RET: Teachers Views on Science and Engineering after Participation in a Sensing and Measurement Focused Site

Dr. Todd Freeborn, The University of Alabama

Todd Freeborn, PhD, is an associate professor with the Department of Electrical and Computer Engineering at The University of Alabama. He has coordinated REU, IRES, RET, IUSE, and S-STEM programs supported by the National Science Foundation, with many of these programs focused on increasing engagement of engineering students in research. His research focuses on techniques to collect and analyze the electrical impedance of biological tissues, the use of fractional-order equivalent circuit models, and exploring impedance-based sensing for health-focused applications.

Dr. Chris Smith Crawford, The University of Alabama

Dr. Chris S. Crawford is an Associate Professor at the University of Alabama's Department of Computer Science. He directs the Human-Technology Interaction Lab (HTIL). His research focuses on human-robot interaction and Brain-Computer Interfaces (BCIs). He has investigated systems that provide computer applications and robots with information about a user's cognitive state. He previously developed the first brain-drone racing system that was featured on over 800 news outlets including Discovery, USA Today, and the New York Times, and Forbes. Along with investigating brain-robot interaction applications, Dr. Crawford also developed Neuroblock, a tool designed to engage K-12 student in neurofeedback applications development.

Dr. Sarah T Dunlap, The University of Alabama

RET: Teachers Views on Science and Engineering after Participation in a Sensing and Measurement Focused Site

Introduction

The National Science Foundation (NSF) Research Experiences for Teachers (RET) program supports summer research experiences for K-14 educators to enhance their scientific disciplinary knowledge in engineering or computer science and translate their research experiences into classroom activities and curricula to broaden their students' awareness of engineering education and career pathways. Recently RET sites have focused on advanced manufacturing/robotics [1, 2], semiconductors [3], and data science [4], highlighting a few (but not exhaustive) set of themes used to introduce K-14 educators across the country to engineering research. One of the motivating goals for RET programs is to improve their students achievement in science and engineering, which has been successfully demonstrated by the program at Columbia University with reported an average of 15.5 more students passing a science exam per participating teacher compared to non-participating teachers [5].

In 2025 our RET site (funded by the NSF) launched at the University of Alabama with a common theme of technologies and applications of sensing systems for physiological and environmental monitoring. This theme was selected because knowledge of how to measure physical quantities of materials, devices, tissues, and the environment is critical to answering research questions across all engineering domains. This then leads to a strong alignment of projects with national and state goals of integrating engineering design and engineering design practices within the context of science content creation.

In the second year of our RET, 11 science and math teachers from middle schools in Alabama participated in research and professional development workshops over 7-weeks. Teachers in our RET site joined us on-campus for 7 weeks at the University of Alabama during June 2025 and July 2025. Each teacher committed to 35 hours per week which were spread across weekly workshops (6-8 hours per week on engineering, sensors/programming, education/curriculum topics), faculty-mentored research (24-26 hours per week), and peer-share sessions (1-2 hours per week). The program concluded with a poster symposium where teachers presented their research to faculty, engineering students, previous RET participants, and other professionals on campus.

Previously, our team reported on the lessons learned from the first site iteration [6]. Here we present the impact of implementing those recommendations and 2025 participant feedback. This work will present the aspects of the program that contributed most to teachers positive and negative feelings and how their views of science and engineering were changed through this process. This is expected to support other engineering educators who are planning to launch an RET site or revise an existing site.

Year 1 Recommendations

After the evaluation of our first year the team had recommendations on how to improve future iterations of the RET site [6]. A summary of the specific recommendation's that were implemented and their impact on the second iteration of the program are outlined below:

- **Communicating Expectations:** The following recommendations were implemented to increase attendance and participation after not meeting our expectations in Year 1:

  1. Attendance requirements were more clearly outlined in all recruitment information and the online program application,

  2. It was communicated in all recruitment information and offer letters that extended absences for vacation/professional development would reduce stipend payments,

  3. Questions in the program application were added to determine if applicants had summer commitments that overlap with the RET prior to making offers.

  These changes improved overall attendance/participation with the 2025 cohort attending on average 31 of 33 days (95%) compared to 25 of 32 days (78%) for the 2024 cohort.

- **Evaluation / Assessment:** The following recommendation was implemented after the evaluation and assessment completion rates did not meet our expectations and limited the data for program evaluation:

  1. One hour each day was allocated during the first and last weeks to work on a subset of the online surveys until the teachers completed them all.

  These changes improved the completion rate reaching approximately 90% with the 2025 cohort compared to 27% with the 2024 cohort.

- **Curriculum Support:** The following recommendation was implemented to help teachers plan lessons and activities for their classrooms after receiving feedback about this as a challenging aspect of the program:

  1. Two hours weekly was dedicated to teachers planning activities, getting support from the PI, and preparing material orders so teachers had everything needed to launch activities in their classroom. For further context, teachers in our RET have a budget of up to $2000 to spend on materials/supplies after completing the RET program.

  As a measure of the impact of this change, only 4 of the 11 2024 teachers (36%) had purchased materials within six months of the summer program completing. This increased to 6 of 11 teachers in the 2025 cohort (54%). Also, two teachers from the 2024 cohort purchased their materials with support from a 2025 cohort teacher who made their purchases during the summer, highlighting the ripple effect of this change. As an example of how this change impacted teachers, the following response was provided in the post-program survey when teachers were asked about the workshops: *"I'm especially thankful that [PI] was willing to step in and assist with the mBot2, which uses a block-based coding system that is much more accessible for 6th graders. His support made a big difference and helped me feel more confident about using this technology with my students."*

Based on the positive effects of all these changes in year two they are recommended to be continued for the third iteration of the program in 2026.

Evaluation and Assessment Surveys

To evaluate teacher satisfaction and perceptions of the RET, teachers were invited to participate in online surveys by the external evaluation team from the Institute of Social Science Research (ISSR) at the University of Alabama. The survey included items measuring teachers' satisfaction with various aspects of the program, attitudes toward teaching science and engineering, and self-reported knowledge gains regarding engineering and research. Additionally, on the final day of the program the evaluation team conducted a focus group during which feedback/discussion from the teachers was solicited. This focus group feedback was then summarized for the program coordinators. The evaluation details from a few of the evaluation questions are provided below to highlight the positive and negative elements of the second iteration of this RET site:

- **Overall Program Evaluation:** On the post program survey, using a 5-point scale where 1 is poor and 5 is excellent, teachers provided an overall mean rating of 4.5 for the program. This supports that the 2025 cohort had a very positive experience. To further evaluate what elements contributed to their experience, teachers rated their level of agreement with a series of statements. A 5-point scale was used to capture how strongly they agreed with statements describing either the nature of the program (e.g., was challenging, provided mentorship) or its impact on their teaching (e.g., gave me opportunities to learn new skills for my classroom). Mean ratings ranged from 3.90 to 4.60, indicating that overall teachers had positive experiences. The highest rated items were 1) provided me with mentorship, 2) gave me insight into emerging areas of research and challenges in engineering and computer science, and 3) provided me with the opportunities for networking that will impact my work in schools. Each of these items received a mean rating of 4.60 indicating that in general, the majority of teachers (n = 7 - 8) strongly agreed with these items. The lowest rated items were 1) helped me feel confident in my ability to teach science, 2) helped me feel confident in my ability to engage my students in research, and 3) was challenging. While these were the lowest they were still rated between 3.90 and 4.00 on the five-point scale indicating that most teachers agreed they benefited from these aspects of the RET.
- **Positive Experiences**: On the post program survey teachers were asked to rank which components contributed the most to positive feelings about the RET. The top five results were 1) spending time with your peers, 2) learning new skills that I could use in my classroom, 3) networking opportunities, 4) interactions/guidance from mentor, and 5) learning to code. Additionally, teachers were asked to describe the best parts of the program in an open-ended question. Teachers described the RET program as a transformative professional experience that deepened their content knowledge, strengthened their teaching practice, and rekindled their passion for learning. Many highlighted the value of engaging in real-world STEM research and gaining firsthand insights into how classroom concepts apply in professional settings. The program expanded their mathematical and analytical skills, improved their ability to design authentic and student-friendly lessons, and exposed them to new career pathways to share with students. Equally meaningful was the sense of community with teachers noting they valued networking with peers, professors, and

Aspect of the Research Process	Post	Pre
Collecting data	4.30	2.90*
Designing a research poster/presentation	4.10	2.10*
Presenting research findings	4.00	2.40*
Preparing a research presentation	3.90	2.50*
Managing a research project	3.40	2.10*
Troubleshooting problems	3.90	2.80*
Interpreting research findings	4.00	2.90*
Designing a research study	3.60	2.60
Performing a literature review	3.10	2.40
Research process (n = 9)	3.78	3.20
Developing research questions	3.30	3.00

Table 1: Questions about teachers knowledge of aspects of research process and their mean values at pre and post timepoints. Asterisks (*) denote where post-program mean values are statistically significantly different ($p < 0.05$) than the pre-program values based on a paired samples student t-test.

professionals, which fostered collaboration and provided long-term support. Several expressed that the program reignited their own love of learning, inspired them to pursue further education, and boosted their confidence to take on new challenges. As an example, one participated reported *"This program helped me to believe that even at the age of 47, I am still capable of learning new content that initially seems challenging."*

- **Negative Experiences**: On the post program survey teachers were asked to rank the factors that contributed to any negative feelings. One teacher reported that nothing contributed to negative feelings in their open-ended response and therefore did not complete the ranking. Among those who did the top five factors identified were: 1) lack of assistance or development of technical skills applicable to the classroom, 2) the research project itself, 3) developing education modules, 4) weekly seminars, and 5) limited mentor contact. These highlight programmatic aspects that our team can further explore to continue improving the teachers experiences in year 3.

- **Knowledge of Research Process**: On both pre- and post-program survey, teachers were asked to rank their knowledge about specific aspects of the research process where 1 is "Not at all" and 5 is "Substantial", with each of the specific aspects given in Table 1. The mean values at both pre and post-program timepoints for all aspects are also given in Table 1. Overall, teachers' reported knowledge gains in all aspects with the greatest increases for 1) designing a research poster/presentation, 2) presenting research findings, 3) collecting data, and 4) preparing a research presentation. To evaluate if these increases were statistically significant, a paired samples t-test was applied. All items except designing a research study, performing a literature review, developing research questions, and research process overall had statistically significant ($p < 0.05$) increases. This supports that this RET program did yield improvements in teachers perceptions of their knowledge related to research.

- **Teacher Attitude Scale**: Before and after the RET program, teachers completed the

Teacher Attitude Scale Characteristic	Post	Pre
Enjoyment of STEM Subjects	4.70	4.65
Improving Abilities to Teach Engineering	4.82	4.86
Pedagogy for Teaching Engineering	4.93	4.78
Relevance of Engineering	4.80	4.75
Characteristics of Engineers	4.42	4.38
When to Teach Engineering	4.46	4.44

Table 2: Teacher Attitude Scale (TAS) characteristics and their mean values from 2025 RET participants at pre and post timepoints. Note: Pre and post-program values are not statistically significantly different ($p > 0.05$) based on a paired samples student t-test.

> Teacher Attitude Scale (TAS) [7]. This is an instrument designed to assess teacher's perceptions and attitudes toward engineering, including their confidence in teaching engineering concepts, their recognition of its relevance to students, their willingness to integrate engineering activities into their curriculum, and their understanding of careers in engineering. This instrument has 30 questions which are grouped into one of six characteristics (which are outlined in Table 2. The average rating from 1 (lowest agreement) to 5 (highest agreement) of responses for each grouped characteristic at the pre and post timepoints are given in Table 2. From a paired samples t-test of the pre and post program values, there was not a statistically significant difference for any category. This is attributed to the small sample size, the limited variability in responses, and the high values of responses. These suggest strongly positive teacher attitudes toward teaching engineering prior to the program (which would be difficult to increase or improve on). While participation in the program did not increase the already highly positive attitudes towards teaching engineering, it is important to note it did not decrease them either supporting that our program and its activities did not negatively influence teachers perceptions.

Conclusion

The implementation of recommendations after our first iteration of our RET site improved attendance, evaluation/assessment completion rates, and curriculum development (as evidenced by teachers purchasing materials for their classrooms). With the increased completion rates of surveys for evaluation and assessment, teachers in the second iteration reported high-satisfaction with the program and its elements as well as improvements in their perceptions of their knowledge related to engineering.

Acknowledgments

This material is based upon work supported by the National Science Foundation, specifically the Division of Engineering Education and Centers in the Directorate for Engineering, under Grant No. 2302144. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

[1] M. B. Sarder, “Board # 283: Nsf ret: Empowering stem educators and revitalizing manufacturing in the u.s. midwest,” in *2025 ASEE Annual Conference & Exposition*. Montreal, Quebec, Canada: ASEE Conferences, June 2025. doi: 10.18260/1-2–55647

[2] F. Aqlan, “Board # 235: Developing the next generation of stem innovators: Ret site in manufacturing simulation and automation at the university of louisville,” in *2025 ASEE Annual Conference & Exposition*. Montreal, Quebec, Canada: ASEE Conferences, June 2025. doi: 10.18260/1-2–55594

[3] H. Mehraban, J. D. Cribbs, E. Dyke, J. Stine, and J. Hu, “Board # 297: Ret: Acquisition and retainment of semiconductor knowledge among k-12 stem teachers,” in *2025 ASEE Annual Conference & Exposition*. Montreal, Quebec, Canada: ASEE Conferences, June 2025. doi: 10.18260/1-2–55662

[4] K. G. Herbert-Berger, T. J. Marlowe, V. Anu, and S. A. Robila, “Board 326: K-12 teachers and data science: Learning interdiscplinary science through research experiences,” in *2024 ASEE Annual Conference & Exposition*. Portland, Oregon: ASEE Conferences, June 2024. doi: 10.18260/1-2–46906

[5] S. C. Silverstein, J. Dubner, J. Miller, S. Glied, and J. D. Loike, “Teachers’ participation in research programs improves their students’ achievement in science,” *Science*, vol. 326, no. 5951, pp. 440–442, 2009. doi: 10.1126/science.1177344

[6] T. Freeborn, C. S. Crawford, and E. M. Steele, “Board # 298: Ret: Year one lessons-learned from a sensing and measurement focused site for middle school math and science teachers,” in *2025 ASEE Annual Conference & Exposition*. Montreal, Quebec, Canada: ASEE Conferences, June 2025. doi: 10.18260/1-2–55663

[7] C. P. Lachapelle, J. D. Hertel, M. F. Shams, C. S. Antonio, and C. M. Cunningham, “The attitudes of elementary teachers towards elementary engineering (research to practice),” in *2014 ASEE Annual Conference & Exposition*. Indianapolis, Indiana: ASEE Conferences, June 2014. doi: 10.18260/1-2–23121