Roylco's

Art of ENGINEERING

Art + Engineering = Amazing!

Peter Nosalik

Roylco's Art of ENGINEERING

Art + Engineering = Amazing!

www.roylco.com

Peter Nosalik

Canada: 30 Northland Road, Waterloo, Ontario, N2V 1Y1
USA: PO Box 13409 Anderson, SC 29624
Europe: 50 rue Liancourt, Paris, France, 75014
United Kingdom: Site E, Lakeside Business Park, Broadway Lane, South Cerney, Cirencester,
          Gloucestershire, Gl7 5XL, UK

Peter Nosalik: 30 Northland Road, Waterloo, Ontario, CANADA N2V 1Y1
Email: peter@roylco.com Twitter: @peternosalik Blog: littlefingersbigart.com

Roylco®

www.roylco.com   © Peter Nosalik 2015

Introduction:

Years ago I attended the National Art Educators Association annual conference. On the last day of the conference in the last slot of seminars was a session on engineering. Daniel Pink was one of the keynote speakers that year and he talked about how design would be the new economic driver for North America. I thought a session on Engineering would be an interesting take on design from a unique perspective, so I attended.

The poor presenter was literally overwhelmed by the response he got to his session. He had expected that art teachers would not be interested in his topic. Likewise, he thought that the last session on the last day would be poorly attended. Boy, was he wrong. The room was packed! It was standing room only. He was so nervous that he struggled with the content of his session.

His workshop was based on an engineering activity he had done in one of his classes. For this activity, he wanted to create something he had never done before. He wasn't sure what to expect, but he was willing to experiment along with his students. I was disappointed when he finally revealed the nature of his classroom engineering project. He went through the process of how his class of 6th graders created an elaborate marble maze by taping cardboard tubes up on a wall and configuring them so a marble would run through the entire maze. He told us that the students were engaged in the process, but that it took much longer than he had anticipated. In total, he had to dedicate classroom time and wall space for two weeks in order to complete the project. And then he showed us a video of the finished results. In the video, we see a young boy dropping a single marble into the cardboard maze. It ran all the way through in about 3 seconds. The little boy didn't look impressed or even happy with the results. I can understand that....it took two weeks to build and three seconds to complete. It was pretty anticlimactic. Likewise, it was a really ugly marble maze. I have to say that as an art project, it left a lot to be admired. The video, however, continued.

The next scene showed a girl tossing four marbles into the maze at the same time. This time, the first two marbles ran through the maze but the second two marbles fell out of a seam between two of the cardboard tubes. Right after her, another boy came along with a pail full of marbles. He poured the entire pail into the open end of the maze. The combined weight of all of those marbles destroyed the cardboard tubes and masking tape joints immediately and the result was a floor full of loose marbles. The kids in the video cheered! The teacher was disappointed.

I learned a number of lessons from this experience. First, after almost 30 years of working with teachers and students, I never experiment in a live classroom. I work out details beforehand and then work with students. Second, I always have prescribed lengths of time to do projects. I've found that when I give students realistic expectations they almost always meet them. I might have a project that lasts two periods, but I generally want things to take one period (except for clay and some textile projects). Third, I want art class to produce artistically interesting things. I don't mind "ugly" when there is a reason for it, but generally, I want students to be proud of their work. And finally, I want children to have authentic experiences. I don't want to call a marble maze an engineering project. Instead I want kids to work on engineering projects that connect to their lives and their interests.

For a simple alternative to an elaborate marble maze,
create a domino maze with Roylco's R75304 Super Topplers

Let me talk about my background and why I think engineering is important and why I think it belongs in Art Class.

I work for Roylco and we develop, manufacture and market educational materials for younger students. My main focus is on art materials, but I love science and language. I struggle a little with how to make Math engaging for teachers and students, but I'm working on that. My second major interest beyond art is building and building blocks. I believe that any subject area can be taught through art or with building blocks.

Before we get into the meat of the presentation, I'd like to talk about the importance of engineering for young children. If you've ever been in a preschool or early primary classroom, you'll know that children love building and they love taking things apart. They are curious about their environment including the things they play with and use every day. They are literally natural born engineers (just like they are natural born artists, natural born athletes and natural born musicians).

I want to get back to the question of why engineering. I was struck by Daniel Pink's ideas in his book, A Whole New Mind. He describes 6 senses. His additional sense is design: He maintains that we are moving from an era that stresses functionality to one that stresses creative design. He goes on to predict that the future of our economy relates to creative design. In other words, the products we will want to use need to be both functional and beautiful. Excellent Design is our new economic driver. It is a renewable resource that we can use to solve problems and expand our economy and wealth.
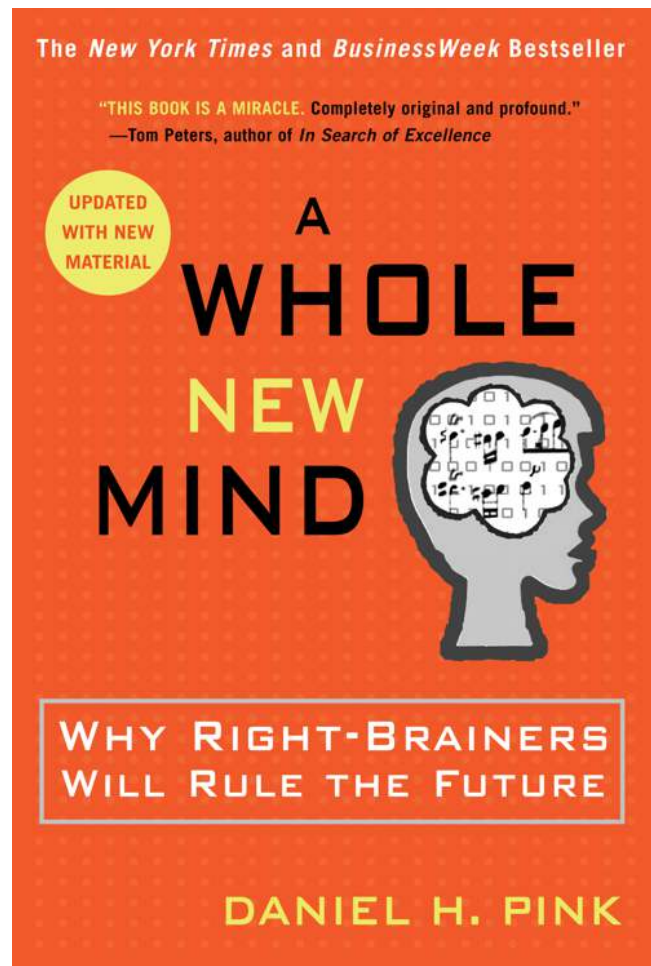
1. Through engineering students develop math and science skills. When I first started working with teachers, we had a term for integrating math, language, art and science together. Now it's called STEM or STEAM, but way back in the late '80s, we called it Whole Language or the Holistic curriculum. I loved all of these educational philosophies; however, I recognize that they put teachers under a huge burden of preparation. We can benefit from integrating aspects of the curriculum into art/engineering projects without the need to go crazy with our preparations. When students undertake engineering projects they naturally use their math and science skills, especially physical science. Likewise, they get to see the everyday importance of math and science in their efforts to solve challenges. You will be helping your colleagues by reinforcing the importance of key concepts and you will be helping your students by showing them the everyday relevance of math and science.

2. Engineering projects for students help build classroom equity. This is very important to me. I work hard to ensure that all students succeed to the best of their abilities. Not only is this gratifying, but success for students results in further explorations. In other words, students who are successful want to continue being successful in their education and will take further risks to achieve success. This has consistently been my experience. Likewise, there is something to be said for failure. I'm not sure how the teacher in my opening example handled the floor full of marbles, but it was an opportunity to explore failure in a positive way. What have we learned from the experience of a broken marble maze? What could we do in the future to prevent the maze from breaking? How could we reduce the length of clean up the next time the maze fails? There is no failure if we learn from our experience. In engineering there is no single right answer. Instead, there are many approaches that can be taken. More than one solution may work just as well as another, so let's explore multiple solutions. Additionally, there are some students who do not learn in a straight forward manner. These are the students who may especially benefit from engineering. I've seen it over and over again where a student who may seem slow in math or reading, suddenly blossoms when undertaking an engineering project. I'm sure you've experienced exceptional artists who performed poorly in other subject areas or the opposite where a bright academic student has trouble drawing or sculpting. Engineering is another opportunity to discover uniqueness in your students.

3. The world is changing and education needs to change with it! Engineering is a generally project-based activity. Even when students are being evaluated alone, they will talk about their projects with fellow students. This collaboration is not only important and even necessary for the success of their projects; it is helping them develop communication skills while thinking creatively and working with others. Collaboration skills were always important, but as our world gets smaller and more complicated due to technology, collaboration and communication skills become even more important!

4. I believe fundamentally in a general education that exposes children to a broad range of influences. However, there is something to be said for preparing students for career success. Most children don't have adult artists in their lives to inspire them to pursue a career in art. Likewise, most students don't have engineers in their lives to inspire them to purse engineering as a career. By undertaking engineering projects, children are exposed to a potential career that they may never have thought of before. You may inspire the next generation of engineers who are naturally gifted without knowing it!

5. Lastly, I want to think about the issues that are the most pressing in our society, culture and planet. I'm thinking about curing cancer, preventing global warming, inventing renewable power solutions to name a few. These big issues will be solved by engineers either alone or in partnership with scientists and researchers, but they will need to be understood by everyone. Even if you don't inspire the next generation of engineers, you will be helping students develop a mindset that is necessary to understand these big issues and it will be through that understanding that citizens will help implement solutions.

So now that we know why teaching engineering is important, I want to talk about it in the context of creating art.

It occurs to me that art education is fundamental to all experimental and expressive accomplishments. Through art, students learn to work with their hands to capture what they are envisioning in their minds. They learn techniques and experiment with styles. I like to think of it as "Hands-on, Minds-on." There is a wonderful feedback loop between the hands and the brain. The brain envisions something that the hands try to recreate. As the hands create, the mind starts to observe limitations of materials while being inspired by others in the room, or the potential of different techniques. The same feedback loop exists in "real life." Through the experience of building a skyscraper or discovering a new material, engineers use the same mental process as artists but in a different context. The biggest difference between art and engineering is that an artist usually works alone while engineers require architects, contractors, technicians and user groups to realize their vision. The two fields are more similar than we realize.
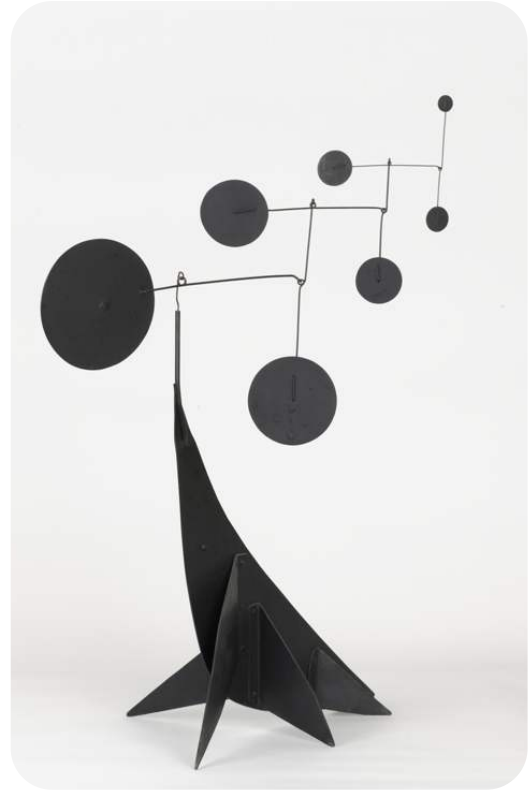
Before we get into examples of engineering projects for art class, I want to finish up with a general observation. I have found that engineering projects in classrooms tend to look rather "Rube Goldberg-esque." Rube Goldberg was a cartoonist in the mid 20th century who was famous for illustrations of excessive contraptions that do simple functions in an overly complicated fashion.

In this illustration a dog, rocket, watering pail and two lover birds are used to wash a shirt. The game "Mousetrap" was inspired by Rube Goldberg. I've seen many student projects that involve lots of odds and ends to create bridges, egg drop devices, catapults, etc. They almost always look sloppy and fragile. This isn't really engineering, although it may demonstrate some engineering principles.
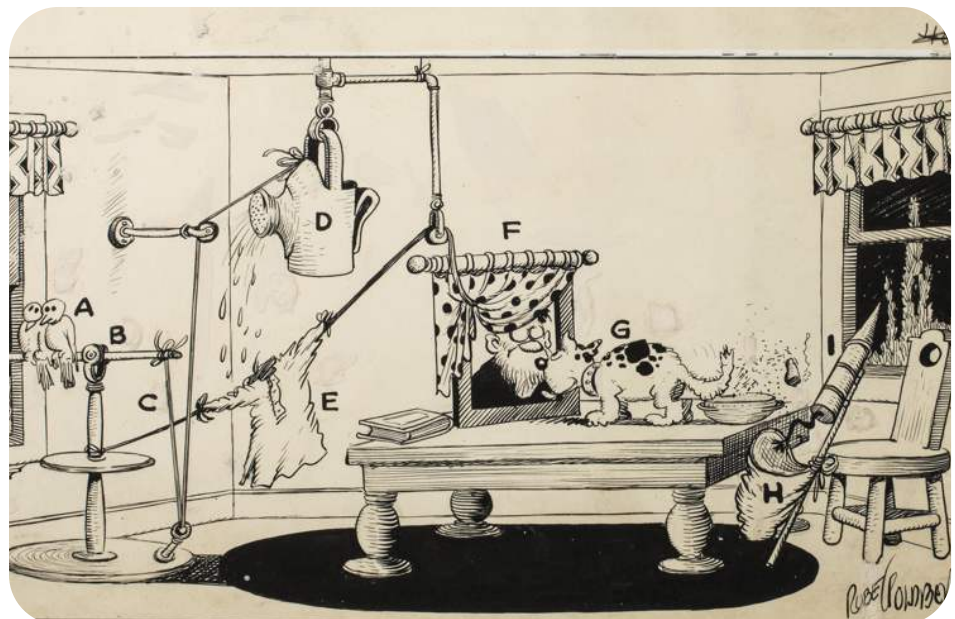
What we want to create is something beautiful that students can take home and show their parents. We want to introduce or reinforce engineering concepts through the creation of art. While this is an unorthodox approach, it's really not that far away from regular art projects. It just involves a shift in mindset.
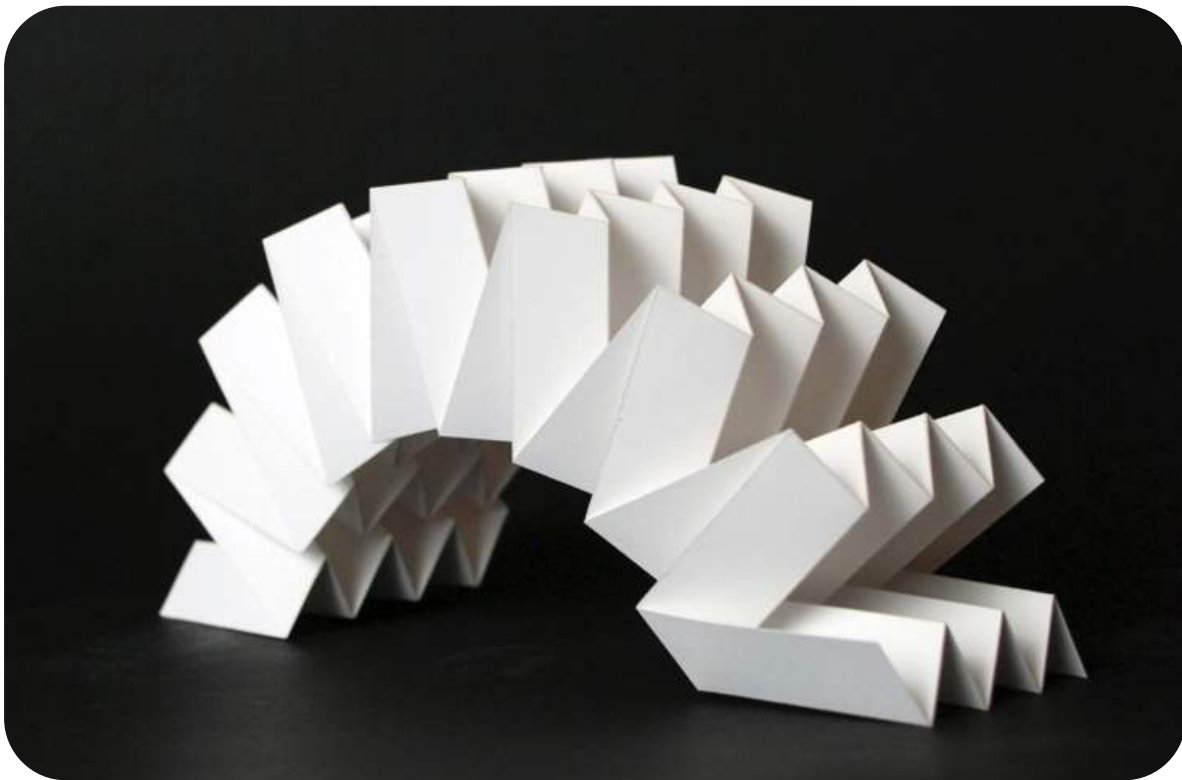
Before launching into the projects, I want to briefly talk about different types of engineering.

There are more than 30 different engineering degree tracks offered by universities and colleges across the country. Some of these include:

Areospace	Mechanical	Nuclear
Biomedical	Automotive	Civil
Architectural	Electrical	Robotics
Chemical	Environmental	Industrial
Systems Design	Manufacturing	Petroleum
Geological	Marine	Nanotechnology
Metallurgical	Ceramics	

and my favourite....Paper Engineering.

Credited to BryantYeeDesign.com

A big goal for me in this exploration of the art of engineering is to create beautiful things that students can take home. That being said, not all of the projects will be easily transportable, so I am a big believer in photography. I want students to be proud to have their engineering projects photographed and the files emailed to their own phones or sent home to parents or published on a classroom blog.

To accomplish good photographs, you need to have a photo booth and the projects need to be transportable to the photo area. Sometimes you may just want students to take pictures of their projects in situ because they are too fragile to move, but try to avoid this when possible. The end result of moving a structure or contraption to a photo booth not only produces a significantly better image (because you can use proper lighting and have an appropriate background) but also requires additional engineering principles on the student's behalf. If they know they will need to move it, they will create something sturdy and robust.

I am a strong believer in sketching out plans prior to starting a project. I've seen children as young as four years old create wonderful blueprints of buildings that they have created and sketches of ideas they want to build. Drawing is a fundamental skill that not everyone is interested in developing. Combining it with engineering will help motivate reluctant artists to spend a little more time and care on their project.

Finally, there are some projects that are just too good to leave in the classroom. Sometimes we need and want to send these projects home. I'll give you a few ideas for these projects, too.

Let's start!

All of the projects I am going to describe have four things in common.

1. Each project has a goal that we discuss before we start. In other words, this is not only about self-expression (although that can be and should be an element of the project). It is about solving a challenge.

2. Each project uses specific materials. A student doesn't need to use all of the materials, but they cannot add more materials. You can amend this "rule" by allowing students to add one element outside of the list, but I think it's a good idea to provide constraints. Sometimes constraints inspire creativity!

3. Students can and should conduct research and talk to other students and adults to come up with a solution to the challenge.

4. There is a measureable goal.

Our task as the teacher is to present the challenge and prepare the materials and measure the results. Let's start with an easy challenge and move forward.

Challenge #1: Mail Call

The challenge is to deliver a message to another person over a specific distance.

The materials are: Paper, scissors, glue, rubber bands, pencils, crayons, markers, pipe cleaners, assorted paper clips, tape, recycled plastic cups or yogurt containers and assorted drinking straws.

The measurable goal is a specific distance. For younger children, this can be 2 meters or 6 feet. For older students, let's say the width of an average classroom, about 7.5 meters or around 25 feet.

Let's brainstorm some solutions for this challenge.

Because this is the first challenge I use to present engineering to a classroom, I like to brainstorm as a class. Once you've brainstormed ideas as a larger group, I suggest breaking the class into groups and then asking each group to work on one of the brainstorming solutions. For instance, one group may focus on paper airplanes while another group works on straw rockets while another group works on a drum. The members of the groups can interact with each other and even with members in other groups, but they need to finish the project on their own.

Once everyone has completed their message delivery system, it's time to test them out. If you want to add mathematics to your lesson plan, ask the students to measure the distance each system achieved and then graph the result.

Everyone needs to start by writing out a message. Some messages, like those used with a paper airplane can be longer messages. For something like the war drum or rocket, the message needs to reflect the limitations of the media. For instance, banging out a long message on the war drum may be too time consuming and has a great potential to get confusing if it is too complicated. Likewise, a scroll taped to a rocket needs to be light weight and small enough to fit inside the straw rocket launcher.
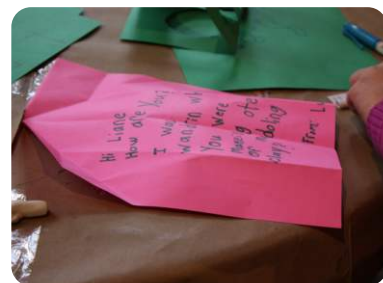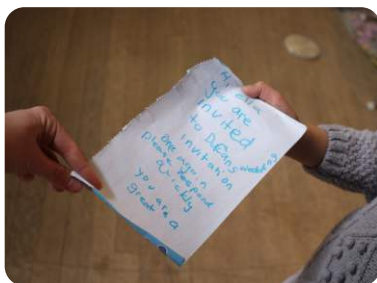
Let's take a look at some possible solutions to the task and test them out together.

1. Paper Airplane

Write the message on the inside of the airplane and then throw it to take off! I've used our R15286 Antique Paper because I think it works really well to focus students' attention on creating an attractive message using good penmanship or calligraphy. Paper airplanes come in a huge variety of designs from very simple to extremely complex. Because of the various styles of paper planes, you can use them for a wide range of ages and abilities. Check out the web for folding instructions.

2. War Drums

For a completely different solution to the challenge, make drums using the plastic container, a sheet of paper and a rubber band. The straws can be used for drum sticks. Cut out the bottom of the container. Cover the top opening of the container with paper and fold over all of the edges. Use the elastic band to hold the paper in place and add tape to seal the paper onto the container. Work out a code for specific words or research Morse code for the entire alphabet.

3. Straw Rockets

My favourite solution to the problem is also the easiest. Write your message on a thin straw. Pinch the top closed and seal the closure with a piece of tape. Insert the thin straw into a thicker straw and sharply blow into the straw to send the rocket flying. There is a trade off between the amount you can write for your message, because writing on a straw is awkward and there isn't a lot of space, however, you can go for distance with these rockets. Try writing a small scroll and taping it onto the thin straw. That works wonderfully.

4. The Direct Method

If you need the message to travel a short distance, simply ball up the paper after you've written your message and throw it to your recipient. It sounds too simple to be effective, but it's the fastest and easiest way to get your message across. For longer distances, try balling up the paper around a heavier object like a box of paper clips. Once students start thinking about how to make an easy idea effective, they are really using their imaginations and initiative to solve problems.

5. Shotgun

Another effective method to cover a longer distance is to make a kind of slingshot to propel a paper airplane. Start by folding up a simple airplane with the message you want to deliver written on the inside. Securely tape an open paper clip onto the bottom of the airplane. Next, cut a slot into one end of a straw. Thread one end of an elastic band into the slot of the straw. Thread the other end of the elastic onto the paperclip "hook" of the airplane. Pull back the airplane to stretch out the elastic and send your paper airplane flying. This can be very effective for travelling long distances very quickly.

After this first exercise, I want to review the process that typical children and typical classroom groups go through to develop solutions for the challenges. This is the normal process that I have witnessed time and time again:

First, students listen to the challenge. The more times you conduct challenges, the more attentive the students will be in listening to the elements of the challenge. In the past I have written out the challenge and recited it directly off a sheet of paper. This way I can be sure to cover all the details and not miss a thing. I also tried handing out copies of the challenge. You might want to do this especially for larger classrooms or if you have students who you know are better readers than listeners. I even got creative with my challenge and told a "life and death" story where the students were put into a "MacGyver" situation and needed to accomplish their task as if their life depended on it. I have to admit that this was a lot of fun for the students, but it didn't really achieve the ultimate goal of finding creative and effective solutions. Instead, the students were more interested in acting out the drama and the solution to the challenge was less important.
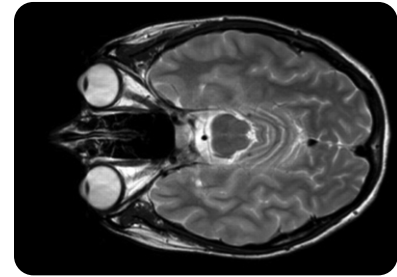
Second, students need time to examine the materials in order to see and feel what they can do. It's very tempting to put a time limit on this exploration, but I've learned not to. It is more important to me that they really have a chance to test the materials. To facilitate this, I combine it with the third part of the process: Research and Discussion.
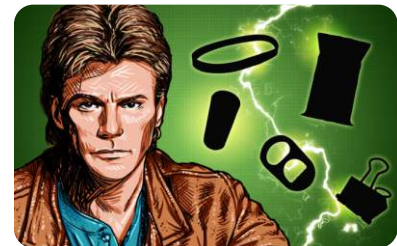
Third, it is important for students to think and talk about the materials and the possible solutions they can use to solve the challenge. To encourage this, I might form groups or I might let the discussions happen naturally—they always do! The most effective way I've found is to simply stroll through the class and ask directed questions. For the Mail Call challenge, I might go to a small group of children who are in close proximity or who have already formed a loose group and ask them something like, "What is the most simple solution to the challenge?" or "Can you work on a solution that only use one or two types of materials?" Once the students get talking, it doesn't really matter if they use my question as a means to find a solution, just as long as they start talking about the challenge and discussing ways to solve it. In terms of research, the internet is very helpful and sometimes it's important, but I like to limit its use simply because I've found that looking at internet solutions can really complicate the process rather than simplify it. Instead, I try to have a few old fashion books lying around that may present some options. A book on paper airplane folding or Morse code is ideal. Books don't answer all of the questions, but they can provide critical information once students form an idea.

The fourth factor is to try and try again. For something simple like the mail call challenge, feel free to set a time limit. I like to start out by saying something like, "Let's see where we are in 15 minutes." Some kids will try to rush through the process and come up with an answer in that time. Others will only get so far. That's fine. After the 15, if they need more time, let them have another 15 minutes. If they have come up with solutions, then test them as a class. What I want to achieve with these 15 minute slots is to give students a chance to try something and fail so that they can make improvements to their design or try something new entirely. Especially when you first start giving students challenges, it is important to let them experiment and learn from mistakes. We'll talk about this more shortly.

Fifth, you want to test the solutions. It's fun to test them as a whole class, but that can take a lot of time. Instead, you can get groups of children to test their solutions at the same time. Not only does this save a lot of valuable classroom time, but it is exciting to watch.

Lastly, you want to repeat the challenge later on in the term and see how the students have retained their knowledge and improved on it. I like to give it at least a month between iterations. For this second challenge, I make the goal harder to achieve. I've found that really challenging the students is very motivating for them.

You will notice that I haven't really said anything about planning out the solution. I have mixed feelings about this. Sometimes I feel that too much planning is a hindrance to creative problem solving. In other words, if a student has a single solution, he or she may not be willing to explore other options. I've seen many examples where one idea leads to another and another. Sometimes planning is important; but sometimes it isn't. When you first start introducing engineering challenges to your students, skip the planning stage and encourage a more freeform process to solve the challenge. After several engineering challenges, add the planning stage to see how it affects the final solution. Let's now talk about a challenge that incorporates a planning phase.

Let's try a structural engineering challenge. Structural engineering focuses on very large projects like skyscrapers. Not only do structural engineers need to be able to build these giant buildings, but they need to make them safe and comfortable for the occupants. In other words, the building must stay upright in all weather conditions which means they can sway with heavy winds, but they can't sway so much that the occupants feel nauseous.

Challenge #2: Building on a Sandy Foundation

Challenge: Build a tall tower on an unstable surface that can support humans on different floors.

Materials: Sturdy box or plastic bin, 2 empty paper cups, R6085 Straws and Connectors, wooden or foam building blocks, cardboard squares approximately 4 x 6" (10 x 15 cm), Roylco R75304 Super Topplers or some other human figures, scissors, empty water pail and plastic shovel. Note: You can replace the sand in this activity with packing peanuts.

Start by pouring the sand or packing peanuts into the plastic bin or box. I like pouring it in so that it creates a hill off centre to the middle of the box. Explain to the students that they need to build the tallest structure they can that can support the weight of 20-50 of the human figures (Topplers). Ask the students to think of one or two solutions to this challenge and then draw blue prints for how they will build their structures. I like to encourage children to always think of more than one possible solution. I think that when kids settle on only one idea, they are more likely to feel like a failure if it doesn't succeed. Likewise, if they have multiple ideas, even if all of the ideas are wrong, it makes them more open to accepting other ways of looking at the solution.

Before we begin building solutions give students the chance to review all of their designs together. My hope is that working individually, students will come up with a wide range of solutions. After they have a chance to hear what each other plans to do, let students revise their ideas. They may eventually all come up with the same solution (that has only happened to me once), but that's okay. We want children to benefit from the knowledge, experience, imagination and creativity of all of their classroom colleagues.
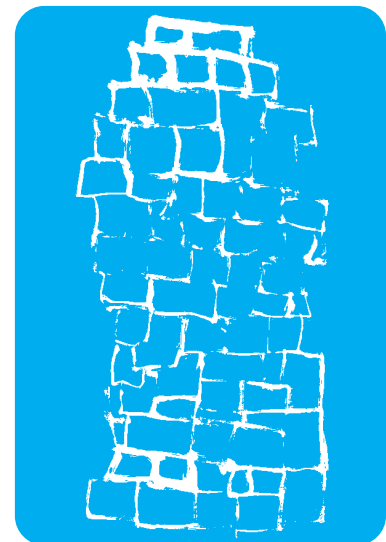
After completing the second round of revisions to their blueprints, let the students try out their solutions. It can take a long time to build each structure, so if time is a problem, I ask the kids to work in groups to select one design and then build that tower. In this case the artwork that they create is the blueprint.

One possible solution is to create a foundation in the sand. Start with the R6085 Straws and Connectors. Depending on how deep the sand is, cut the straws so that the length is just a little shorter than the depth of the sand. Cut some more straws about 10 cm or 4" long. Create a grid of Straws and Connectors that you can bury in the sand. Cover the top of this grid with the cardboard rectangles. Lay the cardboard rectangles over the grid, overlapping as necessary. Build with blocks on the rectangles. Add the Topplers to the different stories of your structure or place them all on the roof top deck.

Once the building is completed, the real challenge begins when you start removing the "sand" from the tray and see how long the structure remains upright. The building should remain standing forever if the foundation is strong enough.

For a slightly easier to prepare challenge, simply pour a layer of sand into a tray and ask the students to build on it. Here we use our R60450 Skyscraper Building cards on a layer of sand in our R59630 Sensory Tray. Because the sand is unstable, the students need to experiment with different card configurations to make the most stable structure possible.
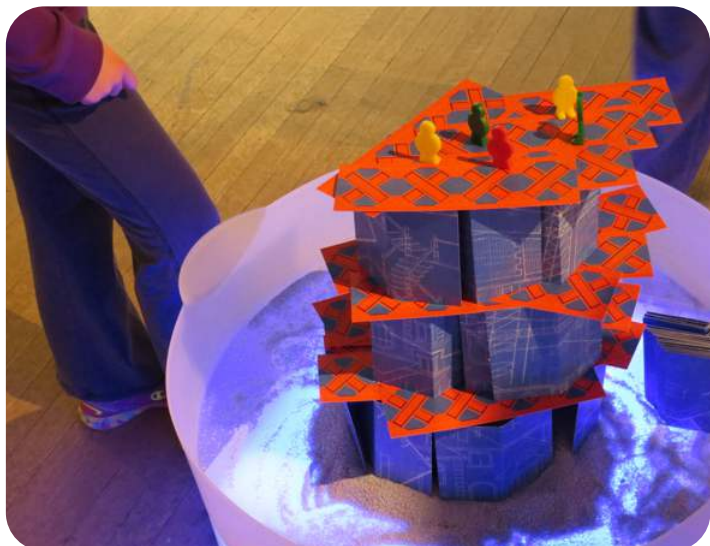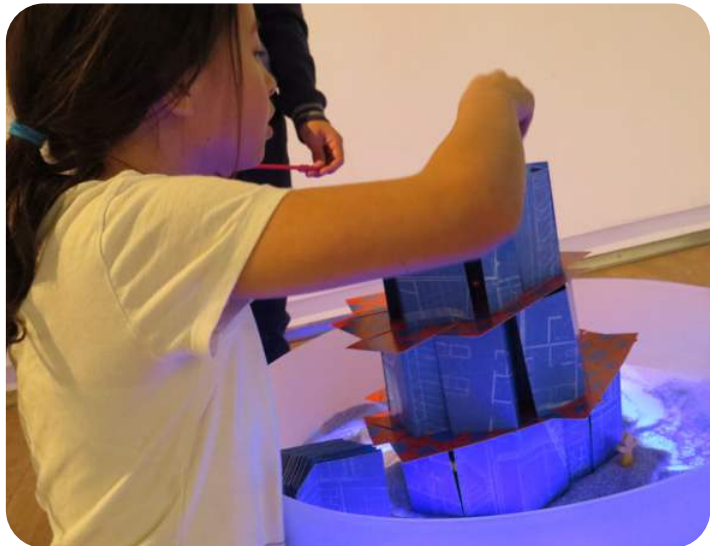
Challenge #3: Earthquake Resistant Buildings

The Challenge: In some parts of the world, earthquakes present a significant hazard. An Architectural engineer may be employed to help create buildings that are earthquake resistant. Let's create an earthquake platform and then try building some structures to see how earthquake resistant we can make them.

Materials: Provide students with 10 x 15 cm or 4 x 6" cards or use our R60450 Skyscraper Building Cards, rulers, scissors, marshmallows, R75304 Super Topplers and toothpicks.

We need to make an earthquake table. There are resources online for making this type of table. They use just simple wooden dowels or plastic pipes that you can buy and have cut at Home Depot, but the easiest way I've found to make an earthquake table is to buy a vibrating hand massager and tape it to the inside of a cardboard box. Alternatively, you can use our R59630 Sensory Tray. It has two levels of vibration and is perfect to use with sand and water activities for younger children.

If you are working with our Skyscraper Building Cards, students can create configurations that will be strong enough to withstand the vibrations for a good length of time. If you are working with regular cardboard squares, keep some of them flat and encourage the students to fold others to create a more stable post.
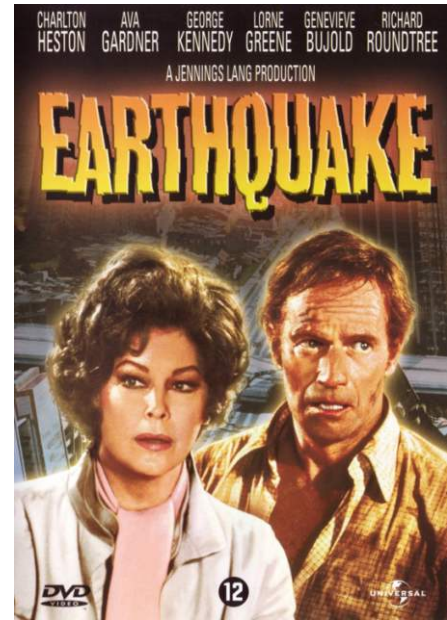
Assembly instructions available from the Network for Earthquake Engineering Simulations, www.nees.org

The marshmallows and toothpicks are a bit misleading. They seem like part of a solution where the students create a flexible foundation that will absorb the vibrations and then build on top of that. In practise, the marshmallows don't really absorb the vibrations enough to make a big difference. I really like when students theorize that the marshmallows will absorb the kinetic energy. It gives us a chance to talk about what other materials could do a better job. If we have time, we can test other solutions, but I keep this separate. I've only had one opportunity to work on these other solutions with one student who was really interested in earthquakes and engineering. We had some free time in a later class so I was happy to work with him on it. The experience was wonderful because he was generally reluctant to do art projects and the other kids in the class were interested in what we were doing, so he became the star for that period. It was motivating for both of us.
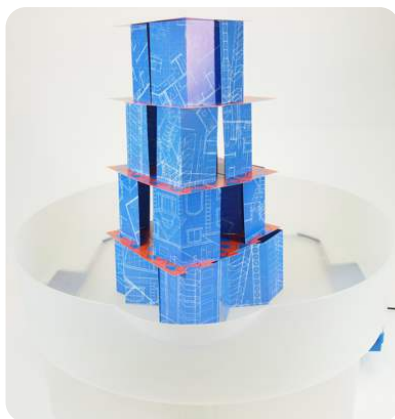
Build a tower	Activate the vibration	Time how long it takes to fall

My favourite solution was when one child took a bite of the marshmallow, chewed it a bit, and then spit it out and used it as glue to hold the cardboard squares and posts together. It was both ingenious and effective, however, it didn't really speak to the true nature of the challenge. That being said, it's great to encourage a resourceful view of materials. I found in subsequent challenges, that class took an "out of the box" approach to their materials. It really showed me how one person could have a big impact on the way the rest of the group responded to challenges.

Once the towers are built, place them on the earthquake table and activate the vibration. Time how long it takes for the first cards to fall off and how long it takes for the whole building to collapse. I like to have two rounds of construction so that students can learn from their trial and error. This is an important aspect of engineering. In university and college, engineers learn from the mistakes of those who have gone before them. In Canada there is a custom that upon graduating, new engineers are given a ring in a secret ceremony. They are told to wear the ring on the pinky finger of their working hand as a reminder of the integrity of their profession. The myth is that the original rings were made from an iron bridge that collapsed in 1907 killing 75 workers. This bridge collapsed because of poor planning and design by the overseeing engineers. While that may not be the original origin of the ring story, it is still a strong reminder that engineers must learn from the mistakes of the past.
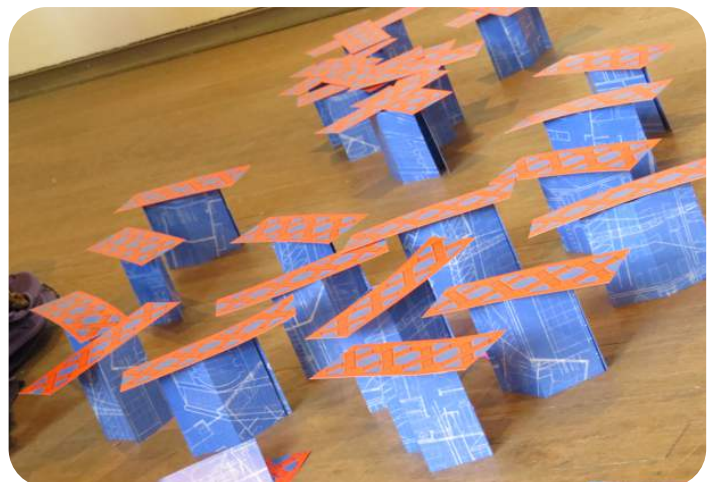
Students will propose many different solutions

When you repeat the earthquake challenge, notice how significantly more sturdy the towers become. Because this is a quick process, you can repeat it several times in one classroom period to see if the students can come up with a design that refuse to crumble even under prolonged vibration! If you want, you can ask the students to work in small groups or you can encourage them to build several towers on the earthquake table at the same time.

To make this an art project, photograph the towers after they are built or try to take action photos as the towers collapse. Some of these images are absolutely beautiful!

Challenge 4: Engineering Moto: If it isn't broken, take it apart and fix it!

I've talked to many, many engineers and they all seem to have one thing in common. When they were children they frustrated their parents by taking household appliances apart and then trying to put them back together. They always chuckle when they say that they got the blender or toaster back together with only one or two spare parts. I love the idea of "creative destruction" to create art.

Invite your students' parents to donate small, broken appliances to the class. Once you have several, bring in some tools like screw drivers and pliers and ask students to take apart the appliances. You can encourage the students to look for the cause of the malfunction, but for our purposes, it really isn't important. There is a popular movement developing called, "Take It Apart Parties" where teachers invite parents and students to take broken appliances apart to discover the workings inside. Check out www.educationworld.com for more information.

Electronic Thermos

Once you have the appliances taken apart, ask the student to arrange the pieces to create art, either representational or abstract. I ask students to arrange their materials on a flat surface and then photograph the results versus creating permanent sculptures. That way, the same pieces can be repurposed by several students. After a couple of years or if you have a lot of donations, you can create sculptures using this material. The results can be amazing.

Challenge 5: Hurricane Mobiles

The challenge: Aerodynamics starts with an understanding of the nature of wind and air. For something invisible, air has a lot to do with how we travel quickly. Airplane wings use Bernoulli's Principle to achieve lift. Cars need to reduce wind drag to achieve fast speeds. Let's introduce students to the nature of air movements with beautiful mobiles that are sturdy enough to survive strong winds.

Materials: Provide students with thread, mobile bases such as Roylco's R51302 Nature Mobile Maker or R51303 Sky Mobile, assorted craft material either gathered from nature such as leaves, twigs, pebbles, small pine cones, etc., or make ornaments with paper, craft buttons, pompoms, etc. and a table fan.

This is both a beautiful and challenging project because we're going to add a twist. Talk to your students about mobiles and how they work. Most common mobiles are designed to hang inside the home. We want our mobile to be more robust, so we're going to test it with a table fan! The mobile needs to be robust enough to withstand the force of the fan's wind pressure on the ornaments.

Beautiful and inspiring artwork by, Anthony Howe, www.howeart.net

Start by describing how to make a mobile and then show students the fan. As a group, talk about options for ornaments: Should they use heavy ornaments or light ones? Does the length of thread attaching the ornament to the mobile make a difference? Should larger ornaments be placed on the bottom of the mobile? Avoid showing students a finished project, but get them thinking about their solutions. As an option, students can test ornaments in front of the fan, or they may think of blowing on an ornament while still at their desk, but it is really meant to be a challenge about thinking about wind and how materials respond to it.

Give students time to work on the mobile and then test the finished pieces in front of the fan. It's beautiful and fun! The goal is to make a mobile that is both robust and beautiful. I encourage students to continually test their mobiles in front of the fan so they can develop techniques to make a mobile that can survive strong, outdoor winds.

Solution 1: Add kite-like tails to the mobile

Solution 2: Add weight to the mobile

Challenge #6: Digital Design

Challenge: Our technological world is changing like crazy! Not only can our devices do more, but they need to work more intuitively. The great genius of the iPad and iPhone was how simple they were to use. Let's combine engineering with design and ask students to create a robot. They need to determine what the robot's purpose is and how its form relates to its function. They also need to work on the interface on the robot so the operator can control its actions.

Materials: Large sheets of tag board or paper, scissors, glue, markers (I prefer to use only black for this project) and Roylco's R15298 Gizmo Paper.

Ask students to write a description of the robot's function. Maybe it cleans the house or walks the dog. It might provide entertainment or drive a car. Let the students come up with their own functions to replace mundane chores they don't like doing. It's interesting to hear their ideas!

Give each student a large sheet of paper to draw the outline of their robot. Next, give them sheets of Roylco's R15298 Gizmo Paper. This paper is printed with images of technological elements. If you don't have access to this paper, you can print off images of technology from the internet. Let the kids cut out shapes that relate to their robot and paste them on the outline. If necessary, students can draw in additional details. At the end, give students a chance to describe what their robot does and how the operator interfaces with it.

Challenge #7: Marshmallow Challenge

I'm not crazy about this challenge but it is a great way to encourage collaboration.

Challenge: Break the class up into groups of 4 students. Using a standard set of materials, the groups have to build the biggest tower possible that can support the weight of the marshmallow on top in 18 minutes.

Materials: Give each group 20 sticks of spaghetti, 1 yard of masking tape, 1 yard of string and 1 marshmallow. You will need a measuring tape and a stop watch.

The Marshmallow Challenge

20 sticks of spaghetti + one yard tape + one yard string + one marshmallow

www.marshmallowchallenge.com

This challenge has been taken by many, many different groups of people ranging from kindergarten students to CEOs of fortune 50 companies. Who consistently performs poorly? It may not be a surprise, but among the worst performers are recent business school graduates. Who consistently performs well? Again, you may not be surprised that it's recent graduates of kindergarten. Why is this? Young children tend to build a structure and see if it works. If it doesn't work, they make some adjustments and try again. They keep trying until they succeed. Business school graduates, on the other hand, tend to work out a plan and then rigidly adhere to it even if it's not going well. So successful builders tend to prototype and make changes while unsuccessful builders tend to stick to a plan even when it's not working. There is another factor...kindergarten kids don't often need to be the best in the group. They don't try and act like the CEOs of their groups. Instead, they forge ahead as a cohesive group and hand over authority to others as required.

Young children will act just like professional engineers when approaching this challenge. They will start by examining their materials and asking questions.

Unlike professional engineers who tend to make a well-informed plan and then stick to it, young children go through the iterative process whereby they try something and then either develop the technique or abandon it. The continue trying different techniques until the land on something that works.

The key to young children's success with the marshmallow challenge is that they often start by placing the marshmallow on a piece of spaghetti and then try to raise that piece up higher by building beneath it. Older students often try to build a structure and then add the marshmallow to the top at the very end. More often than we'd like, the force required to add the marshmallow to the top, destroys their structure. The marshmallow challenge is a great activity for a wide range of ages and skills. Try it will all of your students. Don't forget to revisit it later in the year to see how much students have retained from the original exercise and how they have developed their engineering and collaboration skills.

Challenge #8: Community Building

The Challenge: This challenge is to develop an understand of the physical nature of a community. What are important things for citizens? What services do they need? How will they get to work and school? Engineers work with city planners to create roads and city systems like water, sewage and electricity. Let's examine the process of city building within the class.

Materials: Provide the students with butcher paper, crayons, cardboard sheets, Roylco's R15297 Architecture Paper, straight edges, scissors and glue.

Start by talking about the elements that make up a town. Do you need a hospital? What about an auditorium or concert hall? Do you need a community centre for sporting events or do you need a stadium for large events? List all of the things that go into a city. Next, split the students into groups. Depending on the size of your classroom, I like four or five groups for this project. My experience is that small groups tend to select a leader who will take the group in a specific direction. For this activity, I like fewer but larger groups because it's harder to manage. Engineers need to work with a variety of people and in "real life" it's sometimes very difficult, so let's model this challenge.

Next, give each group a specific location for their town or city. For instance, let's look at 5 different types of communities: The first town could be a tourist area on the beach of a Caribbean island with a population of 8,000 citizens, and an annual tourist population of 100,000 visitors. The second town could be in the Arctic region of Canada where the citizens fish for food and hunt for seals, but everything else, including wood and building material, needs to be shipped in from the South. This town has a population of 100 families. The third town could be a community based on a strict religious order that doesn't believe in electricity, gasoline powered vehicles or indoor pumping with a population of 450 people. The fourth community has the same climate and geography as your home town, but the 2,400 citizens are all under 20 years of age. The fifth town is on the Moon! There are only 35 people living in this community

After the students have thought about the physical, emotional, societal and spiritual issues surrounding their community, it's time to start planning it out. Make a list of the buildings you will need and the streets and transportation services you will provide the citizens. Use a large sheet butcher paper to organize streets and roughly plan out the building. Older students may want to think about the scale of the city. For a large city use a smaller scale so it fits onto the paper. Next, design the buildings! For houses and apartment buildings, start with a sheet of cardboard. Fold in both sides so they roughly meet in the middle. Stand up your house by folding out the sides to give the house support. Cut out architectural elements from the Architecture Paper and paste them onto the cardboard. Encourage students to spend time on these homes because these will represent the art projects they take home to show their parents. Arrange the homes on the city plan. Add other buildings by drawing them on the paper or use old cartons and recycled materials to create these structures. Roylco makes R60160 Constructa Clips which are perfect to create plain and fanciful buildings. Finish off by photographing the completed city so you can email it to parents.

Once the city is done, ask groups to elect a mayor who can describe the design choices they have used to make their city. The thought process behind this type of project is wonderful! It uses the same process that a professional engineer uses to develop plans: It takes into account what the users of the town need, determines how these needs are met and prioritizes what space is used for what activities. It's about big

When students start creating their cities, don't be surprised if they start to change their original plan. In this example, a child realized part of the way through that they needed to add an airport. Another student felt strongly that the city needed to be wheelchair accessible so he added ramps everywhere. It was an interesting and exciting development to see how quickly the city grew beyond it's original borders.

Challenge 9: The Big Picture

This is my favourite challenge to end with because it ties up so many of the threads we have been using.

The Challenge: Using all kinds of opaque and transparent objects, create a shadowscape on the wall by arranging the objects and shining a light on them.

Materials: Provide your students with building blocks and three-dimensional recycled materials like small boxes and clean yogurt cups. You will need a blank wall and a powerful light source. Try an overhead projector or strong flashlight.

Start by demonstrating some basic properties of shadows. Show how students can affect the size of shadows by moving objects closer to or further away from the light source. Try looking at the shadows cast by transparent versus opaque objects.

Set up a platform that the students can arrange their materials on. Place the platform against or near a blank wall. Set up a light source near the platform. The objective of this challenge is to arrange the objects in such a way as to cast a shadow that looks like a village or cityscape. This can be the cityscape you completed in the previous challenge or you can give them other ideas of city outlines.


Once the students are familiar with casting shadows, I like to ask them if they want to work with the light source turned on or turned off. It would be much easier for them to create city scapes with the light source on, but most groups of students want it turned off so their end project will be more of a surprise. I give them periods of 5 minutes to create their city and then we turn the light on. We take a look at the shadow, turn the light source off and then make adjustments to the objects and add others. After another period of 5 minutes, I turn the light back on to see the progress we've made. It's a wonderful project to get everyone building with light! The students love it!
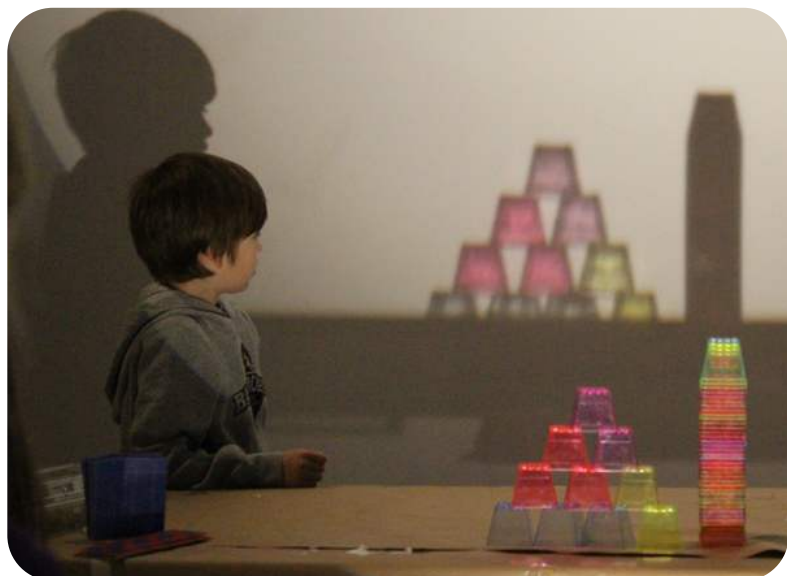
City silhouettes are easy to find on-line. Set up the light source and give the students specific amounts of time to create their shadows. You may need to set up multiple work areas. While the students are working on their projects they will find that objects cast shadows differently if they are positioned near or farther from the light source. Likewise, if they are rotated, their shadows will look different. For reference, check out the work of Tim Noble and Sue Webster and Rashad Alakbarov. Feel free to add a different colour background or put a colour filter over the light source. I have found that an overhead projector is the easiest and best light source. Take plenty of pictures including pictures of just the shadow and both the sculpture and the shadow it casts. This challenge uses the physical nature of objects and the properties of light to make something unique and beautiful.

Note: You can repeat this project on a more personal scale by using a regular piece of paper. Children fold and crease the paper to create an interesting shadow. It is important to get the direction of the light source exactly right. I like having the light source perpendicular to the folded paper.
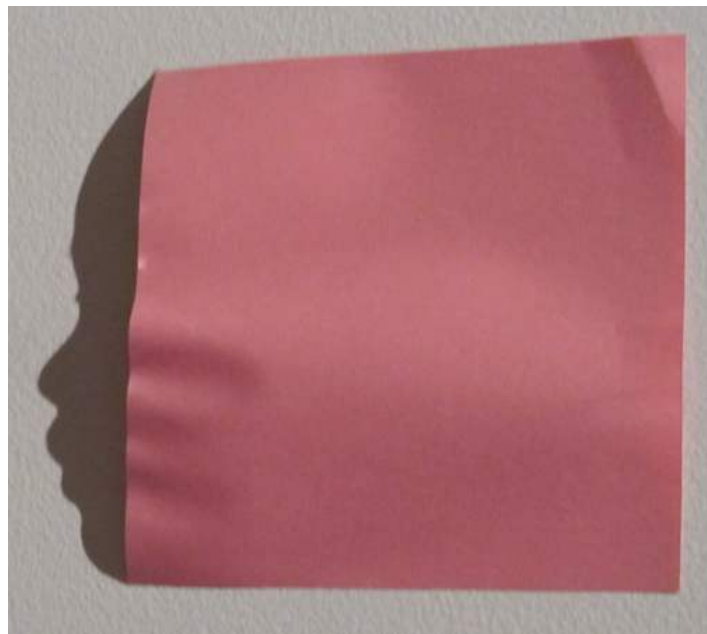
Creditied to Kumi Yamashita, www.kumiyamashita.com

I want to conclude by reviewing engineering and talking about why it's important for Artists and how it can be incorporated into art projects.

Engineering is about learning from the past to improve the future. Engineers work collaboratively with other specialized professionals and stake holders to create machines, buildings, roads and cities that respond to the needs of the people using these systems. When challenged by a unique situation, engineers must think outside of the box or laterally to come up with solutions. In many ways the rolls of engineer and artist are striking similar. At its most fundamental both artists and engineers do the same thing. They explore their materials, develop techniques, concentrate on a subject and create something where nothing had existed before. There are many examples of artists who have an engineering focus. Da Vinci, Calder and Escher come to mind quickly, but there are also many, many engineers who love to draw and paint. Right now we are educating a new generation of designers who think like engineers, but see like artists. The work we're doing is important and exciting.

Roylco's Art of ENGINEERING