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BOARD # 298: RET: Year One Lessons-Learned from a Sensing and Measurement Focused Site for Middle School Math and Science Teachers

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Introduction

The National Science Foundation (NSF) Research Experiences for Teachers (RET) program supports summer research experiences for K-14 educators. The goal of these experiences is 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 [1].

In 2024, the College of Engineering at the University of Alabama (UA) launched an RET site focusing on the applications of sensing technologies for physiological and environmental monitoring. The selection of this theme reflects the importance of measuring the physical quantities of materials, devices, tissues, and the environment to address research questions across all engineering domains. This approach aligns projects with national and state goals of integrating engineering design and practices into science content creation. For the first iteration of this RET, projects from electrical engineering (measuring biological tissue electrical impedance), mechanical engineering (tracking movement using video data), chemical engineering (measuring polymer dielectric properties), civil engineering (measuring concrete maturity), and computer science (integrating programming into STEM focused activities) were available for participants.

The following sections outline the recruitment of the first cohort, the program structure, focus group feedback on the program from participants, and lessons learned from Year 1 (both from a coordination perspective and based on teachers focus group feedback). Recommendations from lessons learned are provided to guide the second iteration and help other educators interested in planning or revising their own RET site.

Recruitment & Participation

To recruit middle school science and math teachers in west Alabama, our program team utilized networks with local school districts established by the UA Center for Community-Based Partnerships and the Alabama Math, Science, and Technology Initiative (AMSTI). Through targeted email outreach, we recruited 11 teachers for the first RET cohort. Based on the self-reported demographics of the participating teachers, the cohort included 9 women (82%) and 2 men (18%). Additionally, 9 participants (82%) identified as Black/African American while 2 identified as White. Table 1 provides details on the participating school districts, including the proportion of students from under-represented groups in STEM (URG-STEM) and the percentage of economically disadvantaged students (household incomes below the state average).

Table 1: Details of URG-STEM student enrollment and proportion of economically disadvantaged students in Alabama school districts that the Year 1 cohort support.

Alabama School District	Participating Teachers	URG-STEM Student Enrollment (%)	Economically Disadvantaged Students (%)
Tuscaloosa City	5	77.1	44.2
Tuscaloosa County	2	42.3	40.0

Hale County	3	70.5	48.4
Greene County	1	99.1	60.3

Overall, our program exceeded its goal (in year 1) of recruiting at least 40% of participants that identify as from an URG-STEM. This supports that our recruitment activities were successful at reaching teachers that serve students from URG-STEM, serve students who are economically disadvantaged, and who themselves are from an URG-STEM.

Summer Program Structure

Teachers participated in 7 weeks of on-campus activities at UA in Tuscaloosa, AL during June/July 2024. Each teacher committed to 35 hours per week, including 5-6 hours of workshops, with the remainder dedicated to research under a faculty mentor in the College of Engineering. The program concluded with a poster symposium where teachers presented their research to faculty, engineering students, and professionals.

To prepare teachers for programming activities (e.g., data organization, visualization, analysis), the first week featured a 3-day programming "boot camp." This boot camp covered programming fundamentals (variables, conditional statements, loops, computational thinking), the Python programming language, and the CyberPi [2] hardware/software platform for experiments and exploration.

The summer engineering workshops highlighted various disciplines and career paths in engineering and computer science, aiming to broaden teachers' understanding of the field and complement their research, which focused on a single discipline. The sensors/programming workshops guided teachers through using the Arduino Uno platform (specifically the Arduino Sensor Kit [3]) to measure physical quantities using electronic sensors. Their goal was to introduce sensors and electronics that teachers could use in their classrooms, demonstrate hands-on activities, and give teachers opportunities to practice programming to control and report values from sensors. The education/curriculum workshops guided teachers in linking their research to educational standards and exploring resources to help teach engineering content in their classrooms. Overall, the specific topics for all workshops are provided in Table 2.

Table 2: Specific workshop topics over the 7-weeks of the first iteration of the RET.

Week	Engineering	Sensors / Programming	Education & Curriculum
1	Program Orientation & Programming Bootcamp (Fundamentals, Intro to Python, CyberPi Platform, Data Visualizations)		
2	Electrical & Computer Engineering Careers Engineering Design Process	Intro to Arduino Platform	Linking Research to Standards
3	Civil Engineering Careers	Temperature & Humidity Sensing	*Teach Engineering* Resources
4	Mechanical Engineering Careers	Light Sensing	Science Visualizations
5	Scientific Posters + Presentations	Accelerometers + Motion Sensing	National Board Certifications

6	Chemical Engineering Careers	Sound & Air Pressure Sensing	Science Misconceptions
7	Summer Research Symposium		

Each Friday of the program, teachers participated in a peer-share session where they shared three successes from the week, two goals for the following week, and one difficulty they faced. This approach drew inspiration from the RET coordinators' experience using peer-shares in a previous Research Experience for Undergraduates (REU) site. Evaluation of the REU program revealed that discussing successes and challenges helped participants recognize that research naturally involves both. This understanding reinforced the idea that struggling is a normal part of learning and applying new skills to open-ended problems [4]. Participants also appreciated learning about other research projects, which fostered a sense of community. Furthermore, Herrington et al. reported that teachers identified peer-share sessions as a feature of RET programs that significantly influenced their science instruction [5]. These findings supported the inclusion of peer-share sessions in our RET.

Focus Group Feedback

On the last day the program evaluator conducted a focus group to collect feedback from participants on all elements of the program (e.g. research experience, mentoring experience, workshops, and peer-share sessions). Ten of the 11 teachers participated in the focus group. From their feedback teachers expressed that they enjoyed the challenge of learning to do a research project and learned skills they could bring into their classrooms to increase student engagement. Teachers noted they gained a fresh perspective on how students feel when learning content they are seeing for the first time. There was an appreciation for learning "how things work," understanding the role of engineers, and learning about engineering career paths to support students. However, they noted that more support during the summer to help them develop their curriculum would be useful and help them transition their research to their classrooms. The teachers were concerned with bringing sensor technology in the classroom because it would not look like they are teaching math or science to their principal. The peer-share sessions were described as "the most fun thing we did!" which continues to support this as a high-impact aspect of research experiences.

Lessons Learned and Planned Year 2 Revisions

Research Activity Plans: Each faculty mentor prepared and submitted a research activity plan (RAP) to the RET coordinators after completing training sessions to ensure appropriately scaffolded research projects for teachers were prepared. These sessions outlined the program goals, expectations, and backgrounds of participating teachers. Mentors were required to submit a research plan specifying the summer research question, its alignment with their lab's goals, lab access and training needs, required tools or software, graduate student support, mentor availability, and planned activities for the program's 7 weeks. Program coordinators reviewed the plans and provided revisions to refine the scope, clarify activities, and ensure adequate summer support. Post-program feedback from mentors indicated that this process clarified the effort needed to translate their research for non-expert teachers and helped them plan realistic goals for the 7-week program. **Recommendation:** Continue the use of RAPs for Year 2 (and recommend

for other RET programs). For Year 2, include further support for mentors in completing them (e.g. samples of detailed plans, suggestions on planning for small deliverables to guide projects).

Communicating Expectations: While program expectations for participation (e.g., daily attendance, participation in 35 hours of activities each week) were outlined in program offer letters and orientation, overall attendance was below expectations. On average, participants were on campus for 25 of 32 days (ranging from 20 days to 29 days). With the rapid pace of this program, the loss of up to 12 days of activities can significantly impact research progress, participation in workshops, and learning about engineering. The most significant absences were attributed to participants having family vacations scheduled, having other professional development activities scheduled, or assuming days without assigned research tasks did not require attendance. **Recommendations:** i) Attendance requirements should be clearly outlined in all recruitment information and the online program application, ii) communicate that extended absences for vacation/professional development will reduce stipend payments, and iii) include questions in the program application regarding summer commitments that overlap with the RET, with preference given to candidates who can commit to all 7 weeks of the program.

Evaluation / Assessment: This RET proved challenging in terms of motivating teachers to complete pre- and post- program surveys. Only 3 of 11 teachers (27%) completed both pre- and post- program online surveys. This is lower than previous REU [4,6] and IRES [7] programs coordinated by the project team, which had roughly 90% completion using the same methods as this RET (e.g., multiple email reminders, in-program time dedicated to completing surveys).This has limited the evaluation of participating teachers' perspectives on engineering, teaching engineering, and their perceptions of their skill-gains. **Recommendation:** Allocate more program time for completing surveys by setting aside one hour each day during the first and last weeks to work on a subset of the online surveys until the teachers have completed the evaluation surveys. Provide additional computing resources (e.g., laptops) for these sessions so teachers can complete them even if they fail to bring their own devices. It is also recommended that participants be paid to complete the planned annual follow-up surveys to compensate them for their time and improve the completion rate compared to the current levels.

Curriculum Support: Although weekly support for teachers to develop curriculum materials was initially planned, the RET personnel's focus on launching and managing the research projects and workshop to support the development of research skills limited this aspect. During the focus group, teachers expressed a need for more support in translating their experiences into classroom activities. **Recommendation:** Dedicate significant time each week (4-6 hours) to **i)** find and evaluate curricula related to their project (week 2), **ii)** collaborate with other participants to identify strengths and weaknesses of curricula (week 3), **iii)** relate content to grade specific standards (week 4), **iv)** revise / improve the lesson to incorporate sensor technology (weeks 5-6), **v)** demonstrate lesson to other teachers for feedback (week 7).

Summary

The first-year of our RET program, focused on applications of sensing technologies, was successful in recruiting a cohort of 11 teachers from western Alabama to participate in 7-weeks of research and workshops at UA. At the end of the program all teachers presented their research

projects, successfully communicating their process and results to both engineering and non-engineering audiences; demonstrating their increased understanding of engineering research from their summer participation. Focus group feedback supports that teachers had positive research experiences and learned skills they could bring into their classrooms to increase student engagement. For the next iteration, increased personnel support and dedicated time each week to developing curriculum are recommended to help teachers translate their research experiences into classroom activities. Administratively, it is recommended that mentor support for developing research activity plans be increased, program time dedicated to evaluation / assessment surveys be increased, and communication of program expectations be clarified and increased in frequency.

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