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This is our community: Designing for Rightful Presence in middle school engineering (Fundamental)

Mrs. Virginia Swindell, University of North Carolina at Greensboro

Virginia Swindell is a 3rd year Ph.D. student focused on the engineering education component of STEM (K-12) at the University of North Carolina at Greensboro. Previously, she served for fifteen years as a Mechanical Engineer at the Air Force Research Laboratory (AFRL) Munitions Directorate at Eglin Air Force Base. In that position, she was immersed in the design, development, and demonstration of traditional munitions (and non-traditional micro-munition technologies). She managed programs for and provided technical direction to the subsystem integration team. Virginia enjoyed the challenge of developing experimental prototypes regarding weapon penetration, designing test hardware, and analyzing structural and dynamic calculations. Ultimately, Virginia realized she had a desire to make a greater impact on today's youth considering they will become tomorrow's leaders. This was the catalyst for her pursuit of a doctoral degree in STEM. Virginia's research is concentrated on understanding the student/teacher relational dynamics and what changes when enacting an engineering curriculum for historically underrepresented youth. Currently, Virginia is actively involved in community-engaged research with minoritized youth engaging in makerspace work. She is also working with middle school teachers in co-developing and enacting an engineering curriculum that attends to students' rightful presence toward justice-oriented ends.

This is Our Community: Designing for Rightful Presence in Middle School Engineering

Abstract

While research has shown that when K-12 students engage in engineering education, their interests, identities and epistemic understanding of science and mathematics are positively impacted, this impact is most immediately tied to the teacher. However, most K-12 teachers feel ill-equipped to teach engineering due to factors that include: 1) the lack of professional development, 2) lack of confidence in content knowledge, and 3) lack of understanding of the engineering education standards. Further, teachers play a key role in perpetuating or challenging dominant narratives. The canonical narrative on engineering is that it is fundamentally a White, male, middle class enterprise. For example, data from the engineering undergraduate enrollment in 2016 showed that only 21.4% of students are female, with African American females making up just 1.3%. Thus, considering how to promote equity in engineering in K12 education is urgent and necessary. In this study in a 7th grade classroom at a Title 1 school with a Black woman teacher, Ms. B, and 100% students of color, we ask: In what ways does an engineering for sustainable communities (EfSC) curriculum that is co-designed with families, support students' simultaneous development of engineering and STEM epistemic knowledge and their rightful presence in STEM? How did the relationship dynamics (as related to power, expertise, and respect) shift between students and teacher and what were the impact of these power dynamic shifts to the process and outcomes of students' engineering learning experiences? We took a research-practice-partnership (RPP) approach in our study where families, Ms. B, and researchers co-designed the engineering curriculum that was then enacted in Ms. B's classroom for 4.5 weeks. We held three, 90-minute family-teacher-researcher RPP sessions that bookended the curriculum implementation, with one RPP session in the middle of the enactment to facilitate dialogue with families and incorporate their feedback. We are guided by the Rightful Presence for justice-oriented teaching and learning framework. The data was analyzed via a grounded theory approach. Data sources included fieldnotes, interviews, audio recordings, and student/family artifacts from both classroom and RPP meetings. Findings include: 1) A hyper-local, sustainable communities culture characterized by familial ties, community concerns and authentic engineering prototypes to address community concerns is integral toward students seeding a rightful presence in K-12 engineering; 2) Teacher Ms. B was the linchpin to the emergence of this culture. We elaborate on the nature of the hyper local EfSC culture in the activities students undertook and discuss the implications for justice-oriented K-12 engineering education.

Introduction

This study has a background canvas with segments that one must understand in the context of the study. Those segments are 1) the development of engineering education historically, 2) teacher's wealth that is infused within the learning environment, and 3) teachers' integration of engineering education in current curriculum.

Sociohistorical narratives about what counts as engineering, what it means to be trained as an engineer, and who can be labeled an engineer can be traced back to the professionalization of engineering in the late 1800s and early 1900s [34]. In the mid-1800s, engineering training was primarily through field experiences, namely in the railyards or on the shopfloor, but by the turn of the century, higher education had become a central pathway for becoming an engineer [34]. This shift allowed another bar to be set for one to become an elite one. This elite one has been crafted as the narrative of a white middle-class male. Due to the positioning of engineering training in segregated colleges and universities, these policies restricted who could become an engineer along racial, gender, and class lines [30].

These underlying principles are still permeating through the education system to this day. However, the strategies have changed. Engineering education has been affected by these strategies in a myriad of ways. One of the ways is known as the "weed out" strategy. This can be seen at the collegiate and secondary levels of education. For instance, the "weed-out" strategy in engineering can be enacted when students and teachers organize classroom activities as opportunities to stratify students and identify who is "cut out for" engineering [29]. Inadequate exposure to STEM subjects may contribute to students being academically underprepared, and fewer experiences with STEM content may also lead to students being less interested in pursuing a STEM major and career [6]. Many schools in marginalized areas focus not on engineering, but rather on basic subjects and the needs of their school. To them engineering is something "extra" and it is of less importance. Unfortunately, these schools are often underfunded and exist in a constant state of survival. This conveyed information is important because it is part of the canvas for this study.

Another aspect of the canvas is understanding the wealth of the teacher. In this study, we work with Ms. B, a black African American woman. Black educators have been deemed to possess certain attributes that make them effective in teaching. These attributes go beyond the standard of knowing pedological content and practices. One of these attributes is "the power of caring". Gay [10] described "the power of caring" as a key component of culturally responsive teaching. Gay [11] also expressed that "the power of caring" is an <u>action</u> oriented in that it demonstrates high expectations and uses imaginative strategies to ensure academic success for ethnically diverse students. In Maxine McKinney de Royston's [24] study on Black womanist teachers' political clarity in theory and practice, one of the participants, Ms. Bailey, describes what caring means to her:

"I feel like when I am in front of them [the students], my hope and desire is for them to know that they are cared for. And I want them to know I will not accept any excuses" (p. 383).

Caring involves a view of teaching and learning that humanizes youth, that looks beyond stereotypes, and instead teaches them in and through their embodied knowledges of self, family, and community [24]. Another attribute is how they perceive themselves. Black educators see themselves not just teachers but more. Pang and Gibson [28] share that "Black educators are far more than physical role models, and they bring diverse family histories, value orientations, and experiences to students in the classroom, attributes often not found in textbooks or viewpoints often omitted" (p. 260-61). Black educators are extended beyond the walls of the school into the community which creates a deeper relationship with students of color. Students can find/see their teacher (black educator) in their church, grocery store, community, and even in their hair salon. With this, they are able to guide and help students of color navigate through their educational journey.

The last aspect of the canvas is the integration of engineering education within the K-12. We know engineering education as the teaching of principles used in engineering. Those principles include the integration of math, science, technology, and other knowledge. In 2017, the White House announced the North Star program, a five-year push for STEM advancement in education. This announcement placed a greater emphasis on engineering education with the goal of increasing the economic and national security of the United States. White House officials stated one of the challenges in fulfilling its mission is the lack of STEM teachers in K-12. STEM integration involves a broad set of skills and abilities, including inquiry, problem-solving, design, systems thinking, modeling, cognitive, metacognitive, and more [17], [27]. The engineering component is the most challenging portion for teachers that chose to teach STEM education. The unfortunate reality is that few K-12 teachers have had formal exposure to the concepts and practices of engineering [1]. Teachers who possess little to no experience in a content area they have been selected to teach usually opt to obtain professional development (PD) in that area. However, gaining access to PD in engineering education is challenging. While PD programs have been shown to be effective on a small scale, difficulties arise with conducting these PD with large groups of teachers [14], [23]. Further, while district and school administrators are typically the ones who decide on PD programs, they are hampered by a lack of a consistent framework for understanding and judging the quality of PD [7]. Finally, there is a lack of skilled facilitators to lead engineering education PD sessions [8].

Embedded in the skills of integrating the engineering concepts into curriculum is the ability to understand and translate the appropriate concepts from the Next Generation Science Standards (NGSS) engineering standards. Hoepfl [15] describes translational errors can occur in standards, curriculum, instructional strategies, and students' interpretation of the provided information. These errors can occur from one level to the next level, compounding the challenges of enacting robust engineering teaching and learning at the K-12 level.

Rightful Presence Framework

The framework that guides this study is Rightful Presence for justice-oriented teaching and learning. Rightful presence focuses on the processes of reauthoring rights towards *making present* the lives of those made missing by the systemic injustices inherent in schooling and the disciplines [2]. In this context, Rightful Presence refers to youth having legitimate membership in their science learning community because of who they are and not because of who they should be [32]. This framework contains three tenets. The first tenet focus is: *Allied political struggle is integral to STEM learning: The right to re-author rights*. Within this tenet, the student, and the teacher work together to challenge and transform what participation in STEM entails in ways that humanize participation and value students as cultural and whole people [32]. The second tenet is: *Rightfulness is claimed through presence: making justice/injustice visible*. The focus of this tenet is recognizing when injustices happen in the STEM learning environment and addressing them through making them visible. The third tenet is: *Collective disruption of guest-host classroom relationships: amplifying the sociopolitical* [3]. This tenet stresses the responsibility of all parties (e.g., more powered teachers and less powered students) collectively working to seed new, more just norms in classroom teaching and learning culture. In this study, we explore the ways an Engineering for Sustainable Communities (EfSC) curriculum that is co-designed with families, might support students' simultaneous development of engineering and STEM epistemic knowledge and their rightful presence in middle school STEM. We ask:

1. How do relationship dynamics (as related to power, expertise, and respect) shift between students, teachers, and parents as a result of co-designing and implementing co-designed lessons?
2. What were the impact of these power dynamic shifts to the process and outcomes of students' engineering learning experiences?

Context

Astro Middle School is a Title 1 school where 100% of the student population are students of color. 100% of the student population is on free or reduced lunch and more than 80% of the student body and their families face housing insecurity. Ms. B is a Black woman teacher with 30 years of teaching experience. At the time of the study, she was in her 6th year teaching at Astro middle school. A dedicated teacher, Ms. B is often the last teacher to leave the school building every day, as she stays behind to tutor various students. She regards the students as her "babies". She spends a significant amount of her own money to make sure her classroom is stocked with snacks and breakfast items such as cereal and fruit because her babies are always hungry. As she told us, "They cannot take a test if they're hungry." On testing days, we have witnessed Ms. B arrive at school extra early to prepare a hot breakfast for her babies which is usually French toast with eggs. Ms. B often states, "They need protein." Ms. B is beloved by her students who described her as "the best but tough" and that "being in Ms. B's class is hard but worth it."

The EfSC Curriculum [36] is an NGSS standards aligned curriculum with two connected, engineering design units focused on engineering for sustainable communities. The two design challenges are: 1) Designing and iterating an electric art card for a loved one; and 2) Innovating and iterating sustainable green-energy powered solutions for the school community. The EfSC approach directly connects teachers and students to their local school community, and values learning engineering and doing engineering with and for community towards building a healthier and more just world. Key science content in this unit included types of circuit and how energy flows through them, energy transformation and types of renewable and non-renewable energy sources. Table 1 below gives a snapshot of the key foci across the 10 lessons.

Table 1: Lesson flow and foci of the EfSC curriculum.

#	Lesson	Key Focus	Integration of Community Perspectives
1	Introduction	Big Ideas in Engineering for Sustainable Communities **Lesson 1:** Introduction	Examining & discussing how youth their age use community ethnography as a part of engineering design
2–3	Iterative Design Cycle 1	Using iterative design cycles to make electric art cards for family/friends, powered with green energy sources **Lesson 2:** Designing Electric Art **Lesson 3:** Sustainable Electric Art	Generating Community Narratives
4–9	Iterative Design Cycle 2	Defining problems and designing solutions through community ethnography **Lesson 4:** Engineering Design Cycle **Lesson 5:** Design Challenge **Lesson 6:** Initial Design **Lesson 7:** Design Optimization with Community Feedback **Lesson 8:** Prototyping Designs **Lesson 9:** Refining Your Prototype	Using community ethnography as a part of engineering design Surveys & observations of peers & community members Dialogs with community on project ideas/design Observation
10	Community Sharing	**Lesson 10:** Sharing Engineering Designs	Community Narratives

Methodology

For this study we utilized a research-practice-partnership [35] approach. We engaged in research-practice-partnership (RPP) and participatory design methodology with parents, youth, and Ms. B to co-design and implement an Engineering for Sustainable Community curriculum (EfSC) across 4.5 weeks of daily 60-75 minutes engineering lessons. The co-design RPP sessions were Saturday meetings with Ms. B, four participating students and their parents, and three researchers. Three RPP meetings took place (each 90 minutes), before the start of, in the middle, and after the end of the curriculum enactment. The co-designed engineering curriculum was enacted in two 7th grade classrooms (33 students). The EfSC curriculum contained milestones such as introduction to engineering, sustainable communities, renewable energy sources, engineering skills-circuitry, community survey (creating and data analysis), engineering design challenge.

Data sources from both RPP sessions and classroom implementation included field notes, audio and select video recording, artifacts, teacher, parent, and student interviews. We engaged in grounded theory analysis [31] which involved multiple stages and levels of coding based on constant comparison procedures, guided by the RP framework. There were two researchers involved in the coding process. The first level of coding involved open coding of the following:

(a) Experiences that had prominent performance, in talk and actions, by students and teacher during the reenactment of the EfSC curriculum that is focused on the community of Astro,
(b) Knowledge and practices that students drew upon during the creation of their engineering artifacts,
(c) Conversations and experiences of the students and their parents related to STEM and interactions with the community of Astro,
(d) Conversations during STEM activities done by students and their parents together during RPP meetings

Themes that emerged from the open coding included: 1) What students and parents define and characterize as STEM and engineering; 2) the new ways of participation by students and parents, through the EfSC curriculum and parent RPP meetings; 3) the organic ways in which concerns about the Astro community informed students' engineering designs; 4) how the teacher Ms. B, students and parents engaged in new ways in engineering for the Astro community.

We then engaged in axial coding across the four themes above, guided by the RP framework, to answer the following:

(a) Was there evidence of the Rightful Presence tenets during a prominent performance. If so, who, where, when, and how?
(b) What are the contributing factors that allowed Rightful Presence to take place?
(c) What are the power dynamics? Did they change? If so, who and how?

Findings

We present two key findings in response to our research questions. In response to RQ 1, we first show how youth voices were individually and collectively amplified through specific EfSC classroom activities that centered youth perspectives, experiences and expertise. Next, we illustrate how parents were more empowered in the RPP meetings in both exploring STEM with their youth and with teachers. Then, we zoom in on a teacher-youth-parent interaction episode to further unpack shifts in power dynamics. We then look across these RQ1 findings' impact on students' engineering learning experiences in the classroom, in response to RQ2.

I. "I Have a Voice": Amplifying individual and collective student voices toward engineering for sustainable communities.

During the reenactment of the EfSC curriculum, the students produced engineering-based artifacts. Lesson 2 was the introduction of the concept "Sustainment of a Community". There was a lengthy discussion (approx. 20 minutes) on what are the key components of a sustainable community. Within that conversation, the emphases transferred from a general community to their school community sustainability. What makes this conversation important is that the students provided their voice, experiences, and concerns. Normally, this conversation would not have taken place in their regular science class. Below is an excerpt from the sustainable conversation:

Teacher: What would be a sustainable community on Astro's school campus?

Jordan: Good adults.
Sabrina: More greenery.
Ami: More trash cans!
Joshua: Better food!
Marcus: Clean water!
Kim: Responsible students.
Olivia: Safety…. no bullying.

Through this excerpt, the students' concerns about their school community can be identified. Recognizing the concerns is the first step in allowing them to have "their voice". Ms. B wanted to recreate the conversation space she had experienced with parents in the RPP co-design meetings where parents had voiced their fears, wishes, and concerns for their definition of "a sustainable community". Parents had named "housing", "criminal justice system", "protected time for play and relaxation" as vital elements of a sustainable community. From the student responses from the transcript above, we see how students are bringing aspects of their whole selves into a school STEM classroom conversation. For example, when Jordan offered "Good adults" as salient to a sustainable community, he is invoking powered relationships in a school setting and hinting that some of such powered relationships are problematic. Another example is safety-no bullying from Olivia. She is implying that the amount of bullying that takes place creates an environment that is not safe for the students.

The next step that amplified their voice was creating a survey that their school community participated in. There were 130 responses to the survey. The students co-constructed the survey with Ms. B, and the research team. The survey contained the following five questions.

1. What category best describes you? Student, School Staff, Parent or other adult in the community
2. What problems related to a healthy and happy school/class community do you think are most important (select 3 or 4)?
3. What other problems related to happy and healthy communities do you think are important at Astro? (open-ended question)
4. What are the most important things we should be thinking about to make sure that our design idea is environmentally friendly (select 2)?
5. What are your ideas for engineering designs that kids could make that could help solve these problems? (open-ended question)

From the survey data, the students learned that many of their peers had the same concerns as them for their school community. For example, the results shown for questions 2 and 4 are listed in figure 1 and figure 2.

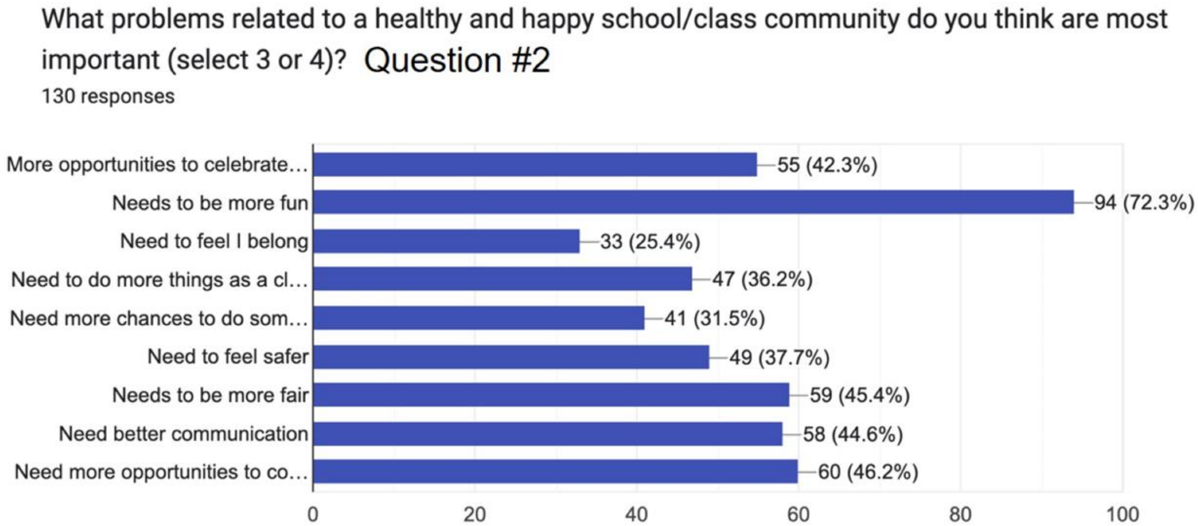

Figure 1. Results for question 2 of the Astro Community Survey

The top five responses for question 2 are needs to be more fun, need more opportunities to complete work, needs to be more fair, needs better communication, and needs more opportunities to celebrate accomplishments.

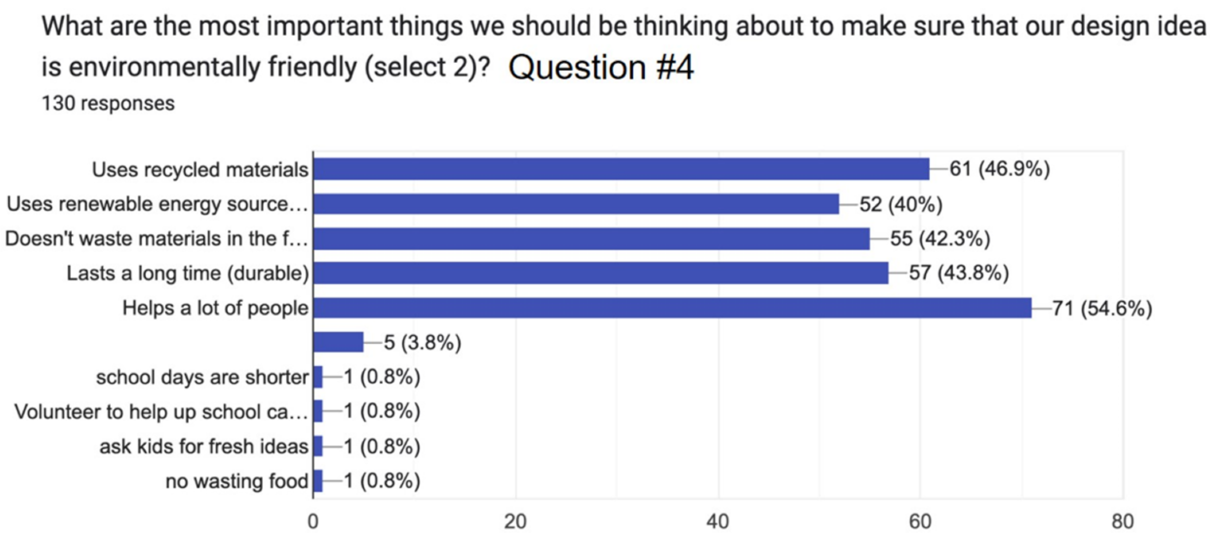

Figure 2. Results for question 2 of the Astro Community Survey

The top five responses for question 4 are helps a lot of people, uses recycled materials, lasts a long time, doesn't waste materials, and uses renewable energy.

Some of the responses that were given for question 3 are respect, morals, be nice, bullying foreign students feeling welcome, communication with teachers, teachers yelling, and nutrition.

This information reaffirmed their voice. The students completed data analysis to determine which data supported the top concerns.

The final design challenge required the students to engineer a functional prototype of an innovation that addresses one of the concerns in the data analysis and to present it to their peers and school staff. Criteria for the design is that it must utilize circuitry skills that were learned within the engineering curriculum. The students were placed in groups of four. Agency was given to the students on what to design and how to design it.

For example, one team (Sam, James, Zen, Nas) created the fun box since 72.3% of survey respondents indicated this as the most important sustainable community concern at their school. This design allows the students to shoot cotton snowballs into a box (the fun box) at the end of class as a way to have fun and move their bodies. To create the fun box, the team chose to use a simple circuit design. The team positioned their circuitry on the inside of the box with a white LED light protruding through the front of the box. The front of the box is decorated with the words "Fun Box". Through this design, this team addressed the community concern of schooling needing to be more fun for students as it helps with their learning. The current routine for the classroom is to complete packets that are geared towards the current subject matter that is being taught which to most of the students was an unappealing way to learn.

Another team of students (Mirah, Josephine, Grace) believed that addressing the survey concern of "needing more opportunities to complete work" would improve grades. This team's solution was to create a color-coded, organization folder holder. They described disorganization as a big factor in how some students pick up the wrong handouts or cannot find specific pieces of assignments they were to do from the classroom. The designed folder holder was divided into six individual sections, each one corresponding to a class the teacher taught. This allowed the teacher to organize handouts more systematically and allowed students to pick up the work they needed to complete from a designated spot. The folder holder featured two parallel circuits, one on each side of the box. Each parallel circuit contained three blue lights and was powered by a solar panel. The purpose of the lights is to draw attention to the folder to remind the teacher and the students to check it daily. This prototype exemplifies that the students' schoolwork is important to them and that they care about their academic progress. It also showed that Mirah, Josephine and Grace were keen observers of the classroom practices and could zoom in on a better organization of handouts and papers in their teacher's classroom as a helpful solution to a more complex challenge. In both projects, we see how the students leverage engineering practices to show care for their community. Figure 3 shows a picture of both design prototypes.

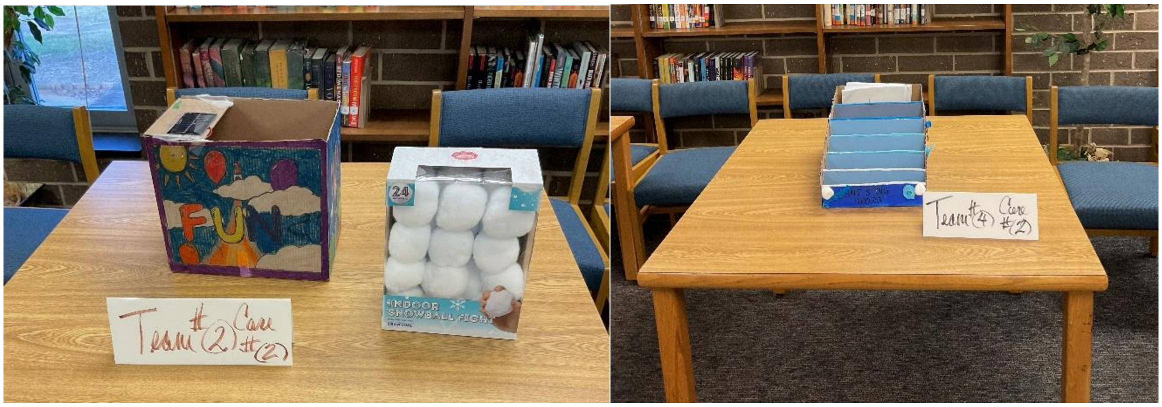

Figure 3: Fun Box and Folder Holder

II. Amplifying parental voice and seeding new power dynamics at RPP mtgs

From the RPP meetings, we were able to explore interactions between the students and their family. In one particular meeting, parents reviewed the results of the EfSC school community survey and their child's engineering design prototype. Families also reflected on their experiences collaborating as co-designer of an engineering curriculum for their middle schooler.

When asked to characterize the affordances of this partnership from a parent's point of view, parents noted how participating in RPP sessions with their youth and their science teacher reawakened their memories of their child's past experiences with STEM and if their child had a long-term interest in STEM. For example, Monica, Sam's mother, shared:

"I know that there are other places that provide opportunities that may not be housed at Astro. So, to be able to have him experience this opportunity, he was excited about it. A lady at church had already exposed him to STEM opportunities online. He had taken to that <u>but also given him the opportunity to know that there are options out there in the world.</u> What he wants to be when he gets older."

Zen's grandmother, likewise, was excited to recount that Zen had always been interested in STEM:

"*Being a grandparent and not actually living with the student, he always tinkered with things as a little one when he came to stay at my house and building and tearing down. This reinforce that this maybe a good track for him to follow up on and to be more exposed to opportunities. <u>But I also see that he needs more encouragement in speaking his truth.</u> He knows what he is doing but he is a little shy with that. He needs to come forth with that. So that to me has been an eye opener."*

Here, we see that Zen's grandmother publicly recognize and validate Zen's long-time interest and engagement with STEM. We also see how grandma recognized that she, as his primary caregiver, has a legitimate and important role in advocating for Zen's STEM learning and encouraging him.

Parents also recounted how joyful it was to witness their youth working hard in engineering and to take pride in their accomplishments with the functional prototypes. Olivia's parent, Karen, shared:

"It has made me excited to see what all she can do. I'm happy for the opportunities she has but it makes me excited. It showed me how smart my kid is so I'm proud of that."

Olivia's mother is proud of her daughter but even more so, she sees that her daughter is excelling above her expectations. In addition, she acknowledges there are more possible opportunities for her daughter due to her "smartness".

Finally, parents also reflected on how unique and valuable the RPP time was for them to work on engineering activities with their youth together as a family unit and for engineering to be a legitimate vehicle for family time for them. John's mother put it most poignantly when she said "*Whatever I do (for her schooling), she is happy."*

Parents also described how the RPP partnership experience is different from how they perceive their children's school (Astro) involves parents. Sam's mother, Monica, explained:

"This experience has been great. I'm not involved with Astro. This one is more hands-on. I would agree with the communication. I feel there is not a lot of communication, so it is hard for me to volunteer for things or get more involved."

Monica narrated a non-existent relationship she had as a parent with her child's school. Monica's desire to be an involved parent at her child's school was thwarted by the ways school-parent communication was limited. This sentiment was shared and echoed by another parent, Kim:

"Connect Ed (Information sent to parents from the school district through email, text or phone) is sent out but not enough time to make arrangements. I don't see the open space or opportunity to have that communication."

Kim emphasized the response time from Astro in communication as a problem. Further, school to parent communication is mostly consigned to reports on students' progress or concerning behavioral issues. Kim distinguished how Astro relates to parents and the substance of those interactions with the RPP meetings of this project. She elaborated:

"This has been great experience. Of course, who wants to dedicate a Saturday? It was fine and it worked out for us to be able to come together because I'm not able to do it on a regular school day. It gave me and my husband an opportunity to see him in action and to see what he is doing."

Here, Kim noted two ways in which her participation as a parent to the project was valued and sought for by the research collaborators: 1) That a time that works for working parents was set aside (a Saturday) for the RPP activities, and 2) the nature of the activities they engaged in with their youth and their youths' teachers were collaborative in nature and disciplinary-focused. It was a time of co-exploring engineering and co-designing engineering curriculum. The parents were positioned as legitimate contributors with valuable expertise to their youths' disciplinary learning. Kim reminded us that as parents, they were willing to sacrifice a precious weekend day to engage in engineering activities with their children. Through these RPP sessions, parents shared their aspirations about their youth to their teacher, worked together in engineering activities as collaborators, and both youth and teachers could witness parents having unexpected expertise relevant to engineering tasks. Parents were able to witness the brilliance of their children executing an engineering task. These processes demonstrated how traditional teacher-centric power dynamics shifted between teachers, parents and youth.

Another example of the power shift that occurred was during the second RPP meeting between the teacher and the student. At this meeting we had an African American girl and her mother, 2 African American boys (one with mother and other with grandmother), and an Asian American boy and his mother. This meeting focused on the student teaching the parents how to create an electric art card with copper tape, 3-volt battery, and an LED light. During this meeting, the students had to teach their parent/grandparent the three types of circuits, how to make them, the correct way of laying the copper tape, and how to attach the LED light to the circuit. Below is an excerpt from the meeting.

Researcher: Students, you will have to teach your parents about the three different types of circuits you learned in class. You must explain why we don't use one of them. You will have to strategically help your parents create a circuit and design an art card. Remember your circuit is based upon your design and your design is based upon the circuit. They go hand in hand. Okay, you ready.
*Ms. B:*Laughs* Let's see you teach!*
*Students: *laugh nervously and groan* in response to Ms. B*
Students begin to instruct their family. Ms. B walks around the various pairs of parent-child groups smiling, observing and teasing the students with phrases such as "now you know how hard it is to teach!"

Let's see you teach! With this comment, Ms. B gave her power as the expert to the students. We watched as the students became the experts in the room in teaching and guiding their parent/grandparent in creating an electric art card.

III. Power Shifts between youth, teachers, and parents: We all can be Experts

Power shifts can be accomplished through small actions. With the science concept on circuitry, the students must learn how to accurately lay copper tape and create a circuit. During this lesson, the students must create a simple, parallel, and series circuit on practice sheets. Once completed, the circuit would be tested to see if it works by having the LED light turn on. Ms. B gave her power of being the only expert in the room over to the students when she asked for the students who have completed the assignment to help their peers. Those student helpers were therefore positioned as experts as well.

The final performance task in the EfSC curriculum was the engineering design challenge. Students were to create a functional prototype of an innovation that addressed a community concern surfaced by the community survey, that was described above. At this point, Ms. B encouraged a larger degree of autonomy in the students, both in terms of which community concern was most salient to them and therefore what they would want to innovate and build a prototype of. The only factor Ms. B managed was time. The students had 2 ½ days to complete their functioning prototype and be prepared to present it to a local community of stakeholders (including parents, other teachers, local university faculty). There was no issue with classroom management because the students were clear about the end goal and what was required of them. Ms. B gave the students the space to create and build without influencing how and what they should do. She made sure her classroom had sufficient prototyping materials with all sizes of cardboard boxes, cardboard scissors, rulers, art supplies, paper circuit supplies, and anything specific a project may need. For example, one group needed a big plastic water pitcher, which Ms. B immediately went in search for in the school. She stayed late every afternoon and moved desks in her classroom to make sure students had enough space to spread out and work. On the day of the showcase, the students were positioned as the experts and presented their prototypes to an audience of peers, school administrators and local university faculty members. This kind of presentation to an authentic audience is an anomaly at Astro and allowed students to re-author their rights of what it means to engage in youth and community-centered engineering learning.

Discussion

The co-design and enactment of the EfSC curriculum provided students and parents with a voice that extended beyond their science classroom walls and allowed them to take action in making their community more sustainable. All three tenets of Rightful Presence were demonstrated throughout the curriculum. Through these assignments the students were able to re-author their rights as experts in the sustainability of their community and engineering design-Tenet 1. The creation of the survey and the results made visible the concerns of the students' school community-Tenet 2. Collaboration of the students and the teacher to present the design prototypes and survey data to the school staff and students' peers disrupted the typical order of power (the teacher being the most powerful)-Tenet 3. Through this study, we learned that engineering in K-12 can support youth and families seeding a Rightful Presence in a culture characterized by familial ties and community concerns. While engaging in the EfSC unit, youth's whole lives mattered in the learning community. Their experiences, knowledge, concerns and feelings [32] informed their engineering design in the kinds of functional engineering prototypes they innovated to address specific community concerns.

From the RPP meetings, we gained two insights. First, parents were glad to witness and experience the accomplishments and growth of their child/grandchild in the area of engineering, even as they initially expressed doubt that they understood much of what they perceived as engineering. The key words are "witness" and "experience". It is hard for working class parents to see the academic growth of their child in progress due to their long working schedules. When the parents saw what their child could do in engineering, they were encouraged to more actively advocate for their child at school. It has been shown that parental involvement is shown to improve school behavior, mental health, and achievement [9], [18], [19], [20], [33].

The second is the necessity of having students recognize themselves as capable in doing engineering in the context of middle school STEM, and that the engineering is authentically meaningful to them in the here and now. When the students were testing their prototypes and when audience members tried their functional innovations, the sense of accomplishment that they created something tangible to help their community resonated deeply within the students. Beyond a test score, students valued the kind of community-focused engagement they experienced with the EfSC unit.

None of this could be possible without creating a safe place for conversation and action in both settings, the classroom and the RPP meetings. In the classroom, Ms. B had to be willing to cede power to the students in their decision-making. Ms. B created a conducive space in her classroom by not condemning any wrong answers in reference to sustainability, circuitry, engineering, and the students' concerns about the Astro community. Importantly, Ms. B herself, had some of the same concerns about the Astro community. Further, Ms. B's teaching philosophy was to continually build her students up as possible future scientists, engineers, and informed citizens who would make a difference. Within the RPP meetings, a STEM-related space where parents, youth, teachers and researchers worked together to figure out engineering for sustainable communities conveyed that everyone was an important stakeholder that brought "wealth" to the EfSC engineering table. These multistakeholder collaborations were integral to building deeper relationships between the family and teacher that support students' seeding a more rightful presence in middle school STEM.

Conclusion

Integrating engineering education into K-12 curricula can be complex and challenging. From this research, two components were revealed that could aid in the integration of engineering education into K-12, the amplification of voices in the community and the redistribution of power from the teacher to students and parents. This work is labor intensive and is contingent on developing trusting relationships between teachers, families and students. Supporting the development of such relationships is dependent on creating new spaces, such as the RPP meetings, for new activities to take place where teachers, family and students move beyond their canonically schooling scripted roles. Teachers also need to be supported with professional development opportunities to experience doing engineering themselves, in ways that are authentic to them as whole people. We hope that this study illustrates how such a collaboration might take place and helps push the field forward as we work towards justice-oriented STEM teaching and learning in middle schools.

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