Team Profile

Abstract

Ignite is a Duke-led outreach program that partners with local middle school students to co-create hands-on engineering projects addressing community challenges. Grounded in human-centered, place-based design, the program builds STEM confidence, resilience, and problem-solving skills through Health, Light, and Water curricula.

In Spring 2026, 71 students participated in an eight-week program, designing pulse oximeters, renewable energy flashlights, and water filters tied to Durham-based challenges. A mixed-methods evaluation using surveys, interviews, observations, and engagement data showed significant gains in STEM attitudes, engineering identity, and grit, along with consistently moderate-to-high engagement. In-person sessions yielded stronger and more stable engagement, while virtual sessions supported growth in verbal reasoning. These findings inform ongoing curriculum improvements and support Ignite's development as a scalable, community-engaged engineering education model.

Introduction

Ignite is a community-based, multi-tier engineering design program that aims to broaden participation in STEM through near-peer mentorship and human-centered design. Ignite uses a train-the-trainer model in which Duke undergraduates, called Trainers, are prepared through orientation and curriculum training to serve as near-peer mentors rather than traditional instructors. They guide middle school participants, known as Learners, through human-centered design challenges connected to global issues and the UN Sustainable Development Goals. This experience is structured through detailed Trainer guides (Figure 1) that provide lesson plans, objectives, activities, materials, and role assignments across curricula like Light, Water, and Health, helping ensure engaging and adaptable sessions in both in-person and virtual settings. Through this approach, Ignite builds a collaborative learning environment that strengthens STEM identity, problem-solving skills, and creative confidence for both Trainers and Learners, while contributing to refine its evaluation methods and explore opportunities for sustainability.

Lesson Plan Information:

Class Duration: 2 hours	**Class Setting:(e.g. MLS/Zoom)** MLS
Lists of Standards (NC Essential Science, Next Gen, AE3, etc.): Students learn about the components of a flashlight and how they work together. 7.P.1: Understand the relationship between the structure and function of objects. 7.L.1: Analyze how parts of a system interact and contribute to the overall function.	**Safety Precautions:** 1. **There should always be 2 Trainers working with students; there should never be a situation where 1 Trainer is alone with a student, either in-person or on Zoom.** 1. **CAUTION: The soldering iron is extremely hot. Be aware of burn risk for yourself and for your students. Make sure they know not to directly touch the tip of the iron. Also make sure students are wearing safety glasses and that there is no battery connected for safety reasons.** 2. **Approximately 2 Trainers will be helping at the casing station using a hand drill. Please wear your hair back and wear safety glasses while using the hand drill.**
	Burn first aid basics: • **If a burn occurs, immediately cool the area under *cool (not cold)* running water for 10–20 minutes** • **Do not apply ice, butter, or creams** • **Cover lightly with a clean, non-fluffy cloth or sterile gauze** • **Seek medical attention if blistering, large burns, or if burn is on the face/hands/joints**

Materials Needed for Lesson:

Materials already in lab:

- 5 pre-existing hand cranks
- Resistors 330 ohm (~100 count) or above (from resistor graveyard box)
- Wires (multicolored)
- Soldering kits
  - Soldering stands
  - Soldering irons
- Wire stripper (5 total)
- Wire cutters and wire shaver (more than enough, can bring 7-10 each)
- Casing material
  - PVCs
  - Plastic boxes
- LEDs (small LEDs, up to 4 per student ~80 LEDs)
- Safety glasses (25 pairs)

- Hand drills for casing (1 count)
  - Should go into trainer training
    - Know how to lock the drill in order to safely put in the bit (Direction control button needs to be put on the central position)

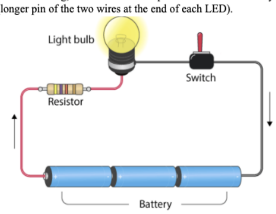
Testing station:
- 2 Lux Meters
- Rulers

Materials needed:
- 23 Mentos gum boxes
- ~15 hand cranks

Lesson Activity:

Lesson Background/Introduction:

Station 1: Circuitry (Trainer 1)
Students will assemble their simple circuit at this station. Please note that in contrary to Week 3, students will be using **regular wires** instead of alligator clips, which they will assemble at the soldering station later. Use the following diagram as reference (note: we will not be including the switch component). For troubleshooting, check first that the positive end of the battery is connected to the positive end of the LED (longer pin of the two wires at the end of each LED).



Station 2: Soldering (Trainer 2 & 3)
To start, trainers need to go over the safety precautions, as outlined in red and reiterate the steps by giving a quick demonstration. While students are working, trainers need to float around to offer help when needed and make sure students are safe.

Steps:
1. Using a wire stripper, strip two pieces of wire so that metal is exposed
2. Clip wires onto clamp stands and wind/braid the metal pieces together
3. Cut a length of solder and turn on the soldering iron
4. After soldering iron has heated, hover the solder over the exposed wire and use the heat of the iron to melt the solder onto the wire
5. After the wires have been connected, clean the soldering iron with the steel wool and make sure all the solder is removed from the tip of the iron.
6. Turn the iron off.
7. Wrap up the exposed wire with electrical tape.
8. Clean up the work station.

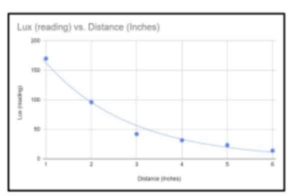
Station 3: Casing (Trainer 4 & 5)
Students will follow through on the design of the casing of their flashlight that they came up with during Week 3. If they had previously designed something of their own design, but want to switch to the standard Mentos box design, students are more than welcome to, and vice versa. Make sure that the hand crank component is fully visible on the exterior of the flashlight.

Station 4: Testing (Trainer 6)

Students will be testing the flashlights they designed using a device called a Lux Meter. The procedure is as follows:

1. Place the light in a dark box
2. Hold the photodetector 1 inch away from the light and record reading
3. Repeat step 2 by holding the photodetector 2, 3, and 4 inches away

Then students can record their results on Excel to make a graph to be included on their poster designs using the Testing section.



Agenda for the day:

10 - 10:10 am: Introduce stations

For the rest of class (10:10 - 12pm):
- 2 trainers at the at the soldering station
- 1 trainer at the casing station (also responsible for demonstrating drilling)
- Split the remaining 3 trainers at the non-soldering stations

**Benchmarks 10:50 am – Half of the students need to be done with soldering.
**With 10 minutes remaining: Have students wrap up what they are working on and start the clean up process.

Homework Assignment for Next Week:

Complete the green (Results of building prototype section).

Assessment of Activity:

Be aware of the knowledge-based metrics students will be asked at the end of the program: Knowledge Metrics

Figure 1: Screenshots of the Train-the-Trainer guide for the 2025/26 Light curriculum, featuring excerpts of Week 5.

Methods and Team Structure

Team Members

Success for the 2025-26 Ignite Bass Connections team was made possible by an interdisciplinary team that consisted of both Trainers and Researchers, who each played a role in shaping, implementing, and evaluating the program.

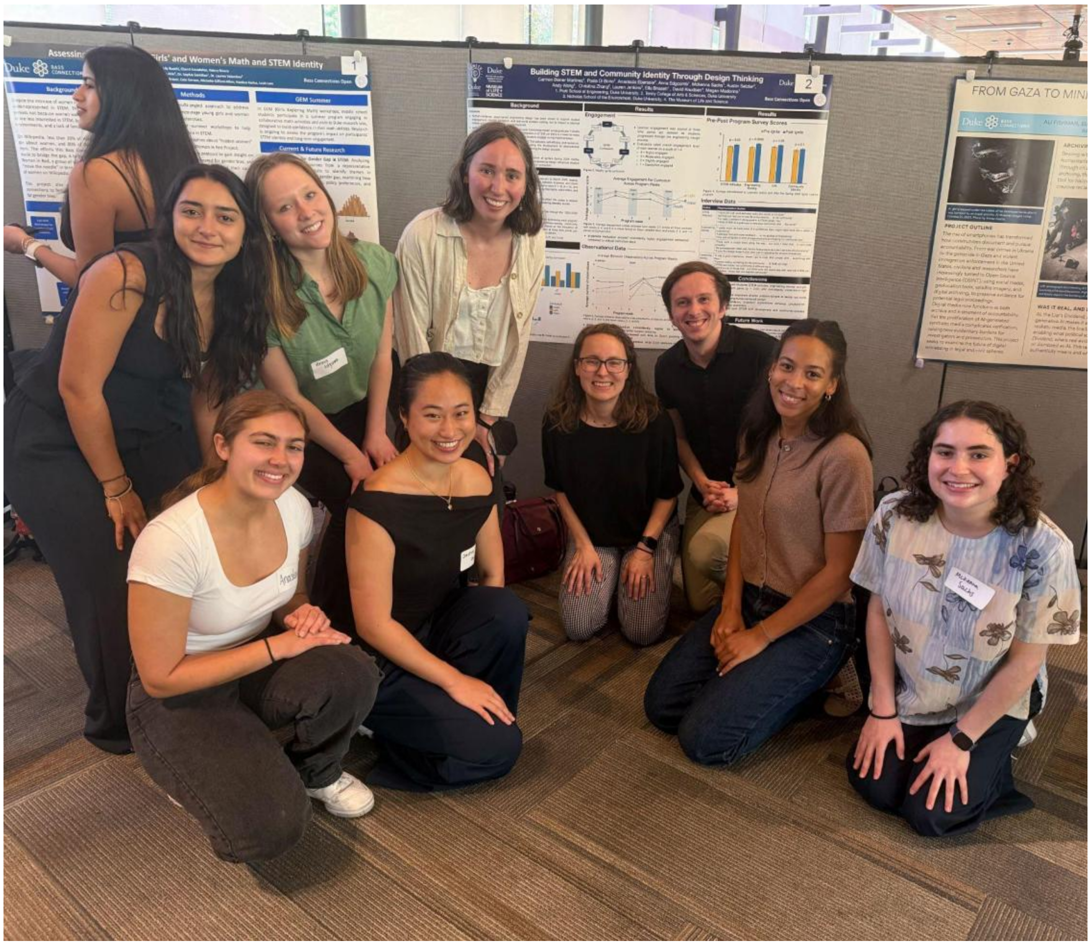


Figure 2: Team presentation at Bass Connections Showcase

Acknowledgment of Team Leaders

Thank you to our team leaders, Dr. Megan Madonna and David Knudsen, for their guidance on human-centered design practices and curricula development. In addition, Katrianna was the TA for our Bass class this whole year, and Ella acted as our program coordinator to support the research team and trainers.

Methods

Fall 2025

The major changes we implemented this fall focused on standardizing and improving our evaluation methods to reduce variability between researchers. We completely overhauled the pre- and post-surveys to gain a deeper understanding of student personality types, while also making them more engaging by shortening the length and focusing on more impactful questions. In addition, we refined the data collection scale to make it more comprehensive and reduce ambiguity in how observations are categorized. We also introduced separate data collection scales for in-person and Zoom classes to better account for the limitations of the online format. The metrics for these scales were developed more thoughtfully, and we took care to revise and refine them until they were clearly defined and consistently applied.

Spring 2026

In the Spring semester, our data collection strategy utilized a mixed-methods approach to comprehensively assess program impact. This spring, we collected pre- and post- program surveys using a 5-point Likert scale to measure changes in community identity, grit, STEM attitudes, and engineering identity. During each of the 8-week program sessions, we collected two time points of engagement scoring, recording the frequency of students classified as engaged, neutral, disengaged, or absent at each time point. We also structured in-person observations during Weeks 3, 5, and 7, focusing on behavioral markers such as collaboration, inquiry, and tinkering. Finally, we gathered qualitative insights through interviews and field notes, enriching our understanding of how students experienced and applied human-centered design in real time.

Results

Demographics

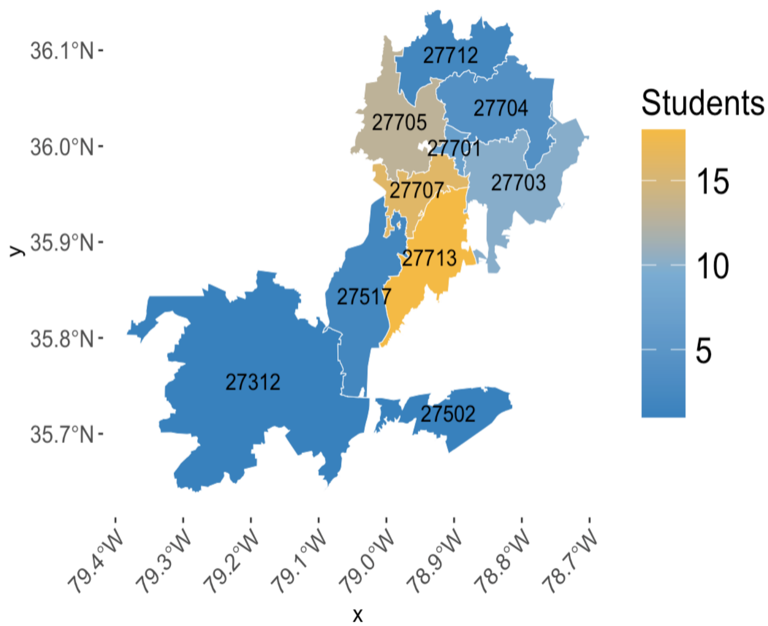


Figure 3: Zip Code Density Map of Students

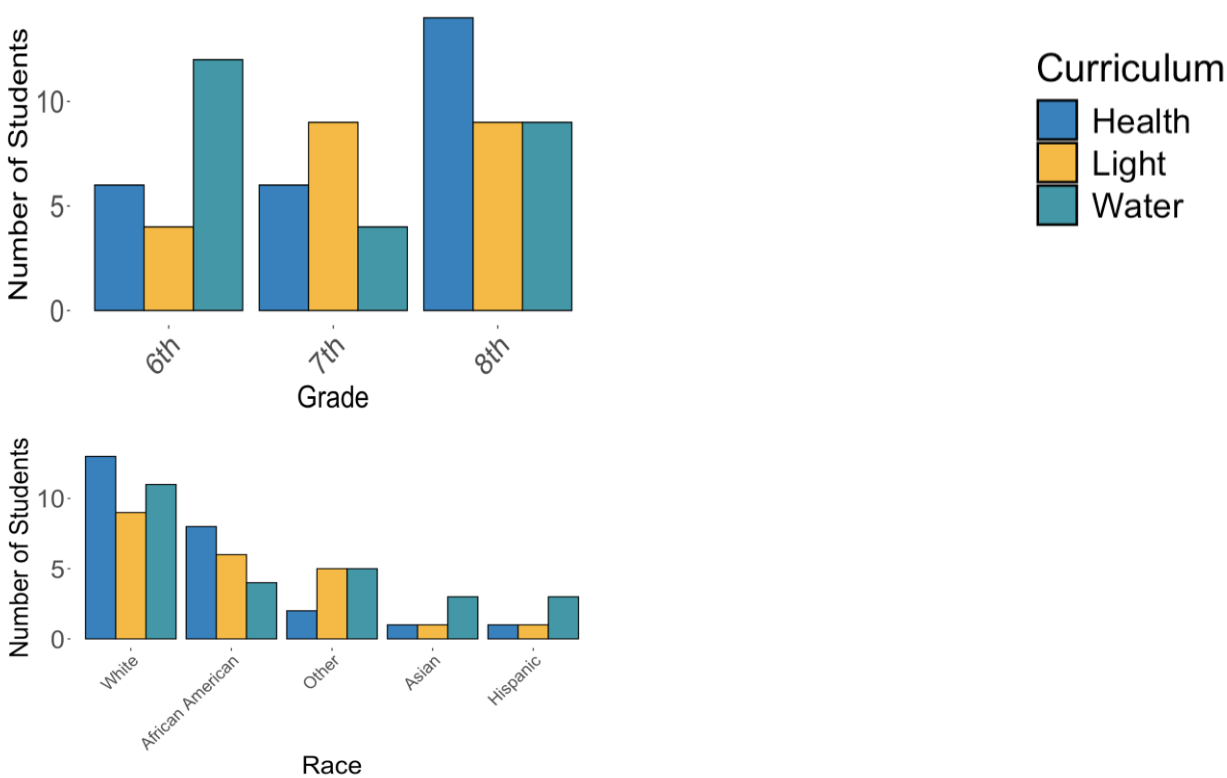


Figure 4: Racial Identity and Grade Level by Curriculum

This year, Ignite participants are all students from Durham Public Schools, representing a geographically concentrated group with the highest density of participants coming from neighboring zip codes in a primarily suburban area (Figure 3). Racial demographics show a majority of white students, and participation is relatively balanced across grade levels, with no single grade predominating across the different curriculum tracks (Figure 4).

Implementation

The 2026 Ignite program followed a hybrid model, alternating between in-person and virtual programming via Zoom. The curriculum was structured around the human-centered design framework, with Weeks 1-2 focused on Hear, Weeks 3-5 on Create, and Weeks 6-7 on Deliver (Figure 5). In-person sessions were two hours long, while Zoom sessions lasted one hour.
Each week, we recorded attendance across each curriculum, capturing both expected attendance (excluding students who withdrew) and total attendance (including those who withdrew). A total of 71 students were accepted into the program, of whom 11 withdrew before completion.

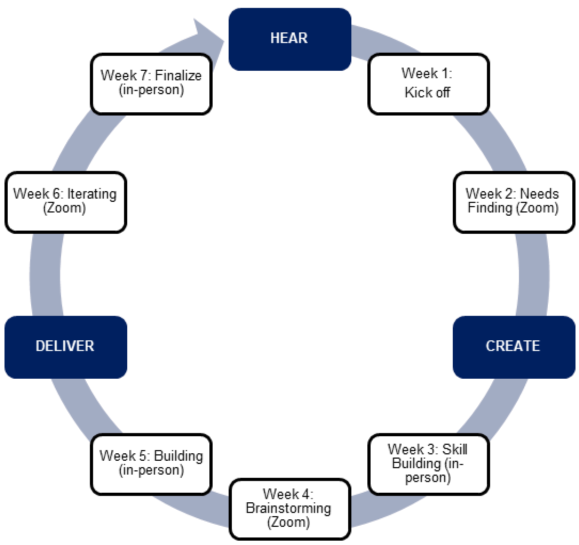


Figure 5: Weekly Ignite curriculum plan illustrating progression through the human-centered design process, from Hear to Create to Deliver.

In addition to attendance, student engagement was recorded at three time points in each session (minutes 15, 35, and 55 for Zoom sessions; minutes 30, 70, 110 for in-person sessions) using a 4-point scale ranging from 1 (not engaged) to 4 (highly engaged). Engagement during in-person sessions was consistently higher than during Zoom sessions across each curriculum (Figure X). Among all curriculums, Water had the highest average engagement scores, while Health had the lowest.

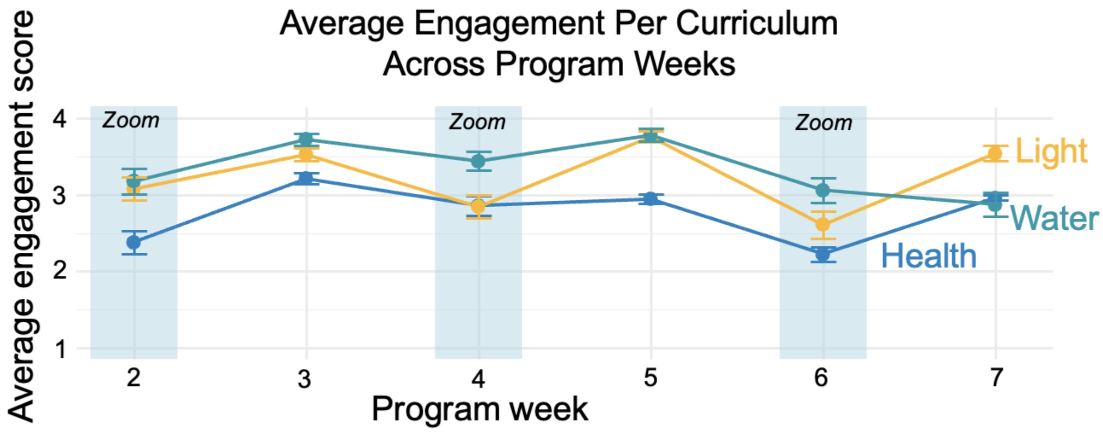


Figure 6. Average engagement scores recorded from weeks 2-7 across all three curricula, with weeks 2, 4, and 6 in a virtual format on Zoom (shaded blue) and weeks 3, 5, and 7 in-person at Durham Museum of Life and Science.

To evaluate patterns of engagement throughout the program, student behaviors were tallied in each session. Artifact and prototype production was consistently higher during in-person sessions, affirming that hands-on environments more effectively supported tinkering and active creation. In contrast, answering with reasoning increased overtime in Zoom sessions, indicating growth in their verbal reasoning skills in a virtual setting. Positive behaviors remained relatively stable across in-person sessions, whereas Zoom sessions show greater week-to-week variability, suggesting less consistency in engagement on Zoom (Figure 7).

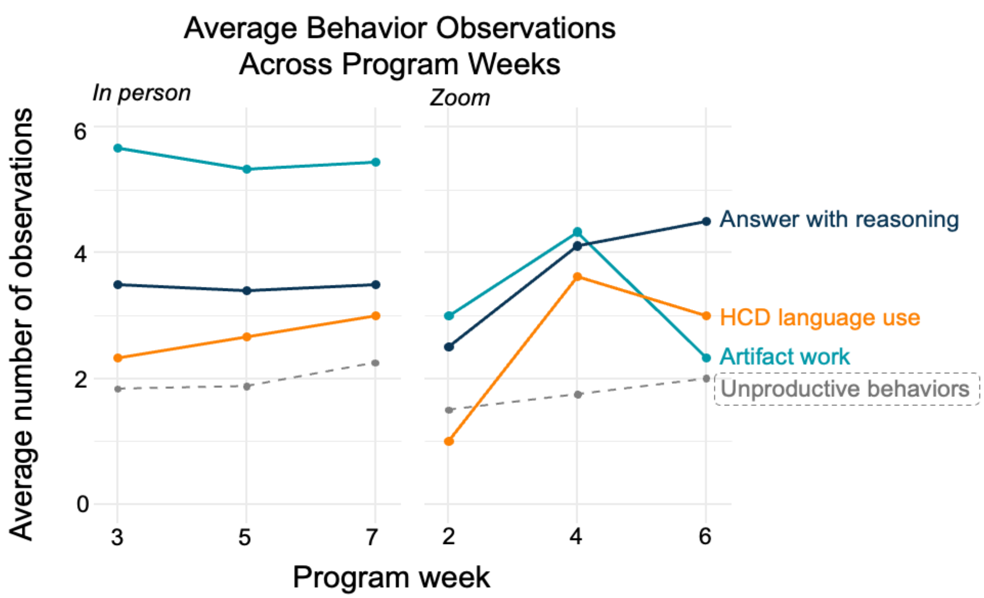


Figure 7. Average behavior observations for all learners, comparing in-person weeks (3, 5, and 7; left) with Zoom weeks (2, 4, and 6; right), for answering with reasoning (navy), HCD language use (orange), artifact work (teal), and unproductive behaviors (gray).

We observed increases across all categories measured in the pre- and post-preogram surveys. There were statistically significant increases in STEM attitudes, engineering identity, and grit ($p = 0.003$, $p = 0.0008$, and $p = 0.03$, respectively), along with a marginal increase in community identity ($p = 0.10$) (Figure 8). These findings show that the Ignite program is effective in promoting positive development across our key student outcomes.

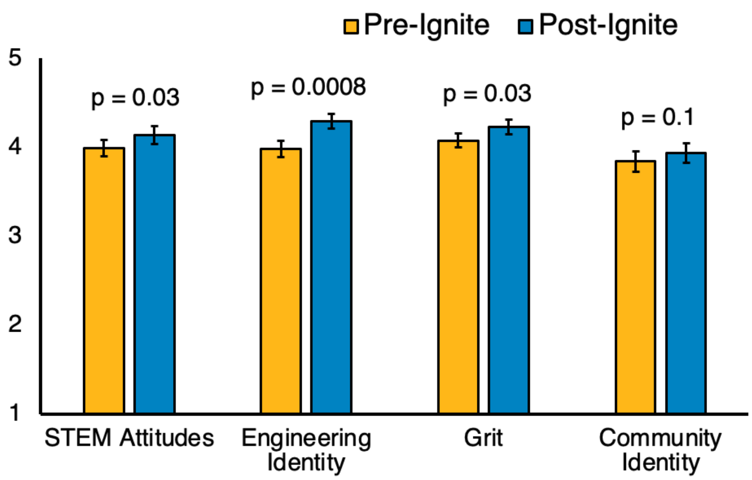


Figure 8. Surveys administered to Learners before and after the Spring 2026 Ignite Learner program show an increase in all key student outcomes. Graph displays Likert scale responses.

Interviews

A total of 31 verbal, semi-structured interviews were conducted on Duke Day. Each student was asked a block of questions related to the design process, community impact, STEM confidence, or program feedback. Subsequent analysis of interview transcripts yielded representative quotes aligning with our four established core identity dimensions. The table shows meaningful participant insights across the following domains: (1) STEM Attitudes (2) Engineering Identity (3) Grit and (4) Community Identity (Table 1).

Table 1: Post-Ignite interview quotes

Code	Interview Excerpt
STEM Attitudes	“There's a lot of things that our community still needs help with, and with STEM, you can definitely make things that can help the community and help you live in your community better.” “I think [STEM] is a good way to help your community and … the world.”
Engineering Identity	“I’m more confident to do good in [science and math] classes … because I know how things work outside of class in a different environment. So it'd be easier to learn things in [those classes] with outside knowledge.” “Before I was really interested in engineering … but I [only] kind of knew how to do it. … Now, I actually feel like, oh, I could actually assemble a circuit … I definitely feel a lot more confident in my abilities of engineering.”
Grit	“The first prototype was a little bit harder [than I expected]. But then the next one was easier, and then the last one was very easy because we had done it multiple times.” “If your first design doesn't work, then just try adjusting the amount of materials.”
Community Identity	“If someone [in my community] has something broken or if someone has an issue, like the power outages or something, I could come up with a worthy solution and then create that solution like I did with the flashlight.” “In my school, it's very, very old, over a 100 years, and we should use human-centered design to help with just getting around because the ceiling is falling on students.”

Longitudinal Enrollment Data

Changes to implementation this year included selecting more students from Durham, especially Durham Public Schools, for inclusion in the program. Because of program growth, many more students apply for Ignite than are accepted, giving the Ignite program significant flexibility to determine which students are included. While the majority of students enrolled in the program each year were from Durham Public Schools (Figure 9), this year’s increased focus resulted in an important demographic shift in students completing the program.

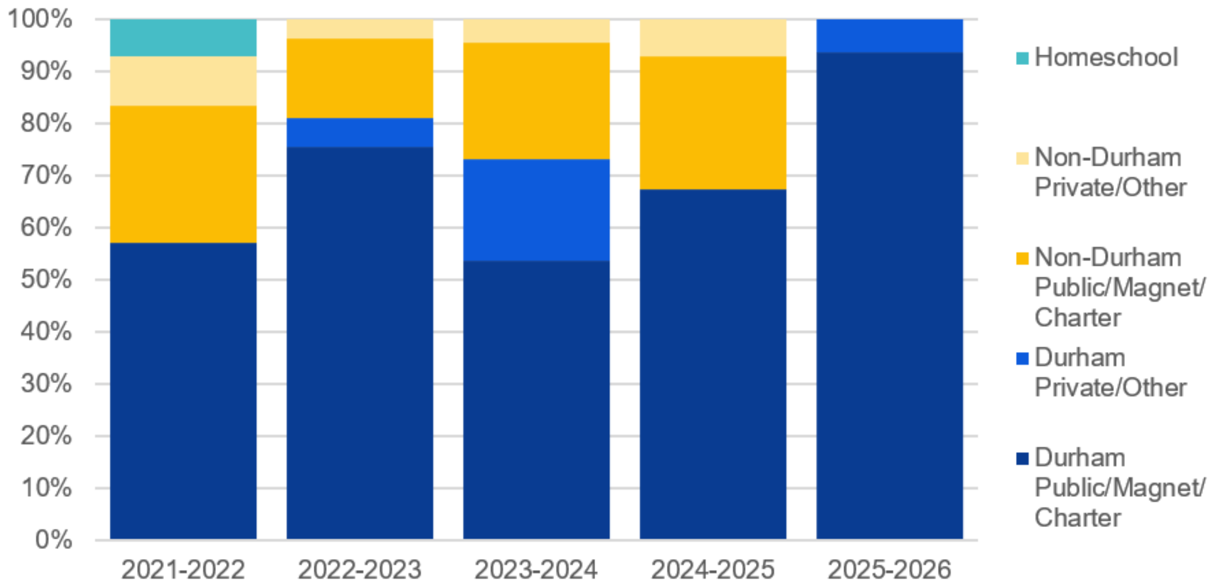


Figure 9: Longitudinal enrollment data showing breakdown of school type, 2021-2026.

Future Directions

Future work will integrate Ignite's interviews, surveys, and observational data to identify which program elements most influence student outcomes. The Summer 2026 Data+ team will analyze key themes and drivers of changes in STEM attitudes, engineering identity, grit, and community identity, while interview analysis will further capture student growth in confidence and resilience. Ongoing efforts will refine observational methods, examine differences between in-person and virtual sessions, and explore long-term retention among returning participants. These improvements will strengthen evaluation consistency and support Ignite's continued growth as a community-centered STEM education model.

Conclusion

Ignite's mission is to empower a diverse population of young problem-solvers to develop solutions for relevant community needs. Our research focuses on the program's emphasis on equipping students with the skills to address global challenges that are also reflected in their local communities and lived experiences. This year's team aimed to refine and update the program's evaluation methods to most effectively measure how successful we are in reaching our goals. Our findings show that Ignite has been successful in achieving its key outcomes, including improvements in students' grit, community identity, engineering identity, and STEM attitudes (Figure 8). Moving forward, our insights can inform further adaptation of the program to strengthen the impact of HCD curriculum in fostering global citizenship and community-oriented problem-solving.