In the fall of 2020, STEM Next Opportunity Fund launched the Million Girls Moonshot (MGM) Initiative, a nationwide out-of-school time effort aimed at empowering gender equity and engineering mindsets in STEM across all 50 Mott-funded State Afterschool Networks. Over the next five years this movement aims to “inspire and prepare the next generation of innovators by engaging one million more girls in STEM learning opportunities through afterschool and summer programs” (https://milliongirlsmoonshot.org).

Hearing this call to action, and with support provided through the initiative, Vermont Afterschool, Inc. quickly pivoted in the summer of 2020 to design and implement a female-focused engineering-based program, Linking Engineering to Life (LEL). The LEL program was structured for female middle schoolers to learn about the engineering design process, the value of an engineering mindset, and connections to engineering college and career pathways. Essex Junction Rec & Park (EJRP) in Essex Junction Vermont was one of 13 organizations located across the state of Vermont that volunteered to participate during the inaugural year. The following case study shares the exciting story of EJRP’s implementation of this innovative program designed to engage historically underserved girls and non-binary youth.

About EJRP

Located in Essex Junction, Vermont Essex Junction Recreation and Parks (EJRP) provides a variety of learning opportunities and engaging community events for area youth and families, with offerings spearheaded by a program coordinator who has been with the organization for four years. EJRP employs 21 full-time staff members and serves over 1,000 youth in preschool through 8th grade.

Afterschool enrichment and sports-based activities including mountain biking, rock climbing, Legos, tennis, arts, etc. comprise the primary focus of EJRP program; however, academic-based programming including Science, Technology, Engineering and Math (STEM) are also implemented, but less frequently (e.g., Wicked Cool for Kids).

According to staff, one of the main hurdles of offering STEM programming has been identifying adequate staffing to plan and implement quality content. Teen counselors primarily facilitate programming at EJRP and STEM is not a comfort area for most. While willing and agreeable, the program coordinator has many daily competing priorities and demands so her availability to implement STEM activities is limited.

Linking Engineering to Life (LEL) Model

Knowing the challenges some sites face around implementing and staffing STEM programming, in the summer of 2020 Vermont Afterschool, Inc., which received an Innovator Award from the Million Girl Moonshot Initiative, developed the Linking Engineering to Life (LEL) engineering-based program for girls and non-binary youth in 5th-8th grades. The model was purposefully structured to be flexible for in-person, virtual or hybrid implementation during the pandemic and, according to the facilitator guide, the design “focused on eliminating barriers to involvement such as access to technology, transportation, gender and racial identity, economic disparity, learning styles and geographic location in Vermont.”

Spearheaded by project lead Tracy Truzansky, LEL provided a free comprehensive curriculum, toolkit, supporting materials and virtual staff training at the launch and throughout programming. LEL clubs were made all the richer with the pairing of college mentors from the University of Vermont College of Engineering and Mathematical Sciences to help lead the curriculum.

Acknowledging the value of the LEL program being free of charge from Vermont Afterschool Inc. to EJRP and other participating programs,
the coordinator highlighted the accessibility of the engineering programming for families because of the nominal fee required for materials by the site to participate, “I got people signed up who normally can’t afford to sign up for some of our programs, which was great.”

**Image 1: Linking Engineering to Life Facilitator Guidebook**

LEL was structured in two parts: Part 1 focused on the engineering design process through hands-on activities and supporting materials. Examples of a few engineering tasks included designing a bandage that can hold a volume of blood, designing safety features on a car that will protect a “human” passenger during a crash, and designing a trap to catch an invasive toad. Part 2 challenged the youth to “roll up their sleeves” and apply their learnings through a self-guided hands-on project selected by the collective student team.

At the outset of Part 2, youth had the option to pick from one of the project ideas suggested in the supporting LEL guide or a project of the group’s own choosing. All youth at EJRP had to come to consensus on the selected project and contribute to the various phases of imagining, planning, creating and improving. Youth selected an exploration into how to clean dirty water by designing a filtration device from the list of project ideas and the project lead and facilitators quickly coordinated ordering materials for youth to begin their design work at the launch of Part 2.

LEL materials provided to participating programs included a comprehensive 45-page guide for facilitators that detailed structure around facilitating engineering activities and included a bank of vetted activities and resources related to equity, access, and representation in STEM. The guide offered explicit identification of engineering design practices within each activity within the appropriate criteria and constraints.

Each session included:
- An icebreaker activity
- An instructional video on the engineering task
- An inspirational video about an underrepresented women or non-binary person in a STEM field
- A prompt/activity related to equity and access

Participants received a LEL Playbook that mirrored the facilitation guide. This guide included a project overview, ideation spaces to prompt creative problem solving, and a set of resources on the engineering design process, definitions related to both STEM concepts and to equality, equity, and justice.

The guide for facilitators and playbook included detailed instructions and resources. Instead of instructing facilitators and youth to follow instructions exactly as written, the guide and materials empowered facilitators and mentors to choose ideas and activities from the vetted activities and resources and were encouraged to maintain the role of facilitator - “Strive to be ‘the guide on the side, not the sage on the stage’” — to support youth in taking the lead in a creative context.

At the end of programming participants completed a LEL Diversity & Inclusion Program Survey designed by the Vermont Afterschool, Inc. that explored connectedness, sense of belonging, diversity/equity/inclusion (DEI), program content, and likes and dislikes so the team could collect learnings to guide improvement for year two. Regarding adopting the LEL program the coordinator shared, “I just think middle school is incredibly hard to program for, it’s hard to find things that interest them, it’s hard to find things that the school doesn’t offer, or the local teen center doesn’t offer, and I want to be able to give them quality…I really want it to be worth it for these kids to do and to look at and be interested in.”

**Table 1. LEL Program Schedule & Participation**

<table>
<thead>
<tr>
<th>Program Schedule</th>
<th>Sessions</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part 1:</strong> November to February</td>
<td>Monday from 3:30-5:00pm</td>
<td>Leads: 2 mentors, EJRP teen staffer Participants: 12 girls/non-binary youth</td>
</tr>
<tr>
<td><strong>Part 2:</strong> Month of March</td>
<td>Wednesday from 3:30-5:00pm</td>
<td>Leads: 1 mentor, EJRP teen staffer Participants: 8 girls/non-binary youth</td>
</tr>
</tbody>
</table>
LEL generated a high level of interest when advertised by the coordinator at EJRP and shared within the local school district, such that a waitlist had to be created. The table above summarizes offerings and participation for parts one and two of the LEL program during 2020-21.

During Part 2 of the program youth enrollment decreased and only one UVM mentor was able to stay on due to class schedules. While disappointing that the second mentor was not able to continue, this allowed the junior staffer to take more of an active role in implementation, something she voiced enjoying when interviewed.

When asked about youth retention rates, staff attributed the drops to girls having other obligations, interest in trying different activities after a multi-month component, feeling Part 1 was comprehensive enough, and for some feeling LEL was too academic for afterschool. Staff did highlight, however, that the girls who continued were very engaged and dedicated to finishing the program. One staff member shared, “I think that the girls that stayed were really in, they were really excited…I think in the second session, knowing that everyone who’s here wants to be here, they were committed, and it was really exciting.”

Up until the last week of programming when COVID protocol required implementation of virtual learning, LEL remained in person at EJRP with participating youth working with the program staff and UVM mentors directly.

**LEL Training & Supplemental Supports**

In addition to building the LEL program and comprehensive facilitator guide designed for girls and non-binary youth, fully stocking the toolkits, and driving materials to the 13 participating organizations, Tracy—the project designer and lead—also provided a comprehensive virtual training on the LEL model to all participating program staff and UVM mentors. She created videos to support implementation throughout the program and established regular check-ins and key office hours.

Four elements or “threads” underscored staff training and these are detailed in Figure 1. Given the focus of Million Girls to empower gender equity, guidance on recruitment and engagement of historically underserved populations in the field of engineering was one key element integrated into the LEL training, as was the lens of equity and access. Please note, for the purposes of this case study the LEL materials and training are not being formally evaluated, rather they were reviewed and reported on.

**Figure 1. LEL Professional Support Focus Areas**

<table>
<thead>
<tr>
<th>Focus Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls and Non-binary Youth</td>
</tr>
<tr>
<td>Recruitment and engagement of historically underserved populations in the field of engineering: girls, non-binary youth, youth of color, youth with marginal economic means and youth for whom “science capital” (the opportunity for STEM learning outside of school) is limited.</td>
</tr>
<tr>
<td>An Engineering Mindset</td>
</tr>
<tr>
<td>Ten practices that define the values, attitudes, and thinking skills associated with engineering.</td>
</tr>
<tr>
<td>The Engineering Design Process</td>
</tr>
<tr>
<td>An iterative process that uses data to inform designs to solve a problem under specific constraints.</td>
</tr>
<tr>
<td>Equity and Access</td>
</tr>
<tr>
<td>Creating a climate of inclusiveness that actively seeks to remove barriers to participation while reflecting on stereotypes and bias within the field of engineering.</td>
</tr>
</tbody>
</table>

To deepen staffs’ inquiry and assessment of engineering learning, the project lead also offered an abbreviated training on the Afterschool Coaching for Reflective Educators in STEM (ACRES) module “Asking Purposeful Questions.” Both the EJRP staff member and the UVM mentor took advantage of this optional training and one shared, “I’m very glad I did that. I thought it was helpful for my movement in the program, actually knowing that I was teaching important things to these kids and I wasn’t just spilling information to them, they were actually learning.”

The EJRP leads reported feeling fully prepared to implement the LEL program following their training and said the training was “very comprehensive” and “very easy” yet flexible enough for them to personalize content. Formal evaluation feedback collected by the LEL project leader following the training concurred with these findings.

Uptake of supplemental offerings provided directly through the Million Girls Moonshot movement were also explored during interviews.
The LEL project lead revealed that she took full advantage of opportunities provided, sharing learnings with programs, and joked “I think the better question is what have I not done. I personally have attended pretty much every resource that’s been a STEM focused opportunity.” Sessions on equity and inclusion, mentorship and webinars linked to engineering design by Intel and Technovation, were just a few explicitly named.

The Million Girls Moonshot Toolkit, available to all 50 Mott Afterschool States Networks, is regularly updated with tools, webinars, and resources related to the four transformative practices of the initiative: equity and inclusion; engineering mindset; role models, mentors, and families; and STEM transitions and pathways.

In addition to other webinars and resources shared by Vermont Afterschool, Inc. from the Million Girls Moonshot initiative, on October 23, 2020, EJRP program staff and youth participated in the Million Girls Moonshot and NASA live event Million Girls Moonshot: Meeting the Artemis Generation with NASA astronaut Jasmin Moghbeli. Serving as one of the Moonshot coalition partners, NASA offered to have Jasmin answer questions from students. The program coordinator proudly reported how she shared this resource with program families and district STEM educators and how one of the students selected to interact with the astronaut during the event was actually from the EJRP school district.

Methods

The purpose of the case study was to share the story of LEL programming at EJRP and to begin documenting impact. Data was collected during Part 2 of LEL programming. The student sample of the current study consisted of eight female and non-binary youth ages 10-12, all residing in suburban areas of Vermont. Sixty-three percent of youth identified as White/Caucasian and 38% preferred not to report on race/ethnicity. Two reporting English was not their primary language or preferred not to answer. One youth requested and was provided a scholarship for the program due to financial hardship.

Qualitative data was gathered from four female-identifying individuals including the LEL Project Lead, the EJRP Coordinator, one UVM mentor, and a teen EJRP staffer. Self-report and observation data was gathered for all participants while performance assessment data was gathered from six of eight youth. While the youth sample size was smaller during Part 2 of the LEL program, set requirements are not established for case study sampling and findings from the study of the LEL program provide equally valuable information and insights nonetheless.

To fully inform the case study and the unique story of EJRP, the PEAR team collected both quantitative and qualitative data sources. The following sources were collected during the winter/spring of 2021:

**Figure 2: PEAR’s CIS-S STEM Scales**

PEAR’s Common Instrument Suite for Students (CIS-S). The CIS-S (Figure 2) is a student self-report survey that is rated on a 5-point Likert scale assessing change over time. A response of 1 indicates ‘much less now’, 3 indicates ‘about the same’, and 5 indicates ‘much more now’. STEM-related items used “Engineering” wording (as opposed to general
STEM) for the survey to support the engineering focus and the survey was administered in a retrospective self-change design. For the purposes of this study and to keep the length manageable, the MGM team did not include all scales from the CIS-S (STEM Activities and Relationships with Adults) and added some engineering focused custom items. Participants were asked to report once at the end of programming on their overall engineering attitudes and self-concept and how they have changed because of the recent engineering activities. All youth participating in Part 2 of LEL completed the survey (N=8).

**Penn State's Performance Assessment of Design Skills (PADS).** PADS is a story-based activity completed at the end of programming for participants to share what they learned about the engineering design process. Youth are provided with the challenge “Dr. Fox is an animal doctor. She is having trouble getting large animals up onto her table so she can examine them” and then need to complete various open-ended questions to display their engineering learnings.

For rating of the PADS responses, each item was scored ranging from zero to four with increasing scores indicating greater levels of proficiency in design skills. It is important to note that the numerical values reflected different meanings depending on the question that was asked. As ratings per PADS item were not consistent across, items should be factored individually rather than in comparison. Six of the eight girls complete the PADS; however, one submission was dropped due to the quality of responses so only five are reported in findings below.

**PEAR's Dimensions of Success (DoS).** DoS (Figure 3) is a quality assessment tool designed for certified observers to complete structured observations of STEM activities and apply rating scores ranging from 1 (evidence absent of quality) to 4 (compelling evidence of quality), with a rating of 3 being the benchmark for quality. To become certified, observers go through a rigorous training process during which they practice rating across varying STEM disciplines (e.g., science, engineering) and scenarios involving varied age groups. The 12 DoS dimensions are rated based on detailed evidence.

At EJRP two engineering-based sessions were observed and rated by a certified PEAR staff member with observations completed virtually due to COVID protocol. A third observation was scheduled to take place during the last week of programming, however due to COVID the site was shut on the 28th, and programming ended that week.

**Figure 3: PEAR's Dimensions of Success (DoS) Quality Assessment Framework**

Understanding the importance of engaging youth in aspects of the engineering design process, PEAR developed a booster with input from Dr. Cary Sneider (a senior science advisor for STEM Next and lead of the Million Girls Moonshot evaluation) to supplement the Inquiry/STEM Practices dimension of the DoS Framework.

The Inquiry/STEM Practices dimension assesses the presence of STEM practice(s) and the degree to which they are carried out appropriately and authentically by students (i.e., doing STEM practices in the ways that STEM professionals do versus superficially going through the motions of the engineering design process). To score a four in this dimension, an activity is required to authentically engage youth in at least one STEM practice.

Specifically, the DoS Engineering Booster assesses which specific components of the engineering design process (e.g., testing a design, communicating findings) were present in an engineering activity and assesses the authenticity of those engineering design practices (i.e., whether youth are engaged in engineering design practices in the ways that engineers would carry them out). Observers consider the seven steps of the engineering design process (as defined by the
Next Generation Science Standards (NGSS) and indicate whether each practice was observed and, if applicable, whether the practice was carried out authentically. For the purposes of this case study, the updated DoS Engineering Booster was also scored.

**Qualitative Interviews.** Four 60-minute qualitative interviews were conducted, and transcription quality was assured by the PEAR team using the Otter transcription platform. To collect multiple perspectives interviews were completed with the following people:

1. the LEL project lead
2. the EJRP program coordinator,
3. the EJRP teen counselor
4. the UVM mentor.

A formal multi-step thematic analysis involving coding of qualitative data and translating codes into themes for reporting was not completed by PEAR staff. Instead, interviewers reviewed all transcripts for trends that emerged across interviewees and identified supporting quotes. Some quotes presented in the case study were edited slightly for readability.

**Image 3: LEL Girls During Programming**

**Archival Review & Event Attendance.** Information provided by the LEL project lead and EJRP coordinator were reviewed and summarized to enrich reporting. Sources included the comprehensive LEL curriculum, video recordings of key events during the program, and informational background information.

**Quantitative Findings**

**Common Instrument Suite-Students (CIS-S)**

**Overall**
At least 75% of youth reported positive change on 6 out of 7 CIS-S scales on this survey. These scales were: STEM engagement, STEM career interest, STEM career knowledge, STEM identity, critical thinking, and perseverance (see Table 2). Sixty-three percent of youth reported positive change in their relationships with peers, in alignment with team-work—a key tenet of the engineering mindset (see Figure 4).

**Figure 4: Engineering Mindset Practices Guiding the Million Girls Moonshot Initiative**

As indicated by asterisks in Table 2, a one-sample Wilcoxon test revealed statistically significant positive change on both critical thinking and perseverance \((p's < 0.05)\), attributes directly linked with engineering mindset detailed under the Million Girls Moonshot Toolkit for transformative practices. Youth did not report statistically significant negative change on any scales.

Compared to national norms, youth reported greater positive change on 5 of 7 scales on this survey scales including STEM Career Knowledge, STEM Career Interest, STEM Identity, Critical Thinking and Perseverance, demonstrating the strengths of the LEL program to support girls/non-binary youth to identify as engineers, persist and learn from failure, and to inspire the next generation of engineering innovators—a key aim of the Million Girls Moonshot Initiative.
Table 2. Mean responses for each CIS-S subscale

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Engagement</td>
<td>3.78</td>
</tr>
<tr>
<td>STEM Identity</td>
<td>3.63</td>
</tr>
<tr>
<td>STEM Career Knowledge</td>
<td>3.47</td>
</tr>
<tr>
<td>STEM Career Interest</td>
<td>3.77</td>
</tr>
<tr>
<td>Relationships with Peers</td>
<td>3.75</td>
</tr>
<tr>
<td>Critical Thinking*</td>
<td>4.00</td>
</tr>
<tr>
<td>Perseverance*</td>
<td>4.03</td>
</tr>
</tbody>
</table>

Additionally, half of youth indicated that they planned to enroll in high school elective courses in Technology, Engineering, and Math, supportive of MGM’s aim to spark interest in key STEM fields. Two out of eight youth expressed plans to enroll in a Science-focused elective (see Table 3 below).

Table 3. Youth intention to enroll in STEM subjects in the future

<table>
<thead>
<tr>
<th>Subject</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Technology</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Engineering</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Math</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Grade**

Students in 6th grade (n = 3) reported greater positive change on all 7 scales on this survey compared to students in 5th grade (n = 5). Specifically, all 6th grade students reported positive change across 5 of 7 scales, except for STEM Engagement and Relationships with Peers.

**Performance Assessment in Design Skills (PADS)**

**Overall**

Six youth completed the Performance Assessment in Design Skills (PADS). The performance assessments were coded by two PEAR staff and analyzed for inter-rater reliability. Raters scored nine items for each of the five youth. Ratings showed agreement on 38 of the 45 total items, with all but one data point showing no more than one point of difference, supportive of the reliability of the tool. Regarding administration, given the length of the PADS (approximately 45 minutes to complete) the program coordinator was not able to have the participants complete the assessment during LEL programming due to limited time. She also expressed concerns about the length of the PADS and the youth’s ability to stay focused on the entire task.

Further, due to COVID protocol and the program going virtual the final week, participating youth had to complete the PADS assessment from home. The PEAR team provided detailed administration instructions for the youth and families, the program coordinator provided small incentives to complete the assessment and she periodically sent reminders to families regarding the importance of completing the task. A 75% return rate was accomplished; however, a response was dropped from the analysis as one youth did not complete the assessment as directed for a 63% total rate.

Due to the small number of PADS entered and the fact that the tool and rating system are still in refinement by the developers, statistical analysis options were limited for the purposes of this case study. Additionally, as IDs were not collected as part of the PADS assessment we cannot directly compare to CIS-S findings and other data points. In future studies we encourage shared IDs to be able to look across tools and identify trends. To provide the richest story possible and explore knowledge gains in participants’ engineering mindset the PEAR team identified key distinctions in the varied levels of engagement with design skills and categorized respondents into three levels: “emerging engineer” (youth with a lower proficiency), “assistant engineer” (medium proficiency) and “lead engineer” (higher proficiency).

Two emerging engineers were identified during rating and these youth consistently scored in the 0-2 range, beginning to identify solutions to the design problem but with fewer details, ideas, and justifications included compared to the three other youth. Two assistant engineers were also identified with these youth consistently scoring across the 1-4 range, including a greater number
of ideas that met the criteria/constraints and providing more detailed, clear justifications as compared to the emerging engineers. Lastly, the PEAR team labeled one participant a lead engineer as this individual consistently scored in the 3-4 range, demonstrated the greatest number of solutions that met the design criteria and constraints, including detailed justifications throughout the assessment. This response illustrates the lead engineer’s thorough justification and ability to balance criteria and constraints, critical to an engineering mindset: “I would use a good amount of materials because that would help me in case I need to build something else I could use the same materials. I would use my budget wisely because that would help me find good materials at a very good price. I would use what I can and can’t do carefully because that would help me see what parts of my idea I have to lose because of my criteria and constraints.”

PADS findings also align to one staff member’s observation about varied youth interest and engagement in the engineering process, “You could tell there were kids who were there, and they were very interested in engineering and the whole process. And you could tell there were other kids who were like I just want to build things, and I don’t really care how it happens, but I just want to be able to do the activities and have fun. Part Two was, I think, more interesting for the kids who wanted to be there to learn more about the actual process and the breakdown and the different steps that needs to take. It’s not just about building something as well, like evaluating and restarting and describing your whole plans.”

Findings suggest that the LEL program began to cultivate critical engineering and design skills in youth, especially youth with an interest in the design process and highlight opportunities to further develop proficiency in skills including envisioning and evaluating possible solutions. To present PADS data findings in an aggregate format for a more overall view, a table summarizing the frequency of scores on each item is provided in the appendix.

**Dimensions of Success (DoS)**

**Overall**

As seen in Figure 6, DoS ratings met or exceeded the benchmark of quality for 8 of the 12 dimensions (67% had a rating of 3 or higher). These dimensions were Organization, Materials, Space Utilization, Purposeful Activities, Engagement with STEM, Inquiry/STEM Practices, Relationships and Youth Voice. Notably, Youth Voice, which often scores lower compared to other dimensions (Browne, Noam, & Allen, 2021) met the benchmark of quality in both observed activities.

The levels of quality observed in this dimension as well as Engagement with STEM and Inquiry/STEM Practices provides further evidence of the development of engineering mindset skills such as exploring materials, using a systematic engineering design process, and identifying as engineers. Further, it is exciting to see strong ratings in the Purposeful Activities dimension, which looks at the degree to which youth are moved towards a STEM Learning Goal, as the Purposeful Questions training was an opportunity offered by the project lead that staff felt supported their facilitation of STEM programming.
Meanwhile, DoS ratings that did not meet the benchmark of quality included the dimensions of Participation, STEM Content Learning, Reflection, and Relevance (see Figure 6). The latter three dimensions are traditionally challenging for OST programs nationally; however, across the two EJRP observations these dimensions were rated as 2 or lower which reflect weak evidence of quality implementation across these dimensions (Allen et al., 2019; Browne, Noam, & Allen, 2021).

The lower rating in Participation does not challenge the STEM-specific merits of the activity (i.e., the quality of the content presented or the STEM practices present)—rather qualitative evidence that accompanied the two observations highlighted that a subset of the youth was more heavily involved in the core engineering components of the activity while other youth were recording a video and not participating in the engineering design components. When youth are involved in a team project, it is typical to see youth take on different roles—however, within these roles it is important that all youth are provided opportunities to engage with STEM-meaningful aspects of the activity.

Participation is a unique dimension in the DoS Observation Tool, however it plays a role in other key rubrics (e.g., Purposeful Activities, Inquiry/STEM Practices, Relevance) as these dimensions cannot score a four if fewer than half of youth are involved in the specified dimension at a high-quality level. For example, in the dimension of Inquiry/STEM Practices, if only a subset of youth are engaged in STEM practices at a level 4, the activity would be rated a 3 as the tool emphasizes the importance of focusing on all youth, not just those who are most engaged.

This suggests that training in how to provide access to all youth with different interests and learning styles and prompt youth to engage in the STEM-related components of an activity could enhance quality in this dimension and in others.

Compared to PEAR’s national sample consisting of 867 unique observations across 27 states, EJRP activities met or exceeded ratings on six of the 12 dimensions including Organization, Space Utilization, Engagement with STEM, Inquiry, Relationships and Youth Voice. These findings reveal strengths in the organization and facilitation of an informal, warm, and positive learning environment, foundational to supporting rich STEM learning. In alignment with an engineering mindset, youth were effectively supported in engaging physically and cognitively with materials, in having agency in their learning, and engaging authentically with engineering design practices.

Alternatively, Participation, STEM Content Learning, Reflection, and Relevance were rated lower compared to national. We recognize the context in which the two observations took place (during the last weeks of programming and after a short period of virtual learning resultant from COVID). As the dimensions with the largest gaps, it is possible that the weaknesses in explicitly identifying the relevance of the engineering activity to youth’s broader contexts and lack of evidence of leads explicitly discussing connection during the activities observed contributed to lower participation among certain youth.

**DoS Engineering Booster**

In both observed activities, five engineering design practices were observed of which the first four listed below were carried out authentically (i.e., in the way that STEM professionals do, at an age-appropriate level) by youth and facilitators (denoted by asterisks).

These practices included:
1) Brainstorming and evaluating possible solutions*
2) Building the solutions*
3) Testing the design*
4) Redesigning based on data*
5) Communicating findings to others

The authenticity of engineering practices was well captured by the following quote from the DoS observer: “Youth created a model and are building and refining their water filter. The practice is authentic—they are building and refining the model themselves and creating their own solutions to problems. They test out the water filter with one sponge and with two to determine what works best.” As opposed to following step-by-step instructions on a worksheet to create a standard water filter model, youth implement refinements.
based on data gathering and observation as engineers would.

**Qualitative Findings**

**Legislator Showcase**

One of the highlights of the LEL program at EJRP was the Legislator Showcase, a thirty-minute event during which youth had the opportunity to speak with two state representatives and two state senators about their experiences after having completed 10 weeks of programming (one being a parent of one of the attendees). Members included Senators Kesha Ram and Christopher Pearson and Representatives Karen Dolan and Tanya Vyhovsky.

Image 4: LEL Legislator Showcase

The Network LEL project lead moderated a conversation between the legislators and the eight girls over Zoom. As legislators posed questions to youth about their experiences, different youth approached the camera and talked to legislators about the engineering design process and explained design challenges they’d completed. One youth explained to the legislators the reasoning behind gender inequities in engineering, “In a lot of STEM fields, women are oppressed, and engineering is a traditionally male-dominated field. It’s more subtle now, but there’s sexism and that’s one of the reasons people don’t make it in engineering. It’s hard to get to that level.”

Following the youth’s description of gender bias, Representative Vyhovsky shared, “I will say that politics is another one of those places that is traditionally pretty male-dominated and so navigating some of the things that I heard you talking about in engineering is something that jumping into politics I know came up for me really thinking about what it might look like differently for me as a woman…the skills you are learning to push through and break those barriers is going to be really important for you.” At the conclusion of the event, all youth gave a thumbs up when asked if they felt more empowered to break down barriers.

By taking up the Million Girls Moonshot Initiative through the development of LEL, the Vermont Afterschool, Inc. was able to share exciting opportunities such as the legislator showcase event, benefitting EJRP and participating staff and youth. By having their voices heard and elevated by state representatives and senators, youth were empowered as girls/non-binary youth who are knowledgeable about engineering and prepared to use their skills to take on challenges, both engineering-related and more broadly in navigating college and career pipelines, which again, elevates key aspects of the engineering mindset practices guiding the Million Girls Moonshot initiative.

**LEL Student Showcase**

On April 1, 2021, all participants, program staff and UVM mentors across the participating LEL programs were invited to gather on Zoom to celebrate the end of the program and showcase the culminating projects each site completed. The Network LEL project lead served as facilitator and around 42 people attended, including one of the PEAR team members. A shoutout to the Million Girls Moonshot Initiative launched the event and then recognition of the 13 organizations, followed by highlighting the 100+ girls and no-binary youth and 22 college-age mentors who participated. The extraordinary efforts of the project lead and supporters to launch the LEL program so quickly before the start of the school year were also acknowledged.

Image 5: LEL Student Showcase
Before each program’s video presentation was reviewed a reminder was set for the task each faced: working as a team they had to apply their engineering mindset, implement the engineering design process, identify a problem to solve, find solutions, and iterate improvements. The EJRP team collectively selected a design challenge from the LEL program, developing a water filtration system. Steps from the challenge are detailed below and taken from the LEL facilitation guide.

**THE ENGINEERING TASK: Clean a cup of dirty water by designing a filtration device.**

- Make the dirty water from the suggested list of ingredients, observe what’s in the water and how you might filter that out – that’s the problem!
- Begin the Engineering Design Process with the **ASK and then** go over each of the criteria and constraints. Make sure everyone has a filtering device from a soda bottle.
- **IMAGINE** - Investigate the materials and their properties and think about your design.
- **PLAN** – Listen to other’s ideas and decide if you want to make adjustments.
- **CREATE** – but don’t test your design until everyone is ready!
- **PREDICT** how well your filter might work, test and consider what worked.

What would you do to **IMPROVE**?

How can we relate this engineering activity to a real-world design – the LifeStraw!

Even though programming pivoted quickly for EJRP from in-person to virtual the team, with guidance and support of the UVM mentor and EJRP teen staffer, youth still submitted a stellar video. Unfortunately, due to COVID protocol not all youth were able to contribute to the video and be featured. Supported by evidence gathered by PEAR’s DoS observer, in designing their water filtration system, youth engaged in numerous aspects of the engineering design process (i.e., brainstorming solutions, testing, and evaluating the water filter) and did so themselves, empowered to identify their own design.

Learnings related to the engineering design process were articulated by one participant who contributed to the development of the team video, “The engineering design process is a simple order of things you must do to complete a project. You start by asking what is the project I am trying to solve. Then you imagine ideas how you can solve the problem; next you plan how to make the object that can solve the problem then you must create a prototype and test it. Finally, make improvement to your prototype and ‘shabam’ you have a well-designed object that can solve the problem. If we had more time on this project, we would have made it more ‘flashy’ and look better. What is better than a working object, an object that looks good.” She went on to detail the elements of an engineering mindset as well, “Over time we have learned what an engineering mindset is. An engineering mindset is the mindset you use while thinking and proceeding to make something that can solve a problem. This mindset requires perseverance, strength, and courage. If your object fails, try it again. If the challenge put in front of you seems too hard, think harder. Over this entire project we have learned about all this stuff and more and had a very good experience doing it.”

**Staff & Network Interviews**

As highlighted above qualitative interviews were completed with Vermont Afterschool, Inc. LEL project lead, the EJRP program coordinator, the EJRP teen counselor and the UVM mentor from the College of Engineering and Mathematical Sciences to collect multiple perspectives on the LEL program. A wealth of findings was gathered during these interviews to guide the development of the case study report. A comprehensive thematic analysis of the qualitative data was not completed, rather the PEAR team integrated supporting quotes throughout reporting and dove deeper into themes connected to the focus of the Million Girls Moonshot initiative. Select themes related to the benefits of girls/non-binary only programming, strengths of multi-tiered female STEM role models, impact of LEL programming on engineering knowledge and mindset, and strengths/challenges/ revisions to LEL engineering model are examined below.

**Theme One: Benefits of Female/Non-Binary Only STEM Programming**

As highlighted at the beginning of the case study, a key objective of the Million Girls Moonshot initiative is to promote girls seeing them themselves as future innovators and to increase
the number of girls who develop an engineering mindset, particularly reaching underrepresented youth. At EJRP the LEL program was designed specifically for underserved girls and non-binary middle school youth. There was a tremendous response to the program by families and youth in the fall of 2020 such that a waitlist formed for session one.

During the interview process staff elevated the benefits of the girls/non-binary youth having the space to collaborate and work together, all the while under the leadership of all female instructors. Staff explained how during the design challenges and showcase projects they observed the participating LEL youth working as a team, showing perseverance, thinking critically and communicating effectively, all skills that are central to developing an engineering mindset. They even saw instances of participants transferring these skills outside the LEL model to other areas of the program or into their own personal lives (e.g., discussing how they built a bookcase at home with their families, encouraging each other to push through challenging rock-climbing routes and trying alternative strategies when struggling).

Acknowledging the high interest of families around STEM-based programming specifically designed for girls/non-binary youth one staff member stated, “I found that in this town girls STEM is what really hits with people. If I put out science programs for boys and girls, I hardly get signups but if I put it out for girls, it is huge…People are really focused on high achievement for their kids here and I think that when you’re marketing to the girls segment it really makes it feel like we’re giving our girls a leg up. We did have one transgender student in the program, and she came out as transgender after the pandemic and her parents wrote to me and were just so happy that we offered something specifically to them and the parents wrote to me numerous times to thank me for it.”

Endorsing the strengths of girl/non-binary-based programming under the leadership of all female staff one individual shared: “It was really a different feeling. We can all kind of relate, we can all share a lot of the same qualities and ideas. I think that since the program was so focused on empowering girls having me and the UVM mentor be there as girls was just a really good idea for them to get to know. The UVM mentor is obviously in college to be an engineer and so for them to see that what we’re saying is true, that you can be an engineer as a female. I think that they could see it, which was just a good role model situation for them.”

While the focus of the program was on girls/non-binary youth, the curriculum was designed flexibly to empower youth and mentors such that they could select design projects they wanted to pursue or prompts around equity and access in STEM to discuss. This flexibility and focus on youth and facilitator input and choice lends itself to being easily adaptable to all-gender programming, while maintaining an emphasis on ensuring youth are represented in the videos, materials, and activities present in the LEL curriculum.

**Theme Two: Strengths of Multi-Tiered Female STEM Role Models**

A unique feature of the EJRP program was its multi-tiered female program/role model structure. From the LEL Project Lead spearheading the initiative and trainings, the EJRP Program Coordinator overseeing the effort, to the UVM mentors leading facilitation, and the teen counselor supporting implementation, the LEL staff and participating youth were completely surrounded by girls/women or individuals who identified as female. While this structure is not a requirement of the LEL model, it was an added strength of the EJRP program. Not only were the youth able to have female role models in STEM on multiple tiers but across roles each staff was able to look to a female lead/colleague. The EJRP teen counselor, a role unique to only this participating LEL program, had the UVM mentor as a role model, and the UVM mentor had the program coordinator and network lead to look to for guidance and training on engineering. While these staffing elements are not always feasible in OST programs and were well suited to a small program with staffing capacity to pilot the new curriculum, this element added a richness to the experience for all and is a testament to the value of seeing oneself represented in STEM and in role models/leaders.

Recognizing the value of girls/non-binary youth learning about STEM pathways at an early age
and actually having the opportunity to interact with college role models studying in the STEM field first-hand the UVM mentor highlighted: “So I thought it was definitely important to have a mentor or a leader being a female in STEM. I thought that was really cool to be able to relate to the girls, that I had gone through what they were going through. As a child I wasn’t really pushed into the math direction and I wasn’t always offered specific engineering activities. I didn’t really have any interested in it until I got to college and I was like, ‘Oh, I’m good at math that should probably be something I’m pursuing if it’s something I’m good at.’ So I thought being able to relay the idea that these girls could do engineering or anything they wanted to at such a young age and not having to learn about it until they got to college, I thought that was really cool and really important.”

Another staff member elevated the important influence of girls/non-binary youth seeing females succeeding in roles they would attribute to being more male-dominated, “I’ve really noticed that it is important to girls to have girls around especially in things traditionally male-led, so things like STEM, things like outdoor sports. I take kids rock climbing and I have girls who flocked to me because I can do something that they don’t see women doing and I think it’s the same with STEM. You know, if they see their male teachers or they see scientists that are men on the news, I think it means a lot to them to have somebody that looks like them.”

**Theme Three: LEL Program Impact on Youth, Leads, and Group**

According to the theory of action of the Million Girls Moonshot evaluation design, networks are meant to provide transformative STEM practices/resources to programs to encourage girls to engage in engineering activities. These programs in turn should provide teaching materials and training to lead staff to help girls develop engineering knowledge. Due to these program offerings more girls should select to engage in STEM activities and those who do should increase their engineering knowledge, including the development of engineering mindset practices. Quantitative data findings seen through the CIS-S, DoS and PADS showed a positive connection to LEL programming and the development of engineering skills in the participating youth. Qualitative findings gleaned through the legislator presentation, LEL showcase event and, as seen below, staff interviews revealed the development of engineering skills in the participating youth and even in the staff themselves:

**Impact on Youth**

One staff member highlighted the depth of youth understanding and familiarity with the engineering design process, “I think when the program first started a couple of girls had a little bit of knowledge about it [engineering design process] and I think they understood the basics of it but when the program started to unfold, like by session two, I would hear some of the girls reminding the other ones like, ‘Oh, yeah, we got to imagine, you know, we got to start by drawing it up’ and they would remind each other of the steps of the engineering process… I think it was just kind of drilled into their mind by the end of the program and so they’re very much like, ‘we know about the engineering process.’”

Staff also observed throughout programming how youth developed critical skills related to an engineering mindset, “I definitely think they learned more about working together. Some of them were all in for engineering, some of them maybe weren’t as interested in the beginning and they learned how to kind of work together. For session two, especially when we could only have one project, they had very different ideas on what they wanted to do so learning to cooperate and work together was definitely a big thing I think that everyone took away and just perseverance in general. We had a lot of little hiccups along the way with our water filter so I think that they got really good at learning to persevere and fix their problems. You know, they had to advocate like, ‘I don’t think this is working, I think we need to do this’ and so I think they just became really good learners throughout this. I think they have the tools they need to further any engineering or STEM related activities in the future.”

**Impact on Leads/Group**

For one EJRP staffer, the experience sparked new interest in teaching and a sense of self-efficacy in facilitating STEM programming with youth: ‘The most that I gained from this was me figuring out that this would be something I would be interested in teaching kids and maybe doing this as a career path or myself maybe finding interest in this topic and sharing this knowledge with others. I thought that the curriculum really clicked for me, and I was like, this is something I’m really interested in, this makes me happy. This is definitely something I
Another EJRP staffer already interested in teaching described becoming more comfortable being assertive and working with an age group she was not accustomed to: “I think I learned a lot about just connecting with middle school girls in general because you know, as I mentioned, they're different than elementary school kids, they are a lot older and they're all interested in their phones and things… I think when you're working with older girls it’s learning to connect with them in a way that we could both work together. I think that was really helpful to learn because I think when I start teaching eventually, fifth grade is kind of the spot where I want to teach so these were kind of the good age groups to practice teaching and taking charge.”

### Theme Four: Strengths, Challenges, Revisions to LEL Program

Providing transformative programming that is innovative, inclusive, and focused on developing engineering mindsets, knowledge, and career awareness in girls is at the center of the Million Girls Moonshot movement. Vermont Afterschool, Inc. met this call to action through the development of the LEL program. The model was rich with hands-on activities, content on the engineering design process/mindset, and vetted activities and resources related to equity, access, and representation in STEM. Resources also included videos for each activity of female STEM professionals reviewing engineering content and making connections to possible college and/or career pathways. To highlight strengths, challenges, and possible revisions to the LEL program as it hopefully moves forward, staff interview questions explored feedback in these key areas.

**Strengths**

Staff highlighted that the LEL materials and activities that involved the most hands-on work that was relevant to youth’s lives was key to engaging youth in engineering. “They definitely loved all of the little things in the kits. They loved looking through the kits and seeing what tasks you’re going to be working on. They loved the hands-on stuff, of course you know, the band aid one. I know they loved making a band aid and the fake blood that they got to make they love them. I think that they were always really excited to be energized and just doing something working together. So, I think that the more hands-on, the more they were engaged and enjoying it… I think when we did programs that related specifically to something that interested them or that they had some involvement with like our final project, we decided to build a water filter, which was similar to something we did in part one and they just thought having something that’s like, very similar and very active in their day-to-day life that was like relatable to them”

The teamwork approach that LEL encouraged supported youth in developing confidence in their ideas: “I think there was a couple days where we had them work together versus separately and I noticed there were more ideas flowing when they were working together versus when they were alone. It was sometimes they’re like, ‘oh, I don’t know if that idea will work’ and they weren’t as willing to take risks when they knew they were by themselves but when they were working together, I think that the risks were, there was just no idea that was crazy to them. They were just ready to dive in.” Additionally, staff reported that they felt the in-person environment supported the development of a strong rapport among the cohort and enabled staff to assess learnings as they were in the room together.

Multiple staff members also noted the live NASA event and the meeting with legislators as highlights of the LEL program for youth.

**Challenges/Revisions**

Staff interviews revealed challenge points and recommendations for improvement following the first implementation of the new LEL program at EJRP.

**Youth Level**

At the youth level, staff noted that some girls were signed up by their family, but they weren’t motivated to be there. Additionally, certain activities that had fewer hands-on components and bore less relevance to youth’s personal lives and interests were less engaging to youth. One staff noted, “If they were ever less hands-on that might be the days that they struggled a little more just because they were coming from a full day of school and they had a lot of energy to get out… we had this one frog catching activity, which wasn’t super interesting to them, because they’re not normally catching frogs in their day-to-day life and it’s not really something they saw going forward.”

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To build youth’s engagement and connection to the content and to the program, one staff member recommended spending more time on discussions around gender inequities, “Sometimes we didn’t have as much time to focus on the actual empowering of the girls. I think that throughout we touch upon stereotypes and things like that and we really focused on how these girls can do it, but I think that sometimes the projects would take a lot of their focus. I think that I would want to spend a little more time than we already had on just girl power and inspirational videos.

Another staff member echoed this and suggested that creating more space for mentors to share more about their experiences could deepen these conversations, “Maybe having the college student be able to share their story. Just because I know it is talked about that women are way less involved in STEM but it’s hard to express that idea to children and they don’t really know why that is…they don’t really understand but having the ability to express what we’ve gone through, why this isn’t as normal…But being able to just share our history with the kids I think that’s super helpful and even just having the program continue.”

Staff/Lead Level
At the staff/lead level, one individual noted the coordination of programming and ensuring all staff and materials were prepared ahead of time was a lift for a small program, “I would have preferred a little more time to prepare for the second part of it [LEL] because we didn’t know which girls were going to sign up for the second part...How am I going to get everything to them? What are they going to need? Are they all going to be on the same page and wanting to do this project? All the kids were happy with what they were doing but I am planner and that is very panic inducing for me when I can’t plan things out ahead of time.”

Staff cited that there were both strengths and weaknesses of the virtual environment of the training. While the online trainings made content readily available and accessible to mentors, easing the lift of transportation and coordination, one staff member highlighted that training in an environment (virtual) that did not match the teaching environment (in-person) was a challenge point: “Well, I think the beginning trainings where everyone was learning what was going to be going on was definitely very hard to do virtual. I think being in person definitely would have made that a lot more interactive... I think being in person doing trainings in person, if you’re going to be teaching in person would have been very helpful, but I understand that with COVID, with everything that was definitely very difficult.”

Case Study Highlights
Data gathered from multiple sources (youth self-report, performance assessment, observations, interviews, and archival sources) and perspectives (network lead, program coordinator, program staff, youth, external observer) taken together tell a very positive story about the impacts of the Million Girls Moonshot Initiative and the LEL program and the future of engineering-focused programming for girls/non-binary youth at EJRP and more broadly across different locations. There are also key areas for the program to grow to reach all youth more deeply and more consistently:

- All participating youth completed the engineering-based CIS-S successfully with data findings collected on their overall engineering attitudes and self-concept and how they have changed because of the recent engineering activities. Greater than 75% of youth reported they were more interested in and knowledgeable about careers in engineering, felt a greater sense of identity in engineering, and developed greater perseverance and critical thinking skills as a result of programming. Further, compared to national norms, youth reported greater positive change on 5 of 7 scales on the CIS-S survey. All impressive results and informative for the program, Vermont Afterschool Inc., and overall Moonshot Initiative, we would encourage the continued application of survey tools for data informed decision making.

- DoS virtual observations were completed for two LEL activities with PEAR’s DoS Engineering Booster effectively implemented for the first time. Findings showed youth outcomes aligned to DoS strengths including Purposeful Activities, Engagement in STEM, Inquiry/STEM Practices, Relationships, and Youth Voice—all critical ingredients to developing an engineering mindset. Moreover, youth were able to successfully engage in numerous engineering design practices within a
single activity, leading the creation, design, and testing of solutions as engineers would. Continued exploration of quality through observations is encouraged, including possible further piloting of the DoS Engineering Booster to deepen understanding regarding engaging youth in aspects of the engineering design process.

- Observational findings revealed that some DoS ratings did not meet the benchmark of quality, these included the dimensions of Participation, STEM Content Learning, Reflection, and Relevance. The latter three dimensions are traditionally challenging for OST programs nationally. We encourage the elevation of further supports and professional development offerings to elevate quality programming, many of which can be built out of the existing Million Girls Moonshot Toolkit.

- The PADS story-based culminating activity completed at the end of programming was successfully completed by five of the eight participants (63%). Performance assessment data revealed that while all youth successfully generated ideas to solve an engineering design challenge, different youth showed varying degrees of proficiency in design skills (note – rating systems for this tool are still in refinement). Program quality observations and interview findings (i.e., lower Participation score) support the varying levels of engagement and participation in core STEM components of programming. Elevating strategies to engage all youth and to help them see the relevance of engineering to their own lives and spending more time on inspirational material (as indicated in a staff quote) might support enhancement of quality.

- Interviews and archival materials emphasized that female/non-binary focused program, representation in STEM/leadership (in materials, videos, activities) as well as at the staff and network lead role was key to fostering identity and empowerment in engineering. Furthermore, events such as the Million Girls Moonshot NASA event, the legislator meeting, and the student showcase, while not required as part of the LEL model, supported staff and youth in having their voices heard, recognized, and amplified and allowed demonstration of STEM knowledge and engineering mindset. Moving forward we would encourage the addition of interviews with other key stakeholders for added perspectives, including youth and parents. Furthermore, we would encourage other networks and sites to explore how similar curricula and facilitation strategies that challenge youth to select and engage in authentic engineering design projects and intentionally embed discussions and content focused on equity and access in STEM could be applied and expanded.

- Lastly, reflecting across the quantitative and qualitative data findings and through reviewing materials, the structure and content of the LEL engineering-based program revealed a flexible, all-inclusive, well-designed model; particularly given this was the first year of development and implementation and it was formally launched during a pandemic. The model included comprehensive guides for facilitators and youth, detailed how to facilitate engineering activities and included a bank of vetted activities and resources related to equity, access, and representation in STEM. The facilitation guide offered explicit identification of engineering design practices within each activity within the appropriate criteria and constraints and females in STEM were elevated throughout. Virtual professional development was also provided to all participating program staff and UVM mentors, at the launch and throughout as needed, a model that was required due to the pandemic but could be readily transferred to in person when normal programming returns. We would encourage the Million Girls Moonshot team to work with Vermont Afterschool, Inc. to explore the scaling of the LEL engineering program across Vermont and other interested Mott State Networks. Data findings from this case study should guide possible revisions to the LEL model and potential professional development opportunities provided through the overall MGM initiative to all networks.
Acknowledgments

The authors of this case study would like to thank the STEM Next Opportunity Fund and leads of the Million Girls Moonshot Initiative for their leadership in STEM education and for funding to support this case study research. We are tremendously grateful to Vermont Afterschool, Inc. and Essex Junction Rec. & Park (EJRP) for providing historical documentation and materials and hosting the PEAR Team for interviews and virtual DoS observations to support this case study. We also thank our dedicated team at PEAR including Gregory Croft, who conducted the quantitative data analysis, Adam Rogers and Bailey Triggs, who developed the structure of the report, Rebecca Brown, who assisted in the development of the DoS Engineering Booster, and Bailey Triggs once more who assisted with the review and editing of the report.
### Appendix

**Performance Assessment of Design Skills (PADS) Scoring Frequencies**

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Citations


