live demonstrations of the modules, and talks with undergraduate mentors.

Eighty-nine percent of the teachers rated professional development a 5 of 5, describing it as “very engaging, one of the best workshops I have ever attended.” They reported feeling prepared to implement the modules in their classrooms. Teachers appreciated that the modules included data analysis and statistics applied to real research and that they could attend monthly training sessions to learn more techniques. The teacher with prior UTeach training noted that while the information in the HRI professional development was not new to them, they valued the opportunity to “reinforce prior concepts [learned], especially with how to guide high school students on how to set up experiments, controls, and use Google Sheets for data collection and analysis,” and commented, “Because of that training, I actually taught my students how to do ANOVA.”

Teachers also appreciated the sense of community; as one teacher shared, “Something I truly appreciated about the class was being in community with other teachers who care and have passion for their work. It helps to rejuvenate me, fill my cup again before my back to school.” Overall, teachers felt that HRI professional development and ongoing training were valuable to them as teachers and as lifelong learners.

Teachers reported that the modules were successful in their classrooms. Specifically, they reported that the module lessons were easy to implement and highly customizable, which they appreciated. Teachers felt that the modules were challenging but still at an appropriate level for high schoolers. One teacher successfully modified lesson plans for middle school students (see Table 1).

The HRI modules helped spark students' curiosity and interest in science by involving them in ‘real’ science via current laboratory techniques. One student, for example, said, “The most memorable part is the fact that we are doing an actual lab that helps us investigate antibiotics and how they work. Learning how to parafilm, spread bacteria or IPTG on the disks, and observe the results helped us develop many new skills.”

The inquiry-based nature of the lessons, where there is not always an easy ‘right answer,’ encouraged problem solving. One teacher reported, “There's a lot of high school experiments that are like, okay, you do this,

and it works because this lab has been done 100 million times... In addition, so, it is truly cool for me to be able to come into class in the morning [when something doesn't go according to plan] and say, make a hypothesis. What do you think is going wrong?"

The HRI faculty researchers reported feeling positively about the opportunity to adapt their research for, and engage with, new audiences. Additionally, the faculty valued the opportunity to explore new areas of their research and generate new scholarly work, especially in the form of publications.

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

In collaboration with UTeach, the High School Research Initiative (HRI) has made significant strides in improving teacher preparation so that Texas high school teachers can lead STEM research experiences in the classroom. Overall, the HRIs demonstrate the sharing of university expertise, biomedical and behavioral science content, and research with high school classrooms. The program sparked student curiosity and interest in science. Teachers reported being prepared to lead STEM research experiences in their classrooms and felt supported by the HRI community.

Positive feedback and the experiences of the participating teachers reflect the program's impact; however, insights from these experiences have highlighted key areas for improvement to strengthen the program for all those involved. Specifically, the lessons learned point to the need for more effective recruitment of the target audience, further division of the modules into curricular pieces, better content alignment with the required courses/coursework, and strategies to improve teacher retention.

Although the current iteration of this program focuses on engaging rural teachers and classrooms, early results—showing that only three out of the eight schools fit this criterion—suggest that this will be a more challenging goal than originally anticipated. Early efforts, such as attending conferences for rural educators and the USPS letter campaign, while resource intensive, were only marginally successful, if at all. On the basis of these insights, and after communicating with other outreach organizations with similar aims, we will adjust our efforts toward local rural newspaper advertisements and possibly an online campaign via Google.

Furthermore, while well received, the research modules could be improved in terms of their structure and overall content. Teachers rarely implemented the Research Modules as designed; instead, many spread the curriculum over many weeks, often squeezing in other curricular content amid the research experience. Since this flexibility is integral to courses,

moving forward, the HRI modules adapt by being further broken down into smaller, more manageable units. Similarly, better alignment of the research experiences with the required courses and standards (i.e., TEKS and NGSS) will be prioritized, allowing smoother integration into the required courses.

Teacher retention, particularly in STEM fields, remains a national problem, and HRIs are not exempt from this issue. We have seen HRI teachers leave the teaching profession, especially those participating in the earlier versions of this program. Supporting teacher retention and job satisfaction, especially among uncertified educators who are more likely to leave, is crucial (Marder, 2024). Moving forward, we prioritize program components that foster long-term support, community, satisfaction, and resilience for teachers. Targeted support will also focus on educators at risk of leaving, including those who may be the sole science teachers at their schools.

With the combined expertise of UTeach and the HRI in teacher preparedness, we are well positioned to continue advancing the mission to support Texas science teachers and enhance STEM education in schools across the state.

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Bios

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