Environmental Sustainability and Electronics: High School Teacher Development through Summer Research Experiences

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Introduction

Electronic and electrical devices greatly benefit society and individuals, and demand for these products is driven by a number of factors, including expanded telecommunications coverage, lower product prices, shorter use cycles, and ownership of multiple devices. The life cycle stages of electronic products are shown in Figure 1, and there are environmental impacts associated with each stage. These impacts are multiplied when demand increases, and are particularly visible at the "End-of-Life" stage, which can include landfill or incineration. A number of studies quantify the environmental impacts of the life cycle of various electronic devices and systems, including cell phones (*1*), desk top computers (*2*), laptop computers (*3*), and data centers (*4*).

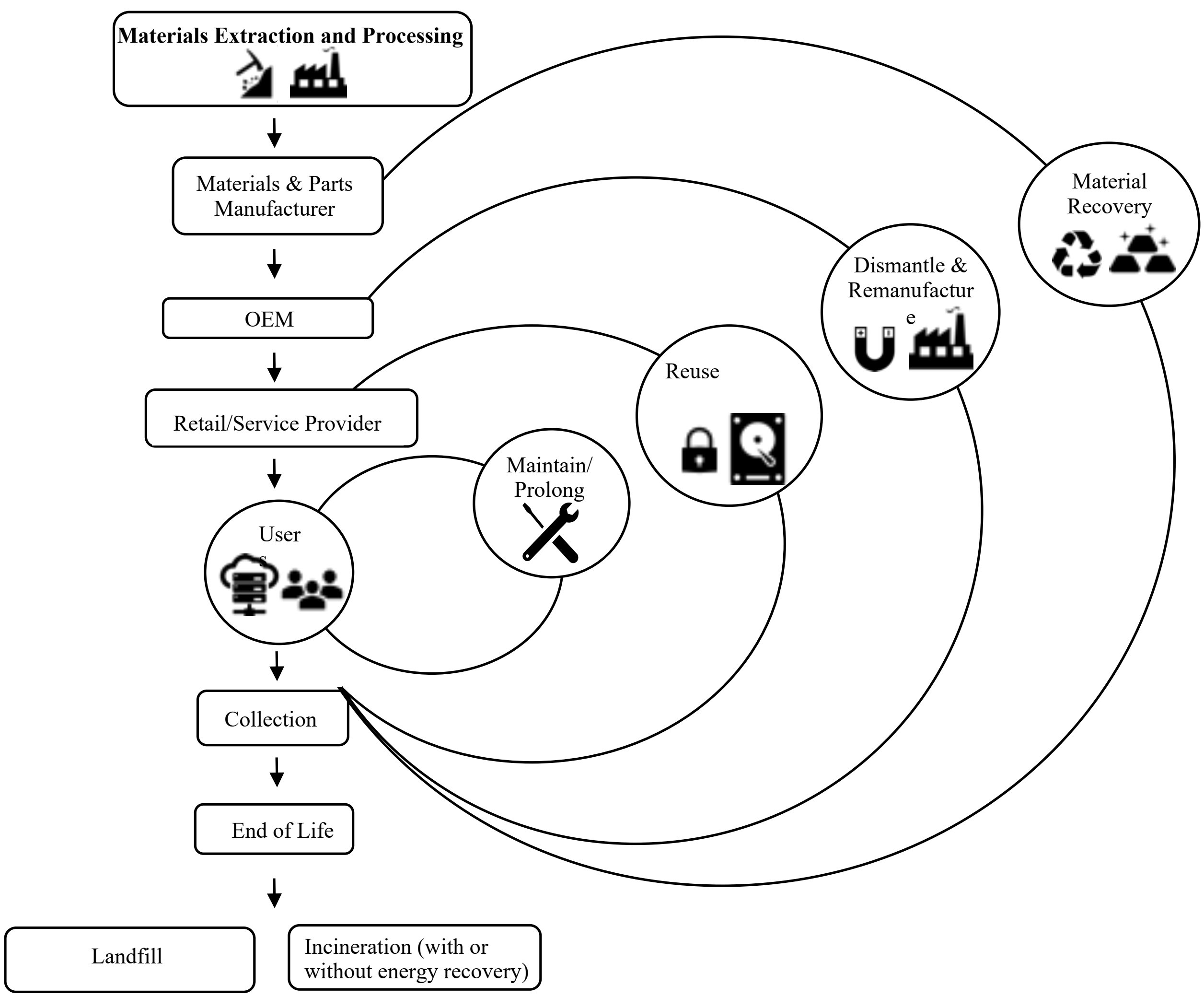

Figure 1: Life-cycle stages of typical consumer electronic products. Diagram modified from Kali Frost.

The number of devices that reach End-of-Life (EoL) has increased, and the estimated global generation of electronic waste in 2016 was 44.7 million metric tons, only 20% of which was documented with a known disposition (*5*). In the United States (U.S.), the mass of electronic waste attributable to consumer electronic products was estimated at 3.36 million tons per year, for 2013 and 2014 (*6*). Although detailed time trends in electronic waste recycling are not available, the estimated recycling rate for selected consumer electronics was 39.8% in 2015 (*7*). In the U.S., only 25 states plus the District of Columbia regulate electronic waste disposal. More generally, it is estimated that industrial economies return much of the raw material to the environment as waste, within one year of extraction (*8*). There are technological and societal barriers towards overcoming the conventional linear cycle of consumption. A societal challenge is the flow of electronic waste between countries, for example from the United States to China. However, the focus of the RET Site was to provide research projects based on the natural sciences for the teachers, so the issue of electronic waste export was not explicitly addressed. Instead, teachers focused on characterizing and solve technical challenges.

Engineers of all disciplines, including environmental engineers, play a critical role in overcoming these barriers and protecting environmental quality. Preparation for college courses in engineering begins in the P-12 schools, including high school science courses. Therefore, positive impacts on high school science students are expected from enhancing teacher proficiency. There are a variety of development and training programs for science teachers. A unique program, described in this paper, embeds scientific research as a key component of enhancing teacher proficiency. The Research Experience for Teachers (RET) Site programs have been implemented studied in a variety of STEM contexts for teacher development *(9-13).*

This paper describes Research Experiences for Teachers (RET Site) that provides a unique professional development program founded on an immersive, summer research experience with engineering faculty mentors at two universities: Purdue University and Tuskegee University. Over the course of 3 years, the Research Experiences for Teachers (RET): Sustainable Electronics program provided a summer research experience and professional development activities to 27 high school science teachers recruited from the states of Indiana and Alabama. Over 3000 high school science student participated in innovative curricula developed by the program participants. Each teacher worked on a unique research project that explored a dimension of sustainable electronics. Teachers also completed professional development activities, such as visits to electronics recycling facilities and advanced electronics manufacturing research sites, technical demonstrations, and they interacted with representatives of electronics companies, through an Industrial Advisory Board.

At the end of the program, teachers presented their technical results and plans for standards-based high school curricula. The new curricula were integrated into existing class content for chemistry, physics, environmental science, and biology, among other science classes. Many of the teachers taught at high schools with high percentages of underserved students. Teachers also continued their own professional development after the summer, by co-authoring research publications with their faculty mentors or presenting results at conferences. Conferences audiences ranged from university academic to P-12 educators in Indiana.

Program Description and Teacher Activities

Logic Model

The program structure and activities are based on the logic model shown in Fig. 2. As previously discussed, there are workforce needs related to environmental professionals, specifically those with an awareness of the environmental impact of electronics. These professionals contribute to overcoming technical challenges and data gaps, and one important aspect of training occurs in high school science classes. Therefore, a program aimed at enhancing high school science teacher proficiency will have a cascade of benefits. In addition, discussing the environmental impacts of electronics as a context for science helps enhance general societal knowledge and awareness. The inputs to the program include high school science teachers from Indiana and Alabama, faculty and engineering graduate students at Purdue University and Tuskegee University who served as research mentors, and an industrial advisory board, comprised of representatives from electronics companies.

Recruiting participants for the RET began in the early winter, with admissions and matching to research projects finalized by spring. During the spring, teacher participants would discuss the research project with faculty mentors, and make tentative plants for the summer. Because the program included two universities, the kick-off and concluding activities occurred on the campus of Purdue University. The six week, on-campus portion of the program began with an orientation week. The orientation week included hand-on demonstrations to topics such as electronics materials properties, global supply chains and computer assembly/disassembly, training from the libraries on how to conduct primary literature surveys, and field trips to advanced manufacturing facilities and recycling centers. During the orientation week, teachers also completed project specific training on laboratory methods, modeling tools, and safety, as appropriate to each research group, and discussion about teaching engineering in a service-learning context.

As the program progressed, participants completed weekly guided discussions about sustainable electronics, each participant's research progress, and connecting the research process to science standards and curricula. These guided discussions provided an important opportunity for peer mentoring (teacher participants providing some mentoring for each other), as well as mentoring from the program directors at Purdue University and Tuskegee University. The guided discussion occurred via teleconference between teachers on the two university campuses. These mentoring activities supplemented the research specific mentoring from faculty and graduate students.

At the end of the program, teachers prepared a technical report, detailing their research findings and proposed curricula, and also made oral presentations (poster or platform) to the sustainable electronics research community at Purdue University. The attendees and reviewers of the final presentations included research mentors, high school principals, the industrial advisory board members, and other stakeholders, such as scholars who studied P-12 education. Program assessment and evaluations were conducted each year (pre-, post- and mid-program) by staff at INSPIRE Research Institute for Pre-College Engineering, and the results reported to the program directors, who would adjust the following summer's program based on the evaluation results.

During the academic year, teachers finalized and implemented standards based curricula in their respective high schools. Common subjects included Chemistry, Physics, Biology, and Environmental Science. Teachers maintained contact with the program directors and research mentors, and provided updates on the curriculum.

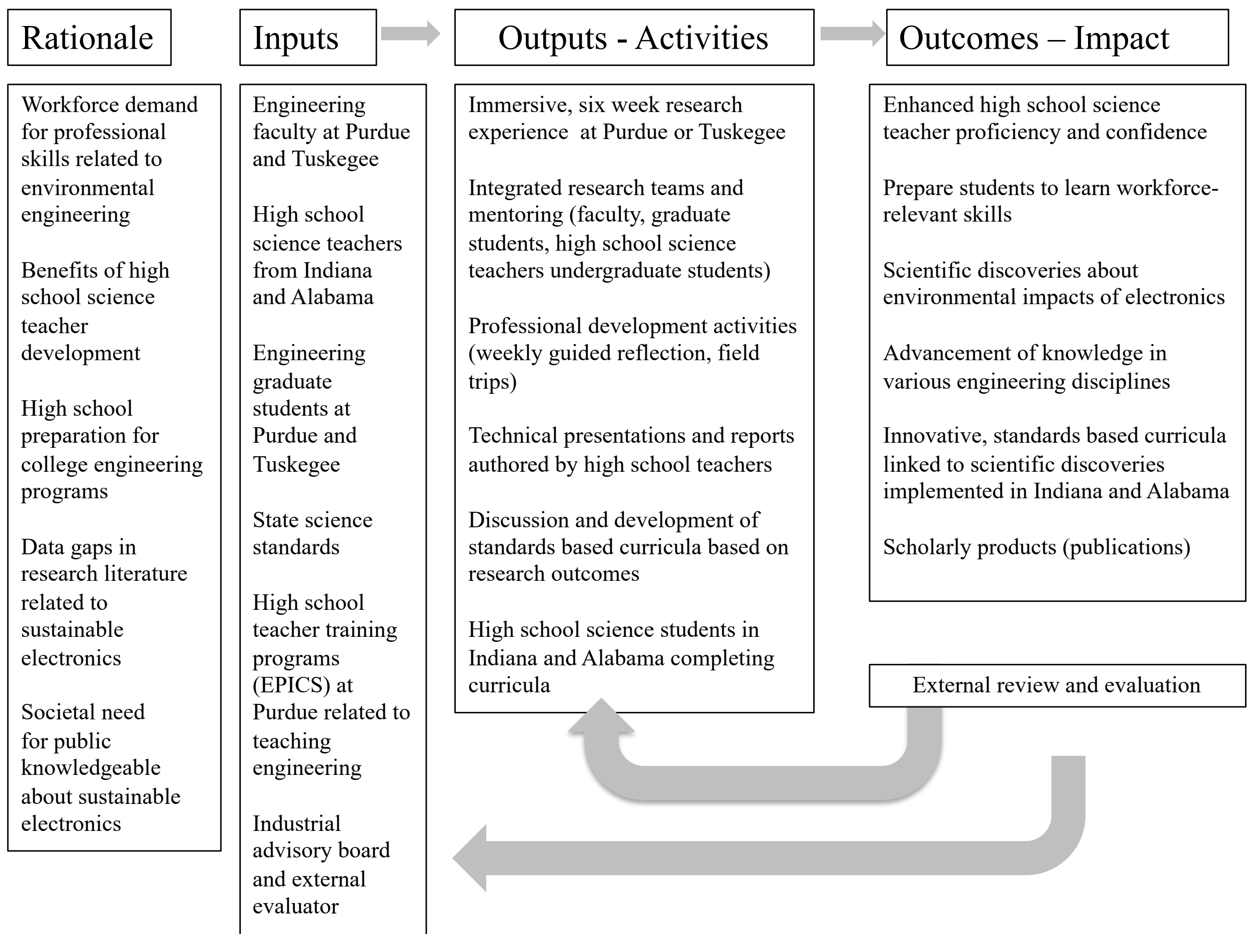

Figure 2: Logic model for the RET Site: Sustainable Electronics program.

RET Participant Characteristics

A total of 27 unique teachers completed the RET program (4 teachers participated in the program multiple times) between 2016-2018. Based on self-reported information, the gender ratio was close to even: 13 men and 14 women participated. Four of the participants were African-American, 2 were Hispanic/Latinx, and the remaining participants were White, not Hispanic. Many of the participants held post-baccalaureate degrees: 15 had completed Master's degrees. Teaching experiences varied widely, from 1 – 32 years of experience, and the median being 9 years. Finally, at least 48% of the teachers worked at Title 1 schools (13 teachers answered "yes" to this question). Title 1 schools enroll higher numbers or percentages of students from low-income families, and these schools receive federal assistance to ensure that students are able to meet educational standards (*14*). The teachers' characteristics reflect the variety of schools at which they interacted with high school science students, and these characteristics are important to keep in mind when considering outputs such as high school science curricula and student impacts.

Program Outcomes

Research Projects

Over three summers in 2016-2018, 27 teachers completed ~30 research projects (4 teachers participated in the RET program more than once). These research projects were aimed at quantifying or reducing environmental impacts from various life – cycle stages of electronic products or systems, including materials extraction, end-of-life management, and production (Fig 1). Appendix A (Tables A1 and A2) includes detailed information about research projects from 2016 and 2017. The projects were all focused on understanding and reducing environmental impacts, and were developed collaboratively between the program directors and the faculty mentors.

Table 1 demonstrates the breadth and common scientific themes for the research projects from 2018. Projects 1-3 explored recycling and economic value recovery as a way to reduce environmental impacts, projects 4-6 investigated various polymer additives to reduce environmental impact of manufacturing and use, and projects 7-9 were based on quantifying or reducing toxicity at End-of-Life.

Table 1: Research Project Titles, Mentors, and Teachers' High Schools for the 2018 cohort

Research Project Title	**Research Mentor(s) (University)**	**High School Name**
1. Training Neural Networks to Identify E-Waste	[4]Yung-Hsiang Lu (Purdue)	Northwestern Highschool Kokomo, IN
2. Analysis of Materials Contained within E-Waste and Potential for Value Recovery	[2,5] Inez Hua and [2,5]Nadezhda Zyaykina (Purdue)	McCutcheon High School Lafayette, IN
3. Exploring the Use of Lignin to Bind Waste Metals	[1]Abigail Engelberth (Purdue)	Crawfordsville Highschool Crawfordsville, IN
4. Tannic Acid: A Potential Sustainable Flame Retardant for Epoxy Systems	[5,7]John Howarter (Purdue)	Oaks Christian High School, West Lake Village, CA
5. Natural fibers as a replacement for synthetic fibers in the Fabrication of Fibers Reinforced Polymer Composites (FRPC) with comparable mechanical properties	[3,7]Michael Curry (Tuskegee)	Robert E. Lee Highschool Montgomery, AL
6. Dual Approach to Driving Crystallinity in PLA Materials: Nanocellulose and Polyethylene Glycol	[7]Jeffery Youngblood (Purdue)	George Washington High School Indianapolis, IN
7.Determining Chemicals Released by E-waste using Static and Accelerated Leachate Testing and ICP-OES Data Analysis	[2,5] Inez Hua and [2,5]Nadezhda Zyaykina (Purdue)	McCutcheon High School Lafayette, IN
8. Investigating the effects of leachate from electronic waste	[6]Marisol Sepulveda (Purdue)	Oaks Christian High School, West Lake Village, CA
9. Exploring toxicity of common household items on brine shrimp using the LC_{50} method	[3,7] Melissa Reeves (Tuskegee)	Booker T. Washington Highschool Tuskegee, AL

[1]Agricultural and Biological Engineering; [2]Civil Engineering; [3]Chemistry; [4]Electrical and Computer Engineering; [5]Environmental and Ecological Engineering; [6]Forestry and Natural Resources; [7]Materials Engineering

Mapping research projects to science standards and curricula

In addition to research results, another important outcome included new curricula for high school science students. During the summer, as research outcomes and themes emerged, teacher participants mapped research elements to science standards (either state or national), and planned new curricula for their classes. Examples of explicitly mapped research projects to science standards, course subjects, and students are discussed here.

The first example stems from the research project "Analysis of Materials Contained within E-Waste and Potential for Value Recovery" and resulted in a unit entitled: "What's in Our Electronics?" that was completed by 110 students in Physics 1 at McCutcheon High School (Lafayette, IN) during Spring 2019. This research project was mapped to the following Indiana state standards:

SEPS.3 Constructing and performing investigations

SEPS.4 Analyzing and interpreting data

11-12.LST.4.1: Integrate and evaluate multiple sources of information in order to address a question or solve a problem

11-12.LST.2.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks

Students completed activities such as reading about smart cellphones composition and chemistry, and a discussion to define electronic waste and the importance of sustainable. This was followed by laboratory work, during which students created simulated samples of electronic waste to test for environmental impacts. The samples were analyzed at Purdue University, in collaboration with the teacher's summer research mentor.

A second example, based on the research project: "Tannic Acid and Potential Flame Retardant Improvements," resulted in a module entitled: "Should there be a ban on e-waste in landfills?" which was completed by ~200 students in 10th grade Biology at Penn High School (Mishawaka, IN) during two consecutive school years(2016-2018). The module was based on the following national and Indina standards:

NGSS HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
IN Biology 2016: SEPS.1 Posing questions (for science) and defining problems (for engineering);SEPS.7 Engaging in argument from evidence; SEPS.8 Obtaining, evaluating, and communicating information

To complete the activity, students needed to choose a supporting or opposing position on the ban, and consider the perspectives of various stakeholders, including politicians, e-waste recyclers, doctors, biologists, ecologists, and recycling business owners, make a presentation to the class, and then discuss their viewpoints and reasoning. Before taking a position, students completed directed readings, related to possible views of various stakeholders, and biology specific discussions such as bioaccumulation of compounds commonly in electronics (such as flame retardants). The explicit connection to the research project was the flame retardant additives.

In addition to standards based curricula implemented in a classroom setting, there were other pathways by which high school students would be impacted. Teachers from Indiana range from schools that are virtual schools to project-based learning (PBL) schools to traditional middle and high schools. On the other hand, Alabama teachers taught at traditional public high schools. For the 2016 cohort, teaching loads averaged 143 students per teacher, with a range from 70 to 240. Classroom project plans included field trips, research papers, public symposia, interaction with public officials, and use of classroom equipment purchased with support funding from the program or from a partnership with school science equipment vendors.

Project Evaluation and Reporting

Methods and approach

Research staff from INSPIRE Research Institute for Pre-College Engineering collected information from RET participants for both formative and summative evaluation purposes. Data collection approaches included administering the following quantitative and qualitative surveys:

- The Design, Engineering Technology Survey (DET) *(15, 16)*
- The Teaching Engineering Self-Efficacy Survey (TESS) *(17)*
- Open-ended survey questions about the RET program specifically
- Mid-program focus groups

The evaluation activities were intended to help the program directors refine the RET program each year, and the evaluation activities themselves also evolved to best meet the needs of the project while minimizing evaluation burden to the teacher participants. The DET survey was administered pre- and post-program each year, the TESS survey was administered only mid-program in 2016, pre- and mid-program in 2017 and pre- and post-program in 2018. The open-ended mid-program survey was used in 2016 and 2017, and replaced with a focus group interview in 2018.

The Design, Engineering and Technology (DET) survey and the Teaching Engineering Self Efficacy Scale (TESS)) were used to measure teachers' attitudes towards teaching engineering and their self-efficacy related to teaching engineering. These instrument were selected for three primary reasons: alignment with the objectives for the RET; specific focus on engineering; and previous use of the instruments for similar purposes. The RET experience was designed to provide teachers with opportunities to gain depth of knowledge in sustainability, energy, engineering and science; experience with conducting STEM research; and pedagogical content knowledge related to teaching engineering and engineering design.

The DET and TESS are most closely aligned with the third aspect of the RET, but we also believe that as teachers gain depth of knowledge of engineering, this will also positively impact their attitudes towards and self-efficacy in teaching engineering. This is consistent with Schrader and Lawless' (*18*) research on learning, where they posit that Knowledge, Attitudes, and Behavior are all interdependent (e.g. teachers' knowledge of a subject will impact their teaching behavior; teachers' attitudes towards a subject will also impact teaching behavior; etc.). While other existing, validated instruments measure attitudes and efficacy related to science, mathematics, and STEM, the DET and TESS are uniquely well suited for our study because of their specific focus on engineering. Finally, these two surveys were selected because previous research resulted in evidence of the validity and reliability of these scales (*16-18*), and prior RET programs have used these instruments for similar reasons (2*0*).

Results from DET and TESS

Teacher responses to the DET survey are shown in Appendix B, Table B1. They survey is based on a 5 point scale. Questions to for which there are significant pre- and post-program differences are boxed. Key findings from the survey include (post-program versus pre-program scores after each finding):

1) An increase in teachers' self-reported familiarity with DET over the course of the program (3.64 vs. 2.90)
2) An increase in teachers' perceptions of their current and future use of DET in their classrooms (3.46 vs. 2.84)
3) An increase in teachers' self-reported knowledge of the National science standards related to Design/Engineering/Technology (3.38 vs. 2.89)
4) An increase in teachers' self-reported sense that they felt prepared to include DET activities in their teaching (3.04 vs. 2.60).

These results are aligned with development and implementation of standards based curricula related to the teachers' research projects, and positively influence student interest in engineering careers. In addition, the survey helped identify barriers to integrating DET in high school classroom, including lack of teacher time to learn about DET, lack of teacher knowledge or training, and lack of administration support. Lack of time was the most highly rated barrier. The RET program was designed to address all of these challenges, except lack of (high school) administration support.

The TESS was administered in the middle of the program in 2016, the middle and end in 2017, and pre- and post-program in 2018. In each case, teachers' responses indicated agreement with all constructs associated with teaching engineering self-efficacy, which consisted of engineering pedagogical content knowledge, self-efficacy, engineering engagement self-efficacy, engineering disciplinary self-efficacy, and engineering outcome self-efficacy.

The survey results can also be interpreted in the context of more subjective information, specifically the research experience, which served as the foundation of the program. Objective outcomes, such as research projects and curricula are described in earlier sections of this paper. An important but more subjective aspect of teacher development during the RET include teacher perceptions of research. Changes in teacher perception provide a good backdrop for thinking about the more quantitative results from DET.

Teacher Perceptions of Research

During the mid-program survey, teachers were asked if their perspective on what research is, or perspective of what is involved in research had changed. Their responses ranged from a simple "No," to "Not really – more like enhanced," to "Yes, my perspective has changed tremendously." Selected teacher responses are shown below.

- No, my perspective has always been it's tedious, exhausting, and takes an incredible amount of patience.
- Not really. I know that it is extremely beneficial, and one must care deeply about the concept being researched.
- I have been doing research for quite awhile, so a lot of the hiccups that I have experienced are not out of the norm. Research is research.
- Slightly—some days are nearly filled with meetings. I typically can't get much research completed on those days. The meetings offer a wealth of info, so I do not want to miss them.
- Not really changed – more like enhanced. I know research is complex and time consuming – but my particular research is not "lab based", but literature and computational so it's not what I expected.
- Yes, research is one of the most valuable pieces to making change. I always knew it was important but now I see just how important it is to the process of making notable change.
- Yes, my perspective has changed. I am surprised on how different the atmosphere is from traditional academic work. The work is much more collaborative and steady than a regular classroom experience.
- Yes, my perspective has changed tremendously. Overall, I feel that research is extensive if you want to yield great or real results. That being said, not all students are able to commit to it; thus, I feel it's more feasible to have variations of it for your different levels of learners.

Teachers who reported significant changes in perceptions implied positive views of research, which align well with the target outcomes of "advancement of knowledge in engineering disciplines" and "scientific discoveries about environmental impacts of electronics" (see logic model).

Conclusions

Over the course of 3 summers, 27 high school science teachers from Indiana and Alabama participated in an intense, six-week program based on a research project related to characterizing and improving the environmental sustainability of electronics. Teachers participated in variety of projects, and delivered curricula primarily in the classroom, but also through mechanisms such as student clubs. Over 3000 high school science students have been impacted by the curricula to date. The RET participants have completed scholarly work (journal articles) related to their research discoveries, and also disseminated their curricula through state and national science teacher associations. Evaluation results demonstrate teacher self-efficacy in teaching engineering, and important gains in teacher perceptions of their familiarity with DET, And current and future use of DET in their classrooms. In addition, the evaluation results also reveal increased teacher perceptions of their own knowledge of the national science standards, and of their preparedness for including DET activities in their teaching.

Appendix A

Table A1: Science Teacher Research Project Titles and High Schools (2017)

Research Project Title	**Research Mentor(s) (University)**	**High School Name**
Water Use in the Semiconductor Industry	[3,6]Inez Hua (Purdue)	Austin High School Austin, IN
Tannic Acid as an Epoxy Hardener	[9]Jeffery Youngblood and 6,9John Howarter (Purdue)	North Newton Jr. Sr. Highschool, Morocco, IN
Natural Fibers as Replacement for Synthetic Fibers in the Fabrication of Fibers Reinforced Polymer Composites (FRPC) with Comparable Mechanical Properties	[9]Alfred Tcherbi-Narteh (Tuskegee)	Robert E. Lee Highschool Montgomery, AL
Exploring toxicity of common household items on brine shrimp using the LC_{50} method	[4]Melissa Reeves (Tuskegee)	Booker T. Washington Highschool Tuskegee, AL
Industrial Symbiosis: Biomimicry in the Photovoltaic Industry	[5,7]John Sutherland (Purdue)	Danville Community Highschool, Danville, IN
The Biological Effects of Cellulose on the Recyclability ABS and HIPS Plastics	[3,7]Michael Curry (Tuskegee)	Sumter Central Highschool, Sumter, AL
Investigation into Cradle-to-Gate Environmental Impact of Cu3AsS4 Photovoltaic Cells	[8]Carol Handwerker and [5,7]Fu Zhao (Purdue)	William Henry Harrison Highschool, West Lafayette, IN
Low Power Image Recognition Challenge	[4]Yung-Hsiang Lu (Purdue)	Michigan City Highschool, Michigan City, IN
Toxicity of Flame Retardants to *Daphnia pulex*	[7]Marisol Sepulveda (Purdue)	Winamac Community Highschool, Winamac, IN
Polymers can be degrading	[6,9]John Howarter (Purdue)	Warren Central Highschool, Indianapolis, IN
Using a Weighted Decision Matrix to Determine Solutions for the Excess of EOL Devices in West Lafayette, Indiana	[3,6]Inez Hua and 1H. Kory Cooper (Purdue)	Michigan City High School, Michigan City, IN

[1]Agricultural and Biological Engineering; [2]Antropology;[3]Civil Engineering; [4]Chemistry; [5]Electrical and Computer Engineering; [6]Environmental and Ecological Engineering; [7]Forestry and Natural Resources; [8]Mechanical Engineering; [9]Materials Engineering

Table A2: Science Teacher Research Project Titles and High Schools (2016)

Research Project Title	Research Mentor(s) (University)	High School Name
Tannic Acid and Potential Flame Retardant Improvements	[8]Jeffrey Youngblood and [6,8]John Howarter (Purdue)	Penn High School, Mishakawa, IN
How Legislation Has Influenced the Responsible Recycling of Electronic Waste	[7,8]John W. Sutherland (Purdue)	Noblesville High School, Noblesville, IN
Life Cycle Analysis of Daily Assessments of Learning Created on Paper and Assigned Through a Chromebook	[3,6]Inez Hua (Purdue)	Fremont Community Schools, Fremont, IN
Effective Recycling of Cell Phones	[7,8]Fu Zhao and [7,8]John Sutherland (Purdue)	Columbus Signature Academy New Tech, Columbus, IN
Exploring toxicity of alternatives to brominated flame retardants using QSAR methods	[4]Melissa Reeves (Tuskegee)	Booker T. Washington High School, Tuskegee, AL
It's All About That Case: Dopamine Surface Functionalization of Hexagonal Boron Nitride Particles	[6,8]John Howarter (Purdue)	William Henry Harrison High School, West Lafayette, IN
3,4-Polystyrene Aqueous Media Delivery Solution Yielding Maximum Adhesion Strength	[4]Jonathan Wilker (Purdue)	Hebron High School, Hebron, IN
Use of Natural Fibers as Replacement for Synthetic Fibers in the Fabrication of Fiber Reinforced Polymer (FRPC) Composites with Comparable Mechanical Properties	[4,8]Michael Curry (Tuskegee)	Robert E. Lee High School, Montgomery, AL
The Biological Effects of Cellulose on the Recyclability ABS and HIPS Plastics	[4,8]Michael Curry (Tuskegee)	Booker T. Washington High School, Tuskegee, AL
Production of modified lignin for flame retardant polyurethane	[8]Jeff Youngblood and [6,8]John Howarter (Purdue)	Hoosier Academy (Virtual School),
Synthesis, Functionalization, and Characterization of cellulose of Nanofibrils and Nanocrystals	[4,8]Michael Curry (Tuskegee)	Booker T. Washington High School, Tuskegee, AL

[1]Agricultural and Biological Engineering; [2]Antropology;[3]Civil Engineering; [4]Chemistry; [5]Electrical and Computer Engineering; [6]Environmental and Ecological Engineering; [7]Mechanical Engineering; [8]Materials Engineering

Appendix B
DET Responses (2016-2018)
(all items used a 5-point scale where 5 was high/strong agreement)

	PRE				POST			
	N	Mean	Std.Dev	Med	N	Mean	Std.Dev	Med
How familiar are you with Design/Engineering/Technology as typically demonstrated in the examples given on the previous page?	31	2.90	1.01	3	25	**3.64**	0.95	**4**
Have you had any specific courses in Design/Engineering/Technology outside of your preservice curriculum?	31	1.97	1.17	2	25	2.24	1.23	2
Did your preservice curriculum include any aspects of Design/Engineering/Technology?	31	2.16	1.27	2	26	2.58	1.63	2
Was your pre-service curriculum effective in supporting your ability to teach Design/Engineering/Technology at the beginning of your career?	31	1.94	1.09	2	26	2.65	1.38	3
How confident do you feel about integrating Design/Engineering/Technology into your curriculum?	31	3.35	1.11	3	26	3.65	0.98	4
How important should pre-service education be for teaching Design/Engineering/Technology ?	31	4.29	0.86	4	26	4.38	0.70	4.5
Do you use Design/Engineering/Technology activities in the classroom?	31	2.84	1.07	3	26	**3.46**	1.24	**3.5**
Does your school support Design/Engineering/Technology activities?	31	3.35	1.36	4	26	3.69	1.29	4
Do you believe Design/Engineering/Technology should be integrated into the K-12 curriculum?	31	4.61	0.67	5	26	4.65	0.63	5
To what extent do you agree that a typical engineer works well with people?	31	3.58	0.96	4	26	3.81	1.10	4
To what extent do you agree that a typical engineer has good verbal skills?	30	3.73	0.91	4	26	3.77	1.11	4
To what extent do you agree that a typical engineer has good math skills?	31	4.84	0.37	5	26	4.65	0.56	5

To what extent do you agree that a typical engineer has good writing skills?	31	3.94	0.93	4	26	3.81	0.98	4
To what extent do you agree that a typical engineer earns good money?	31	4.55	0.72	5	26	4.38	0.64	4
To what extent do you agree that a typical engineer likes to fix things?	31	4.45	0.68	5	26	4.35	0.69	4
To what extent do you agree that a typical engineer does well in science?	31	4.39	0.72	5	26	4.42	0.64	4.5
Most people feel that female students can do well in Design/Engineering/Technology.	31	3.77	1.12	4	26	3.69	1.09	4
Most people feel that minority students (African American, Hispanic/Latino, and American Indian) can do well in Design/Engineering/Technology.	31	3.90	1.16	4	26	4.04	1.04	4
As you teach a science curriculum, it is important to include…								
Planning a project.	31	4.55	0.57	5	26	4.69	0.55	5
Using engineering to develop new technologies.	31	3.87	1.02	4	26	4.23	0.86	4
I am interested in learning more about Design/Engineering/Technology through…								
In-service.	31	4.29	0.97	5	26	4.46	0.65	5
Workshops.	31	4.52	0.63	5	26	4.54	0.58	5
Peer training.	31	4.45	0.85	5	26	4.42	0.64	4.5
College courses.	31	3.48	1.39	4	26	3.50	1.36	4
I would like to be able to teach my students to understand the…								
Design process	31	4.68	0.79	5	26	4.65	0.69	5
Use and impact of Design/Engineering/Technology.	31	4.65	0.66	5	26	4.85	0.37	5
Science underlying Design/Engineering/Technology.	31	4.71	0.53	5	26	4.77	0.51	5
Types of problems to which Design/Engineering/Technology should be applied.	31	4.71	0.46	5	26	4.88	0.33	5
Process of communicating technical information.	31	4.71	0.53	5	26	4.65	0.63	5
My motivation for teaching science is…								
To prepare young people for the world of work.	31	4.52	0.85	5	26	4.04	0.87	4
To promote an enjoyment of learning.	31	4.81	0.48	5	26	4.81	0.49	5

To develop an understanding of the natural and technical world.	31	4.74	0.51	5	26	4.81	0.40	5
To develop scientists, engineers, and technologists for industry.	31	4.35	0.88	5	26	4.12	0.91	4
To promote and understanding of how Design/Engineering/Technology affects society.	31	4.19	0.98	4	26	4.42	0.76	5
How strong is each of the following a BARRIER in integrating Design/Engineering/Technology in your classroom?								
Lack of time for teachers to learn about Design/Engineering/Technology.	31	4.48	1.06	5	26	4.38	0.80	5
Lack of teacher knowledge.	31	3.90	1.25	4	26	4.12	0.91	4
Lack of training.	31	4.16	1.10	5	26	4.31	1.05	5
Lack of administration support.	31	3.26	1.34	3	26	3.42	1.33	3.5
How strongly do you agree that … Design/Engineering/Technology has positive consequences for society.	31	4.87	0.34	5	26	4.85	0.46	5
How much do you know about the … National science standards related to Design/Engineering/Technology	31	2.39	0.99	2	26	**3.38**	1.17	**3**
How enthusiastic do you feel about including Design/Engineering/Technology activities in your teaching of mathematics?	26	3.50	1.30	3	24	3.83	1.05	4
How enthusiastic do you feel about including Design/Engineering/Technology activities in your teaching of science?	31	4.48	0.63	5	26	4.54	0.58	5
How prepared do you feel to include Design/Engineering/Technology activities in your teaching of mathematics?	25	2.60	1.47	2	23	**3.04**	1.02	**3**
How prepared do you feel to include Design/Engineering/Technology activities in your teaching of science?	31	3.39	1.23	3	26	3.73	1.12	4
How is it for you that Design/Engineering/Technology activities are aligned to mathematics state and national standards?	25	3.32	1.22	3	24	3.67	1.01	4
How is it for you that Design/Engineering/Technology activities are aligned to science state and national standards?	31	4.06	1.00	4	26	4.27	0.87	4.5

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