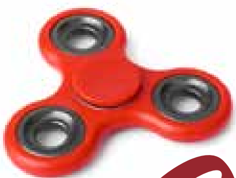
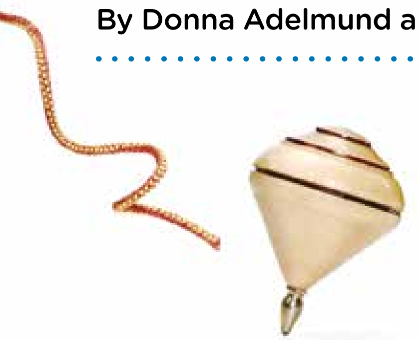


Engineering Spinners

A study of tops allowed third graders to explore the toys of past generations while learning about engineering design.

By Donna Adelmund and Jill Uhlenberg



Fidget spinners have become a fixation among school children and adults. Pappas (2017) hails spinners as both a boon to stress relief and a constraint on the ability to focus in persons with ADHD or autism. Spinners can be a distraction in school classrooms, to the point that many schools have banned them. However, we found them to be an engaging hook to interest students in engineering design. This article describes an exploration third graders undertook to develop basic concepts regarding force and motion as they engineered their own simple spinners.

I was challenged in an integrative STEM course to integrate ramps and pathways along with other STEM content in my third-grade classroom. Journal communications with my instructors in the STEM course resulted in a decision to write an article about the classroom exploration of tops. Through our professional development experiences as a teacher and an early childhood science consultant, we constructed this article.

Engage

When I asked my third graders about fidget spinners, they had many ideas—which were the best spinners and why, how some light up, and where they came from. Most of the students in the class owned fidget spinners. This conversation led me to ask students about other objects that spin. Many had little experience with objects that spin, including those that have held a traditional place in childhood—specifically, tops. None of the children could recall having played with tops at home or elsewhere, so their understanding of how tops work was very limited.

Materials

I wanted to focus on a general exploration of tops for students to gain an understanding of what materials would work well. A wide variety of tops are available, for the most part, at very low cost from multiple sources. Old-fashioned wooden pull tops are available from multiple sources online. Families may also have tops that they will share. I was able to borrow a variety of tops for this investigation and set up a STEM spinning center in the classroom.

Teachers can explore the tops beforehand to decide which ones to place in the classroom. This step prepares teachers to guide students in their learning because they can work through some of the problems themselves before introducing materials to the students. This experience may also help in generating what questions could encourage investigations and explorations of the materials.

I chose the spinners in Figure 1 for several reasons:

- The top with the red silver design and the two smallest ones were the shortest or closest to the surface. I hoped that students could observe the shorter versus taller stems, the sizes and shapes of the top bodies, as well as what happens to the decorated patterns, if anything, once the tops are spinning. The variety of characteristics would allow the students to compare and contrast the different tops.
- The red wooden top in the foreground of the photo is commonly referred to as a tippy top or a flip top. Once spinning, the top inverts itself onto the wooden stem and continues spinning. I thought the tippy top would challenge students and could generate discussions about how it worked. While third graders are unlikely to figure out the equilibrium changes in this top, their preconceptions could strengthen their willingness to explore tops over time.
- The old-fashioned wooden pull string top had a different structure. This top required patience as the children had to wind the string around the stem before they could pull the cord and release the top.
- The tall-handled tops provided a stem that would be easier to grasp. Many of the other tops had very short handles, which could cause frustration in the process of spinning them. Among the third graders, some children were still developing small or fine motor skills, and providing a variety of tops allowed for all children, including children with special needs, to engage with materials.
- The clear plastic tops had an inside piece in the body that appeared to continue to spin even when the top itself stopped. This characteristic led to discussions about how that could happen.

This top selection promised to provide strong opportunities for developing observation skills and curiosity. I hoped to keep the students engaged by having a variety of tops available that included multiple characteristics or that required different methods of spinning. In addition, I opted to label the tops as "spinners" to connect to students' prior experiences.

My plans for the coming weeks involved multiple STEM learning centers with time in the schedule to use them. I also planned integrated literacy connections, social development through large- and small-group work, and engineering through solving a simple design problem.

Explore

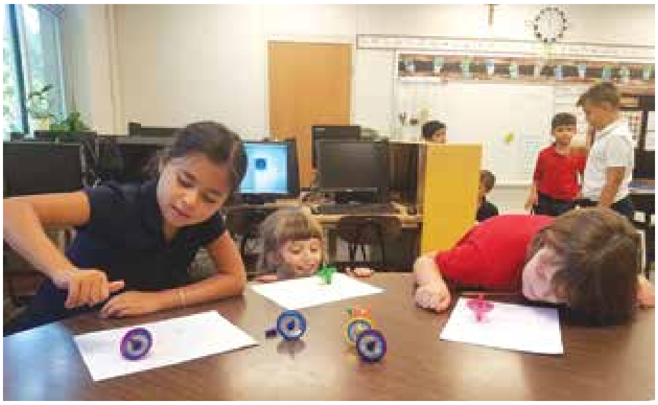
I began by introducing spinners during a daily open STEM time. Students had the opportunity to visit different STEM centers where they could experiment with ramps and pathways, spinners, or pattern blocks with puzzle frames. Students' interest was high because they had minimal STEM center interactions in previous classrooms.

I started by assigning groups of three or four to each separate STEM center but allowed students to move freely after the first round's assignment. I was surprised by how the

FIGURE 1

Tops selected for exploration.

PHOTOS COURTESY OF THE AUTHORS

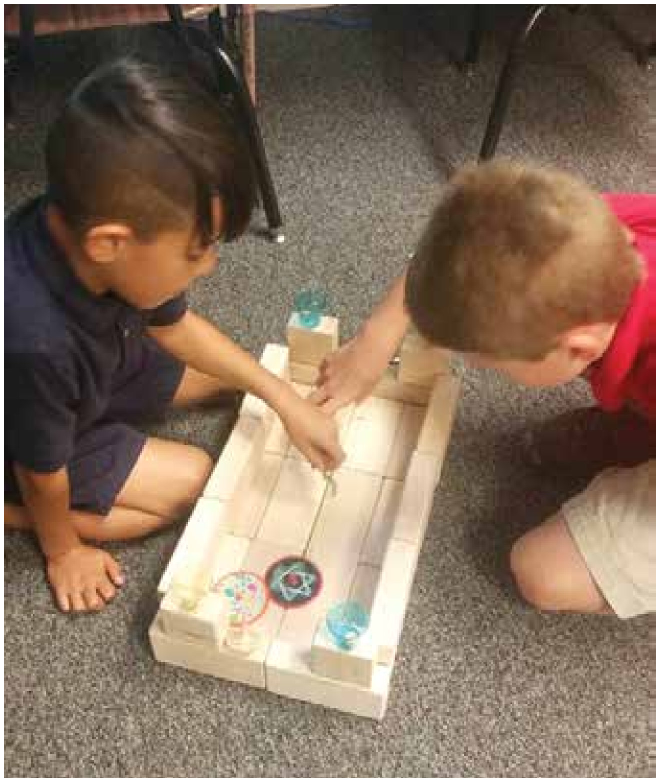


spinners kept several students' attention for an extended period of time. Most of the students chose to work individually on the floor for these tops explorations, but a few remained at the tables.

I circulated the room and conversed with students about their explorations. One was especially interested in the flip top. She found she could spin it most successfully by dropping it as she spun it. The flip top would spin for a short time and then flip itself over onto its stem. Nicki and I discussed why she thought this happened with this top but not others. She offered several simple explanations for why the top was able to flip but was unable to determine a cause for this effect through her own experimentation. Her strongest explanation was that dropping the flip top onto the floor as she spun it was the main reason she was able to get the top to flip over. Nicki commented, "Maybe it works because I am dropping it on this part (pointing at the rounded tip), and then it tips over onto the stick side. You can try to drop it on this part (pointing at the stem end), but it's really hard." A few other students tried this same top, but most preferred to work with tops they could control.

Explain

After a few days of exploring the top collection, I posed the question, "What makes a good spinner?" I allowed students to answer this question about any of the tops they had tried by writing in their science notebooks, which could include drawing pictures and written explanations. I encouraged them to include details based on trying the different tops in the STEM center. After reading their notebooks, I responded to their journals with questions about each of their ideas, thoughts, and pictures to help them expand on their ideas and add more information. Many of my interactions or feedback sessions with the students throughout this process were based on talking through problems or issues and coming up with collaborative solutions. We had large-group discussions after exploration about what surprised them or frustrated them. I encouraged the students to listen to each other and offer explanations or solutions, rather than being directed from me.



Above: **Students compare the motion of tops within a confined area.** ***Above, left:*** **Students get an up-close view of the spinning motion of tops.**

My own journal reflections included discussions of how we could increase students' questioning and simple experimentation. We realized that the students had had no experiences in controlling variables or designing simple experiments at this point. Encouraging them to discuss their criteria for the best spinners was the beginning of this process. We hoped to expand on the idea of controlling variables as the students had more experience in the STEM centers.

Elaborate

The following week, I asked the third graders to compare two different spinners from the STEM center. Students drew each spinner in their science notebooks, investigated and compared them, and described which spinners they believed to be better. The investigations helped students review each top's response to their spinning force, addressing the *NGSS* standard (3-PS2-1) on Motion and Stability. The investigations also moved students toward addressing the science and engineering practices standard (3-5-ETS 1.1), as they had to explain their reasons or criteria for their decisions. The criteria for a good spinner that most students selected included whether the top was easy to spin or how long it would spin. The teacher asked students about the criterion they selected as formative assessment of their learning at this point, encouraging them to record their ideas in their science notebooks.

Over the next week, these investigations morphed into individual students challenging each other's tops to see which was better, with students working together in pairs or small groups to decide on the criteria. The term *better* included, but was not limited to, spinner speed, length/duration of spinning, or if a top knocked another down.

Keeping the tops contained became a problem in their challenges, so students began building containment arenas with unit blocks to better assess the spinners without them traveling too far away. This problem-solving effort also demonstrated students' progress toward the science and engineering practices of creating a solution to a perceived problem reflecting their need to keep the spinners contained. In order for the students to truly evaluate the design of the spinners, they had to solve the initial problem of containing the spinners to compare them. In this first attempt at exploring spinners, I was pleased to see students take control of the problem they discovered and solve it creatively themselves to complete their comparisons of the different tops.

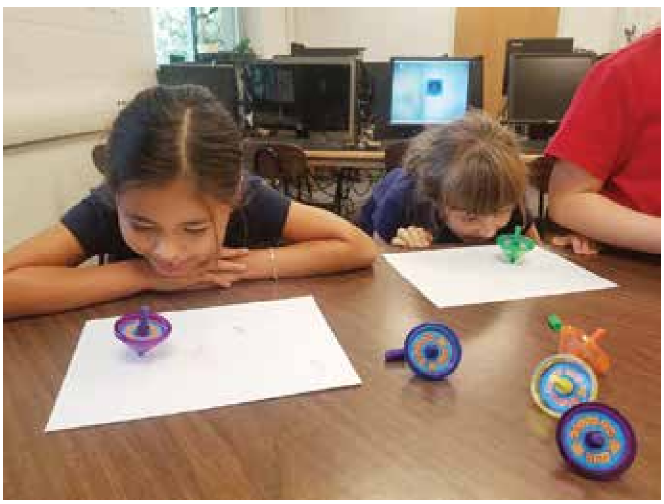
Following their comparisons of two different spinners, I offered a challenge assignment to the third graders to design, engineer, and create their own spinners from items they had in their homes. This assignment further addressed the science and engineering practices standard (3-5-ETS 1.1) and focused on the design process with specific constraints. My goal was not necessarily to fix a problem but to set a goal all my students could achieve successfully based on their observations and interactions with spinners. Constraints I specified included: (1) their created spinner should not cost money, and (2) it could not be premade. Students had a week to complete their new spinners. The students were advised to consult with parents/guardians on both the set constraints and the safety of materials they selected. On the following Thursday, students brought their spinner prototypes to test together at school.

Evaluate

The engineered spinners came in all shapes and sizes. Some were very simple, while others were more complex. It was intriguing to see their creations because they are of the fidget spinner generation, and I was not sure what to expect. Some students had clearly developed and modified their spinners before bringing them to school while other spinners appeared quite simple. Some mimicked the design of fidget spinners, while others were more closely related to what you could consider a "traditional" top.

Students presented and demonstrated each new spinner design to the class. I asked that their presentations answer the following three questions:

Right: **A student attempts to spin "stringy," an old fashioned style of top.** ***Below:*** **More fun with tops.**



- What materials did you use?
- How is your spinner supposed to work, or how do you make it go?
- Would you make any design changes? If so, what?

After each demonstration, the students asked each other questions. Many of the questions from classmates were focused around the materials used or how the spinner was constructed. Every student presented a spinner and explained the choice of materials. Only a few stated they would keep their spinners exactly as they were. Several students said they would make changes for various reasons—either different or stronger materials or different designs. One student who constructed his spinner with corkboard and marbles glued together stated, "I would change the structure of the marbles to be stronger by adding more marbles and using a different type of adhesive to hold them together." His first spinner was hollow underneath, and he felt it would have been more stable and spin better if he filled that space.

Conclusion

In the future, I would extend this exploration over the semester with the investigation of more and different tops. I would also plan for ways to control the tops' travel, such as spinning the tops on cafeteria trays or some other containment methods. This problem solving could be done collaboratively with the students through whole-class meetings or in smaller groups.

Assessments of this exploration were more formative in that students were experiencing the design process for the first time. I used science notebooks and small- and large-group discussions as well as their constructed spinners to determine how to introduce and carry out additional explorations in science and engineering experiences. Because the tops remained in the classroom following the project, additional opportunities to explore force and motion by the students provided further data about student understanding.

For future explorations, I plan to provide greater focus on standardizing variables and exploring the different forces impacting spinners and other materials.

Tops provided an opportunity to integrate curriculum, involving parents and grandparents and their experiences with tops as children. The curriculum could be expanded to include the differences in tops within various countries or cultures, historical information about tops, and ideas for fine arts integration involving colors and designs. Additional science concepts could include how objects spin better or faster, and how they appear while spinning compared to still. My own journal provided insights into how to improve the professional development course for other teachers. Within my classroom, it has become very apparent to me the value of STEM and in allowing my students to freely interact with STEM materials/investigations. There is true value also in allowing them the simple enjoyment of playing and learning through that play. The amazing thing about play is that those involved in it don't ever see it as true work or as a hard challenge because they are enjoying it (and themselves) so much.

While traditional tops are not as sophisticated as fidget spinners, third graders found working with tops to be intriguing. The tops allowed for more diverse interactions than fidget spinners. The students' explorations of different types of tops and their characteristics provided the knowledge to engineer their own spinners from found materials. This experience also supported the idea that engineers and scientists do not often find the best solution to a problem on the first try. ●

REFERENCES

Ashbrook, P. 2011. Objects in motion. *Science and Children* 49 (2): 26–27.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press.

Pappas, S. 2017. Fidget spinners: What they are, how they work and why the controversy. *www.livescience.com/58916-fidget-spinner-faq.html.*

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

Standard

3-PS2 Motion and Stability: Forces and Interactions

www.nextgenscience.org/pe/3-ps2-1-motion-and-stability-forces-and-interactions

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practice	
Planning and Carrying Out Investigations	Students answered questions and designed solutions to movement of the spinning tops.
Disciplinary Core Ideas	
PS2.B: Forces and Motion: Types of Interactions Objects in contact exert forces on each other	Students interacted and observed tops as they exerted different forces.
3-5-ETS 1.1. Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on material, time, or cost.	Students engineered their own spinners based on their criterion for a good spinner and constraints set by the teacher.
Crosscutting Concept	
Cause and Effect	Students tried exerting different amounts of force on tops and noted the differing effects of those forces.

Connecting to the *Common Core State Standards* (NGAC and CCSSO 2010)

ELA/Literacy	
W.3.7 Conduct short research projects that build knowledge about a topic.	Students wrote their comparison data in their science notebooks.
W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into categories.	Students wrote their comparison data in their science notebooks.
Mathematics	
MP.2 Reason abstractly and quantitatively. (**2-PS1-2**)	Students compared two different tops based on criteria they established for their research projects.

Donna Adelmund (*dadelmund@st-francis.net*) is a third-grade teacher at St. Francis Catholic School in Marshalltown, Iowa, and a professional development STEM facilitator at the Regents' Center for Early Developmental Education at the University of Northern Iowa in Cedar Falls. **Jill Uhlenberg** (*jill.uhlenberg@uni.edu*) is an emerita professor and early childhood STEM consultant at the Regents' Center.