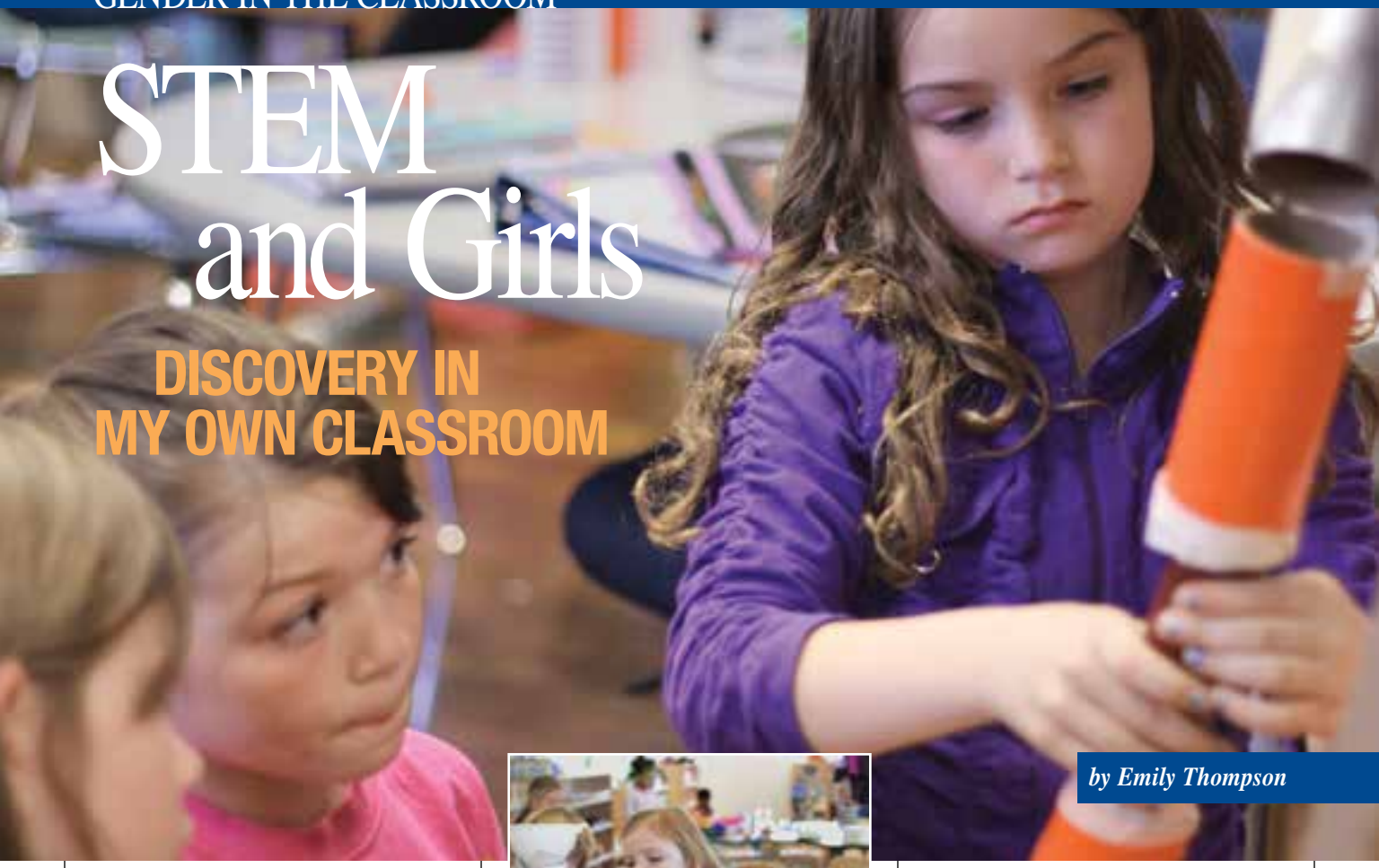
STEM and Girls

DISCOVERY IN MY OWN CLASSROOM



by Emily Thompson

As I watched my two-year-old play with magnet blocks one afternoon, I was amazed by her determination and creativity. She had played with these blocks many times before, but never this same way. Her magnet block set includes small squares and both equilateral and isosceles triangles. I had seen her stack the squares on top of each other and call it a "tower"; I had seen her place the tiles flat on the ground and use play figures on top of them; and I had even seen her create cubes with triangle tops as "homes."

This time, though, was something new: She made her flat surface, stacked cubes atop each other to make a "home tower," and then placed the "home tower" right next to the flat surface. She then added small people and cars and announced that she had made a city. As the days went on, her city grew to be more complex with the addition of familiar locations like a school, library, and river.

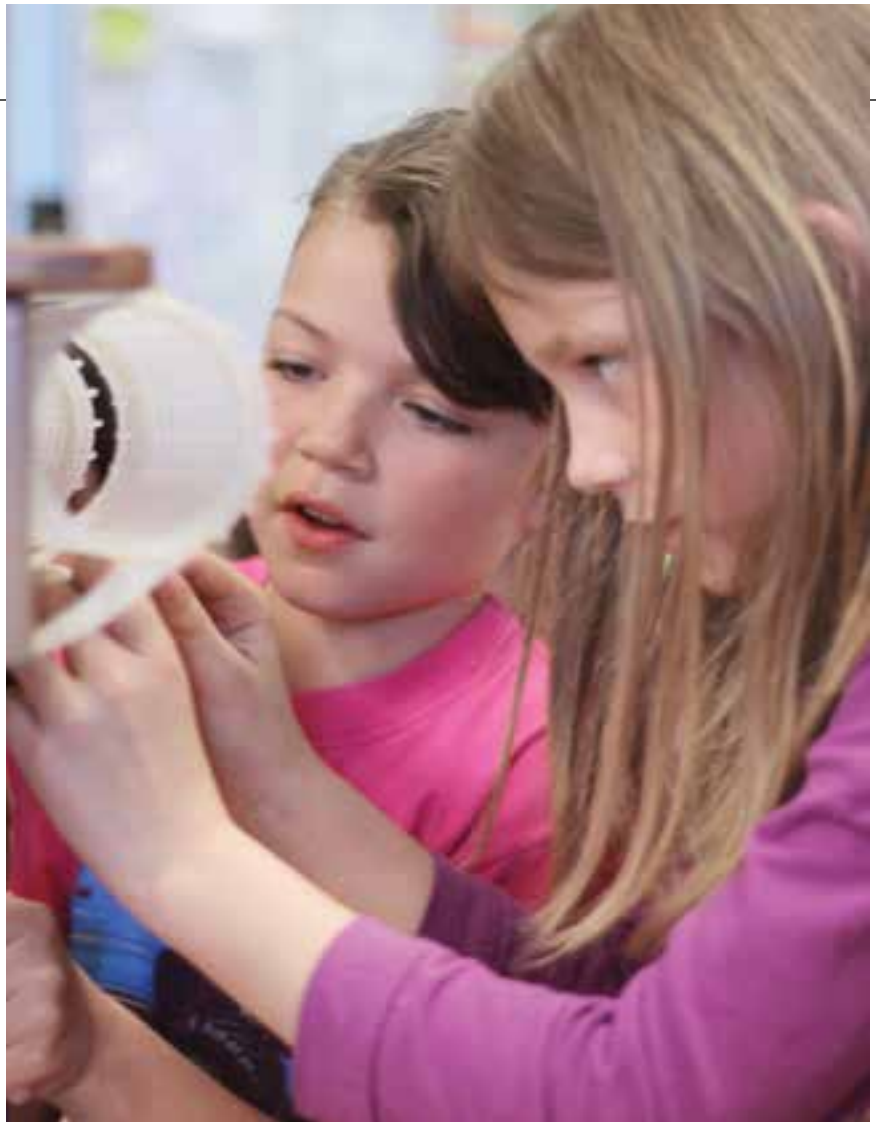
In the early years, girls enjoy experimenting with the physical world every bit as much as boys; it is social constructs, rather than an innate distaste for science and math, which turn many girls away from STEM.

Rigor is what kids *do*

While I was at school one day, I was reading about applying *rigor* to the curriculum. I asked myself, how do I take this inflexible third grade curriculum provided by my school district and make it more *rigorous*? Suddenly, a lightbulb appeared over my head: Rigor is what my two-year-old is demonstrating at home! When she constructs anything, and builds on her own successes and mistakes, she is thinking critically and creatively; with my guidance and developmentally appropriate materials, she is surrounded by an environment that is stimulating, engaging, and supportive; and given the time and space to pursue her own interests, she is experiencing activities that build skills and can be applied in a real world context. That's what rigor is!

My next thought was, how do I apply this newfound connection in my third grade classroom? I started researching online and scouring social media outlets. Most of the discussions on "real world" skills seemed to focus on STEM. I had heard of STEM (Science, Technology, Engineering, and Math) before and even dabbled with it in previous years. But I'd never determined a way to fit it into our busy schedule. As I researched STEM, though, what stood out to me above all else were the statistics involving girls. According to *Generation STEM,* published by the Girl Scout Research Institute (Modi, Schoenberg, & Salmond, p. 19):

- More than half (57%) of all girls say that other girls their age don't typically consider a career in STEM
- Nearly half (47%) of all girls say that they would feel uncomfortable being the only girl in a STEM group or class



One of the benefits of STEM activities is the opportunity to work together to solve problems. These girls have determined a solution to reduce friction in the marble run they've constructed.

- Further, 57% of all girls say that if they went into a STEM career, they'd have to work harder than a man just to be taken seriously

Why should my daughter, or anyone's, be discouraged from exploring her own interests and developing useful skills to help others and make a difference in the world? Children have that innate push to make a difference, and that's a value that STEM promotes. Girls are really interested in STEM, but are uninformed about careers involving science, technology, engineering, and/or math. We could be doing a lot more to promote the connection between thinking critically and creatively (a skill we encourage in both boys *and* girls) and careers in the sciences.

Why don't we?

We do — just not so much for girls. We've come a long way, but gender bias is still very much alive in our society. There's no reason girls should shy away from technology and math; when rigorous scientific exploration becomes a standard in the classroom, girls, just like their male peers, will meet the expectation.

STEMming the tide

I knew STEM could be the answer I was looking for — a way to apply more rigorous curriculum in the classroom while keeping it open-ended and hands-on! More than that, though, it would be a chance to reverse the trend of biased STEM education, at least in my little corner of the world. The statistics led me to the conclusion that future opportunities to explore science and math might be scarce as these girls grow older. It became imperative to make an impression on them now.

To begin, I had to find out what my students knew about STEM and how they felt about it. I gave each of my 22 students a blank index card and asked them to draw a picture and/or write some words about what they thought an engineer was. When students were done with their pictures and words, I asked them to label their drawings (boy or girl, adult or kid, etc.).

After all the reading I was doing about STEM, the results were not surprising. Out of 24 students in my classroom, 10 are boys and 14 girls. Seventeen said that an engineer was someone who works on or fixes engines, four thought it was someone who drives a train, two said it was someone who fixes things, and one child said it was a fireman. Astoundingly, all but two of my students said an engineer was an adult male. (Out of all this information, I was most disappointed that 22 students said an engineer was male — I have more girls in my class than boys!) Clearly, we had a lot to learn about STEM careers.

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As a follow-up, I talked with my students about what each component of STEM means and what those different disciplines include. Together we brainstormed ideas and came up with the following on anchor charts:

- **Scientists:** observe; classify; experiment; make mistakes; solve problems; test things out
- **Technology:** use tools and electronic devices; research; share ideas

through pictures, social media, e-mail, web sites

- **Engineers:** build things; use materials; make plans; revise their plans; reflect and research; solve problems; make mistakes
- **Mathematicians:** use materials; use numbers and calculations; figure things out; use geometry; solve problems

These anchor charts really became a great reference throughout our curriculum. A student who spent time playing with the class crayfish might say, "I was observing the crayfish just like a scientist does!"

STEM and active learning: a natural fit

Planning STEM activities is similar to planning any HighScope activity. The most important things are including the ingredients of active learning and keeping children's interests and development in mind. After we had read an informational article about Inuits building igloos in the Artic, I overheard three girls asking the librarian for "more books about igloos." I thought this would be a great opportunity for a STEM activity. I took a look at my third grade standards and planned an activity for students to build their own igloos. Here's how HighScope's five ingredients of active learning look within this STEM activity:

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1. **Materials:** Provide a variety of materials that all students have access to and enough for the entire group to use, reuse, and use more of! The materials should reflect the content in mind for the activity. For instance, to build an igloo, I provided sugar cubes, frosting, and cardboard bases. Of course, adding new ideas and problem-solving with the materials is always welcome, so students are allowed to use outside materials, with approval.
2. **Manipulation:** Give students the freedom to use the materials in their own ways, try things out, and try again if needed. When students got started building igloos, they really had to reflect. Many of their initial designs were revised as their struc-

"Engineers are superheroes," reflected one student. "They help to save the world."

tures caved in. Most students solved the problem of collapsing igloos by "thinking outside the dome" and choosing to build cube structures (or some other form) instead.

3 **Choice:** Allow students to make choices about who they will work with, how they will solve the problem, or what to do with the materials. For this activity, students selected their own groups. There was no blueprint or rubric. The instructions were simple: Use the materials and your prior knowledge and work together to build an igloo.

When students were finished with the activity, they reflected in their notebooks about what was successful, what was not, and why. Then other students silently traveled around to each group's igloo and put a tally mark in one of two columns — successful or not successful. We found that students were harder on themselves than each other. Natalie explained that she thought a group was successful because their structure did not fall over. Evan reasoned that a group was successful because they had a really hard time and their structure kept falling over, but they did not give up and kept trying! All these ideas really allowed students to make choices about how they were evaluating themselves and others.

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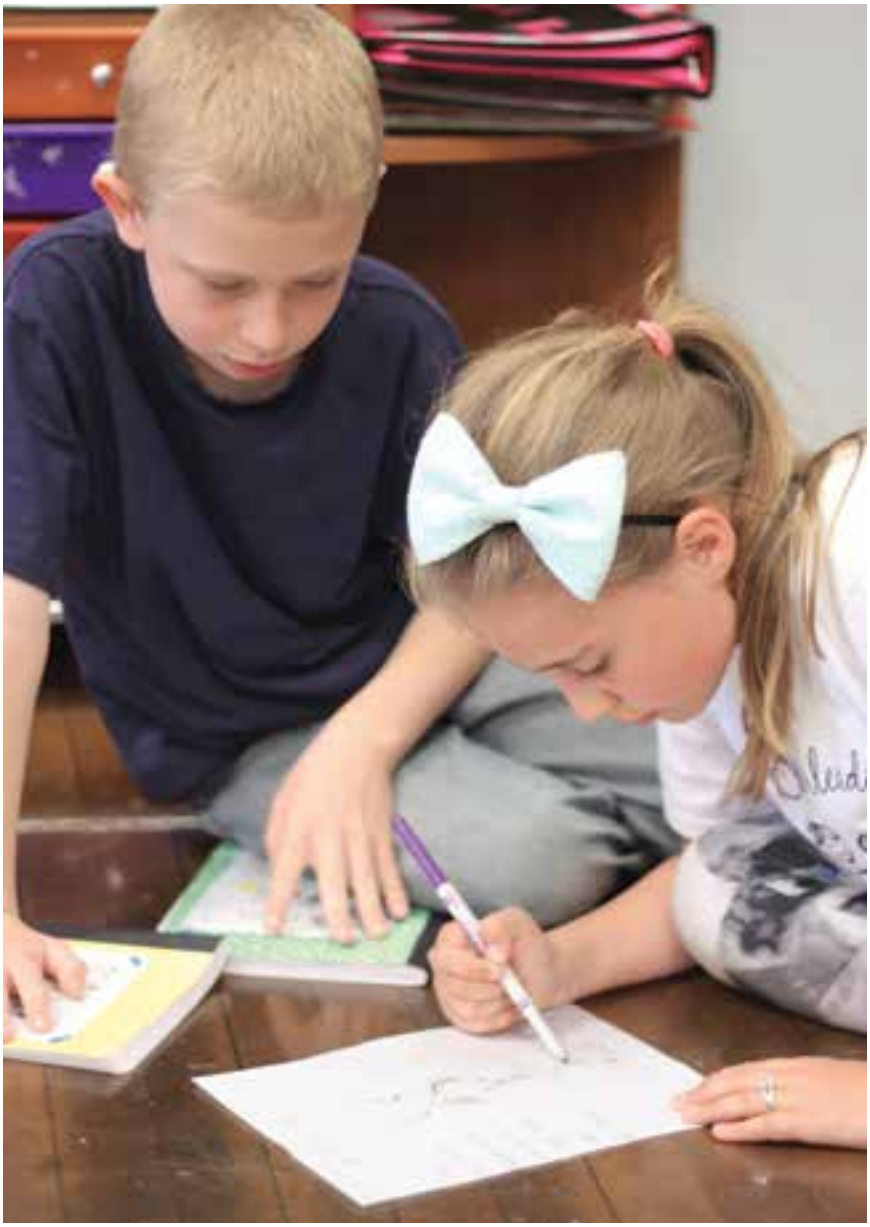
4 **Child language and thought:** Students get the most out of any STEM project when they use their own words and thoughts to make design plans, and when they describe their actions and explain their thinking and reasoning. In planning their igloos, some students really thought about their materials. They considered past experiences. (One student said, "My mom tried to stack two cakes together with frosting and the top slipped off.") I heard another group referencing the informational article that we read and saying they had to "start with a bigger base and then get smaller" as they built it up. Other students went straight to drawing sketches in their notebooks.

5 **Adult scaffolding:** Adults can support students' actions and plans and help them to develop their thinking and reasoning by asking pertinent, genuine questions and by participating in their work. I am always available to the students when they are working on their projects, from the

STEM activities always include a planning stage. In the marble run activity, students first drew blueprints of their ideas to share with their group. This resulted in collaborative models that took the best ideas from each member of the group.



initial planning stages to the actual construction phase. The igloo activity started with the interest that the children had shown in the informational article we read. Knowledge of the developmental level of each of my students and how I could help them to use this project as a fulcrum for further learning was key in "meeting the students where they are at."

Authentic assessment for boys *and* girls

In my classroom I have worked really hard to expose all my students, but especially the girls, to STEM opportunities, encouraging them in different STEM programs, providing them with materials and activities, and incorporating their interests. The best part of any STEM activity is seeing my students engage in such an intense way — when they work together, solve problems, explain their thoughts and processes, and really have fun! The culminating year-end project came during our state testing window, which was really a nice break from the long hours in the computer lab! Students created marble runs (like roller coasters for marbles!) using various tubes and tape. This activity really showcased their innovation, group work, problem solving, and planning skills.

For this activity students were asked to create their own grading rubric as a class. To do this, we looked at the classic marble run toys and their parts and functions. Students' brainstorming was really interesting; they were making so many connections to their prior experiences and knowledge. For example, Andy started talking about a local amusement park, Cedar Point, and how the roller coasters all have at least one twist or loop. Gabe joined in by saying that roller coasters also all have "really cool" names! Kyli referenced the toy marble run at her house and added that there are bottom pieces to catch the marbles. From all of their ideas, students decided on the following criteria for a rubric:

- Completeness: All papers and completed projects are turned in on time, including a sketch and title
- Quality: Your marble run must be durable; it can be affixed to another object
- Effectiveness: Your marble run must work — the marble must start at the beginning and travel all the way through until the end

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- Engineering: Your marble run must contain:
  - something to catch the marble at the end
  - at least two turns or twists
  - at least one split

Students started this activity by completing individual sketches of their ideas, then choosing their own groups and sharing their sketches. This was a great interaction to watch, with all students engaging and contributing ideas. Even those students who are more reserved and sometimes hold back in groups were comfortable enough to show their sketches and talk about their thinking.

Don't forget — in addition to being great opportunities for problem solving and working in teams, STEM activities are also a lot of fun!

Then the groups worked to put all of their ideas together into one group sketch. Once this was complete, they started working on their marble runs, problem-solving every bit of the way. Questions arose, like "How can we make a twist with tubes that are stiff?" and "Some of the tubes are bigger than others and the marble keeps falling out — how do we prevent that?" Students asked for paper to make more flexible twists and paper plates to cut into spirals. MacKenna said, "Mrs. Thompson, I figured it out! We need to cut up paper like a shield to stop the marble from falling out of the tube when it goes from big tube to small tube!"

STEM: Approaches to Learning

Along with the ingredients of active learning, STEM activities also include:

1 **Planning:** For young children this might be a very simple and quick process of explaining what their intentions are. For older students, planning can include materials lists, sketches, and a list of intended actions.

2 **Natural Problem Solving:** STEM activities should include natural problem solving, as opposed to setting children up to fail. In some elementary settings, teachers hold back materials or set students up with challenges that can't be solved. Although their intentions are good, these "predetermined failures" usually only frustrate and discourage students. We want students to feel empowered with these activities and know that they can be successful in solving problems.

Instead, I start with a problem that needs a solution, like when I assigned my students the task of inventing and fabricating a device that they or someone else would find useful. My students came up with some great ideas that fit their everyday lives. One inventor in my classroom, Jade, has a hamster at home and needed something to hold her hamster while she was cleaning its cage. She designed a wooden box that had sand in a section of the box. Apparently, some types of hamsters can't take baths with water because of an oil on their skin, so her invention would be a place for her hamster to take a "sand bath" while she was cleaning the cage!

Another example was invented by a girl named Nalani. She made a small wooden ring that fit over a tube of toothpaste. You could squeeze the ring down the tube to get all the paste out! Another invention that was truly thoughtful was from a girl named Autumn. She wanted to invent something to help her younger brother, who is scared of monsters in his room. She invented "Monster Spray: Guaranteed to scare monsters away (or so your children will think)!" She understood that monsters are pretend, but could not convince her brother, so creating something that gave him confidence was her solution.

3 **Reflection and Revision:** Revision should be an ongoing process for students during a STEM activity. Since these activities are so new to students, they may not be able to foresee all the obstacles they can encounter. For this reason, they should be reflecting on their outcomes and making revisions as needed.

I assigned my students the task of designing and building a marble run. Two groups found that their marble run designs looked great on paper, but were impractical in the classroom. They solved the problem by combining groups and using the workable elements from each group's design. This type of group problem solving, with students really working together to figure things out, is so magical in the classroom!

Reflection and revision relates directly to manipulation and choice. The finished projects for the marble run activity bore almost no resemblance to the students' original designs. But through careful reflection and cooperation, the students realized that everyone made mistakes, and that those mistakes led to better outcomes.

4 **Science, Technology, Engineering and Math:** Of course, our STEM activities must include these content areas. Planning with standards and KDIs in mind will help to keep the activity focused. Reflecting on the marble run project, students recalled that they had strengthened certain elements of their designs (engineering), measured materials (math), used tools (technology), and taken steps to reduce friction (science).

Another group that was having the same issue decided that they were going to build from the ground up (most other groups started at the top). Sam explained, "If we start at the bottom, then we know the marble won't fall out at any point.

> **STEM projects have provided [students] the opportunity to showcase their learning in authentic ways and to have fun doing it — girls every bit as much as boys.**

We want to start with the larger tubes and use the smaller ones as we build up."

During our messy and loud building session, I had students take a break and travel around the room to check out other students' ideas. This was a great time for them to gain ideas from each other and really reflect on what they were doing. Some groups that were stuck found solutions by looking at other groups' work. When all the marble runs

STEM activities are great opportunities for natural problem solving. With the end goal of building a marble run, this student must survey her options and work with other group members to overcome obstacles they encounter.

Girls, just as much as boys, need the opportunity to show off their strengths. STEM activities allow children to develop and exhibit reasoning and problem solving — skills fundamental to all children at any stage in their education.

were completed and named, the groups had a chance to present them and show us how they worked. These structures stayed up in the classroom for some time and students really enjoyed trying out one another's marble runs!

Demonstrating active learning with STEM

After completing multiple STEM activities, I can see a clear change in my students. They are planning throughout our schedule, making connections throughout the day, and problem-solving in ways I hadn't seen before. Don't get me wrong — I don't think this is because the students have changed. Rather, STEM projects have provided them the opportunity to showcase their learning in authentic ways and have fun doing it — girls every bit as much as boys.

The most rewarding part of this STEM journey for me was completing a reflection writing where I had multiple girls and boys explain that STEM is not only fun but can also help solve problems in the world. Sophia wrote, "Engineers can be super heroes because they help save the world. This is what I want to do when I grow up!" ■

Reference:

Modi, K., Schoenberg, J., & Salmond, K. (2012). *Generation STEM: What girls say about science, technology, engineering, and math*. Retrieved from Girl Scouts website: https://www.girlscouts.org/research/pdf/generation_stem_full_report.pdf