FAB@SCHOOL PRESENTS

MAKE TO LEARN:
EXPLORING WIND POWER

2D AND 3D DIGITAL FABRICATION ACTIVITIES

TABLE OF CONTENTS

MAKING WIND POWER

You have a lot of things plugged in at your house—a refrigerator, a TV, lamps, and maybe even something cool like a computer or an iPod. The electricity to power those devices come from power plants, which can be powered by wind, water, burning coal, and even nuclear fission.

But, did you know that out of the 7 billion people in the world, almost one quarter of them don't have electricity? That's about 1.5 billion people! If any of these people want light at nighttime, for example, there's not much they can do about it.

Unless, like a boy named William, they try to make their own electricity.

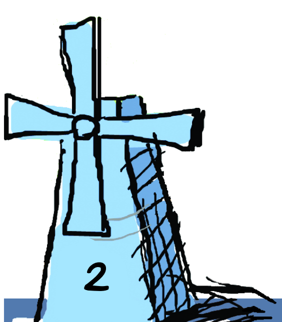
William (whose last name is Kamkwamba) lived in the African country Malawi. Malawi is a poor country, in which most people work on farms and live in rural areas. When the sun goes down at night, many people in Malawi have only the light of fires to help them see. William did not want to wait for electricity to come to his village. Instead, he decided to make his own.

These are a pair of homemade wind turbines. The one on the right is the turbine William made!

He looked around to see what he could use. What he saw was leftover tractor parts, scrap metal, and a book about electricity. So he decided to design a machine, called a wind turbine, which could capture the energy of the wind and turn it into electricity.

William tried, but failed. But William kept trying. He changed a part here and a part there. He designed and re-designed. Then finally, one day, as the blades on William's turbine started to spin—first slowly, then faster, and faster—electricity began to flow. Soon neighbors could see William's house, lit by four electric lights, even in the darkest night.

And now it's your chance to capture the power of the wind.



You can use this book, some basic supplies, and your own hard work and brainpower to build all the parts of a working wind turbine. This book includes a series of experiments and activities that will help you understand better how wind turbines work and how to build one. These include:

1. Making a windmill
2. Calculating the windmill's revolutions per minute (or RPM)
3. Building a circuit
4. Generating electricity with a wind turbine

If you design it well, your turbine will produce enough electricity to power the lights inside the back cover of this book!

BEFORE WE GET STARTED... SOME TIPS FOR WORKING WITH THIS BOOK

This book you're holding in your hands is only a part of *Make to Learn: Exploring Wind Power*. There is also an electronic version, which contains more information about the activities, like videos and objects you can print and cut.

To access the electronic version, visit www.maketolearn.org/wind.

TIP #1: QR CODES LEAD YOU TO GREAT STUFF ONLINE!

This is a QR code:

Taking a picture of these codes with a camera hooked up to the internet will automatically take you to a webpage or a video. To use a QR code, you need a smartphone, or an iPod Touch with a camera, or a tablet, like an iPad. You also need QR code reader software, which your parent or teacher can help you find.

Try QR code above… it takes you to a video of William talking about the wind turbine he built!

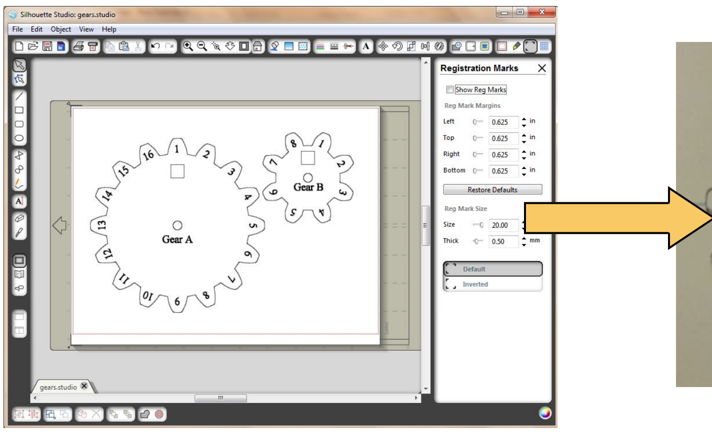
HEY, TEACHERS / PARENTS!

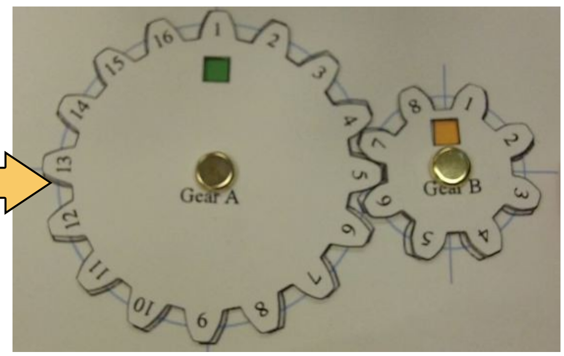
QR code reader software is widely available and usually free to download. Android devices usually have a QR code reader installed, called Google Goggles. There are many different ones available for the iPod, iPhone, and iPad. Once you've installed the software on your tablet or smartphone, launch the QR code reader software and take a picture of the code using the device's built-in camera. The software will automatically open the related web page.

TIP #2: THE "S" ICON STANDS FOR SILHOUETTE SHAPES

Digital paper-cutting machines, called Silhouettes, are great tools for inventors to have! These machines cut paper into shapes quickly and precisely. When you see this icon, it means that the shape or design it is next to can be downloaded free at www.maketolearn.org/wind.

The program you can use to tell the Silhouette what to cut is called Silhouette Studio. If you use the electronic copy of the book, you can click on the icon to open the digital design in Silhouette Studio.

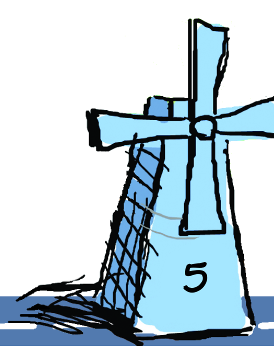




HEY, TEACHERS / PARENTS!

Silhouette Studio is a free download at www.silhouetteamerica.com/software.aspx. It is the software that drives the Silhouette, which is an electronic die cutter. All of the shapes and designs available in this book can be cut by a Silhouette as is, or they can be edited and modified in Silhouette Studio before sending them to the Silhouette.

Check out page 3—do you see the "S" icon next to the picture of Africa? Good! Now you can go to www.maketolearn.org/wind and download a map of Africa and of Malawi. After you cut the shapes out with either a Silhouette 2D fabricator or a pair of scissors, you can glue them into place on page 3.



Things Inventors Need to Know for Their Work

The goal of this book is to provide resources you may need to create your own wind turbine, so you can capture the wind much as William did. Are you ready now to create your own wind turbine?

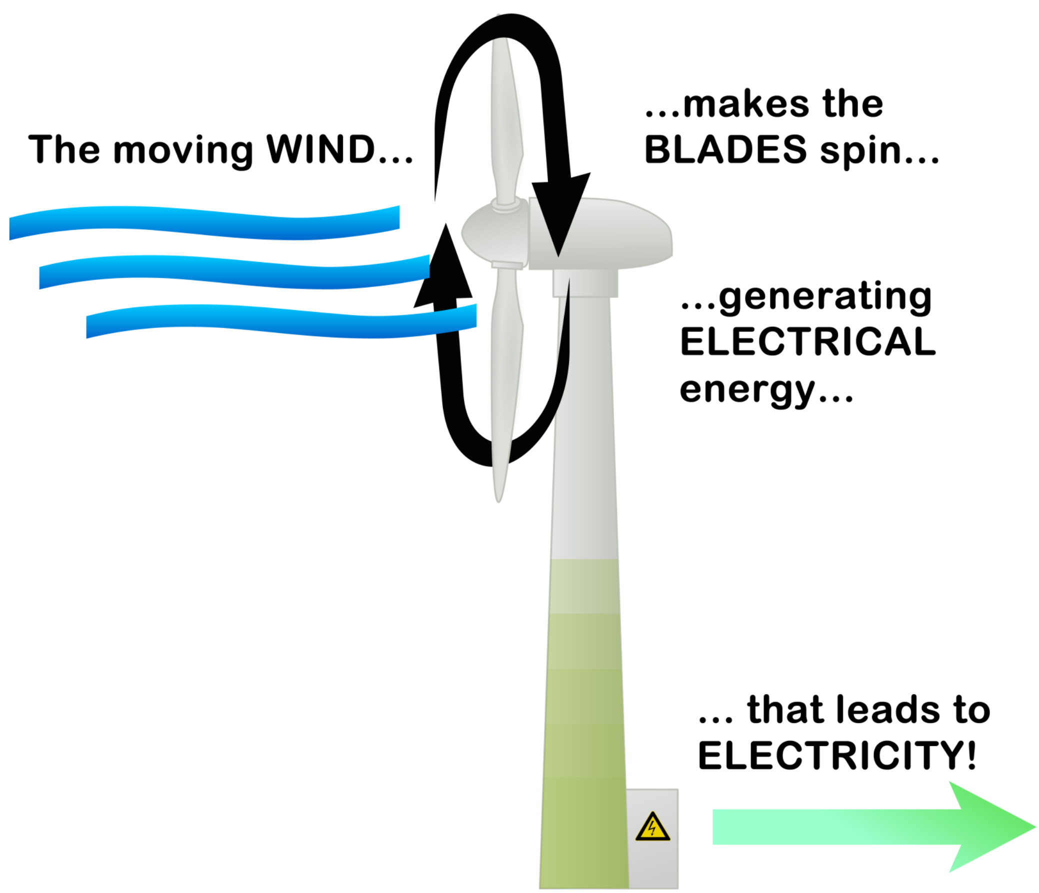
To do that, you need to be knowledgeable about wind, electricity, and gears. You can also learn from mistakes and successes other inventors have made when building machines that create electricity from wind.

How Wind Energy Works

Imagine the chill you feel from a gust of winter wind—the kind that makes you zip your coat all the way up. When you feel the wind, you're feeling the movement of tiny air particles. Whenever something is moving, it holds kinetic energy. Kinetic energy is the energy an object possesses because of its motion. When you are in bed asleep, you have very little kinetic energy because you are not moving much. When you are riding a bike down a hill, you have a lot of kinetic energy.

The good news for you as an inventor is that kinetic energy can be transformed to make electricity. A wind turbine is a machine that will make this happen.

A wind turbine is like a giant pinwheel that can capture the kinetic energy of wind and use it to generate electricity.



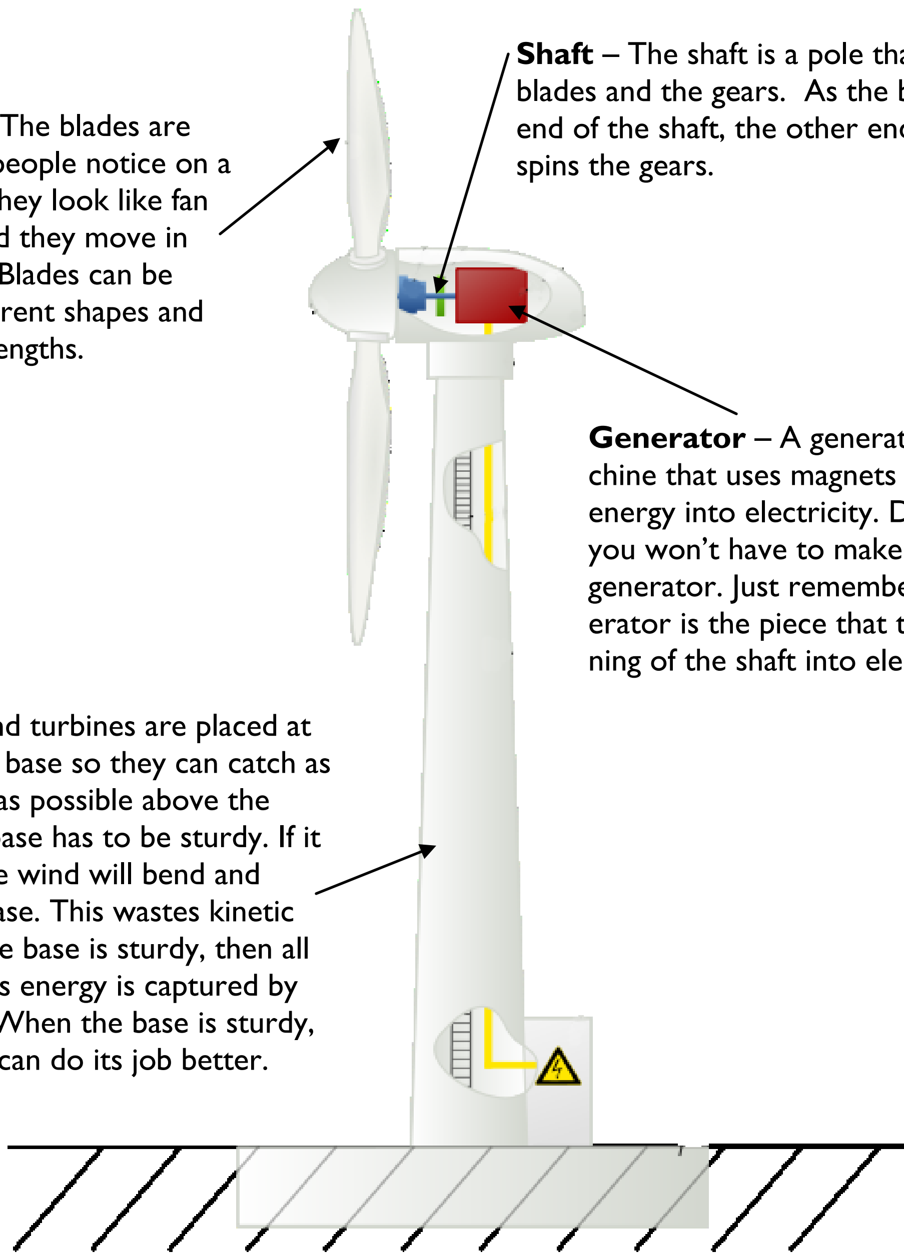
How a Wind Turbine Works

Have you ever blown on a pinwheel? When you do, the pinwheel spins. The same thing happens to wind turbines when the wind blows. The wind causes the turbine's blades to spin.

When those blades spin, they spin a pole called a shaft, which then turn a series of connected gears. Those gears turn a generator. A generator is a machine that that converts the energy of a spinning object—our turbine shaft—into electricity.

The electricity pushed by the generator flows through power lines away from the wind turbine to power all the lights and appliances in your home and in your whole community.

Parts of a Wind Turbine



Blades – The blades are first part people notice on a turbine. They look like fan blades, and they move in the wind. Blades can be many different shapes and different lengths.

Shaft – The shaft is a pole that attaches the blades and the gears. As the blades spin one end of the shaft, the other end of the shaft spins the gears.

Generator – A generator is a machine that uses magnets to turn kinetic energy into electricity. Don't worry—you won't have to make your own generator. Just remember that a generator is the piece that turns the spinning of the shaft into electricity.

Base – Wind turbines are placed at the top of a base so they can catch as much wind as possible above the trees. The base has to be sturdy. If it is floppy, the wind will bend and shake the base. This wastes kinetic energy. If the base is sturdy, then all of the wind's energy is captured by the blades. When the base is sturdy, the turbine can do its job better.

What are design criteria?

Imagine that you work in a pizza place as a pizza chef. Your goal is to make all of your customers happy by producing delicious pizzas. Reaching this goal would be really tough if a customer came in and said, “I would like a pizza, but I don’t know exactly what I’m in the mood for. Can you please make me one?” How would you know what would make the customer happy? You wouldn’t know what size pizza the customer wanted. You wouldn’t know which toppings the customer wanted. You wouldn’t even know what kind of crust to use.

Now, imagine if the same customer came in and said, “I would like a large pizza. I don’t know which type of crust I want, though. Choose whatever you think will taste the best. Also, can you choose two vegetables for toppings, please?” This would be much easier for you to get the order right, wouldn’t it? And getting the order right to make your customers happy is your main goal!

The reason why this would be easier is that the customer has given you design criteria. Design criteria are like rules for you to follow as you are creating something. The pizza customer gave you these design criteria:

- The pizza must be a large.
- The pizza must not have thin crust. It could have thick crust, or flavored crust, or stuffed crust.
- The pizza must have two types of vegetables on it.

Your goal in creating a wind turbine is to light up the village that you will make inside the back cover. When you are working on your wind turbine, you may have design criteria. For example, you may be told that your wind turbine must have 4 blades on it. Or you may be told that the base must be 10 inches tall. Inventors usually have design criteria to follow.

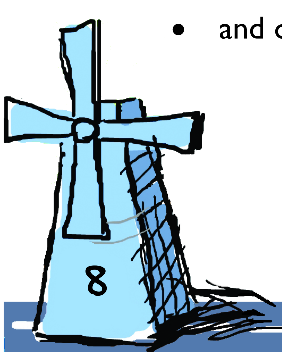
Now you have all the information you need to start the series of Inventor Experiments that will help you build a working wind turbine!

Inventor Experiment #1: Designing a Windmill

The goal in this Inventor Experiment is to build a windmill that stands up and spins when a fan blows on it. To do this, you will need:

- pencil and paper,
- cardstock,
- scissors,
- a ruler,
- and other common classroom supplies, like glue, brads, straws, or popsicle sticks.

*A **wind turbine** is a windmill that includes a generator. Inventor Experiment #1 only includes a base and blades, so it is more accurately called a **windmill**.*



To get started, check out the video of other inventors making windmills. You can find the QR code in the sidebar.

Then, use your imagination and think of a design for your windmill. Begin by drawing your design. You may have to change your design a few times before you are happy with it.

Now, using cardstock, scissors, tape, and any other materials you can find in your classroom, build your windmill!

Be sure to save your windmill after you finish with it. We will need it later.

HEY, KIDS!

Use the following QR code to check out a video of a classroom of 5th graders doing this activity.

Design Criteria for Your Windmill:

- [ ] The windmill must be freestanding, and the base must stay in place.
- [ ] The base must be between 8 inches and 10 inches tall.
- [ ] The blade assembly must spin from wind power (provided by a fan) only.
- [ ] There must be at least 2 blades and at most 8 blades.
- [ ] Be sure to save your windmill after you finish with it!

These inventors planned and built their own windmills, too!

REVOLUTIONS PER MINUTE (RPM)

Engineers who build windmills pay close attention to how fast the blades are spinning. The faster the blades spin, the more electricity the turbine is able to generate. The speed of the blades is measured in revolutions per minute, which is abbreviated RPM.

Revolutions per minute (or RPM), is the number of times something revolves around something else in one minute. In this case, we are talking about blades revolving around the shaft.

If the blades of your windmill revolve 25 times in one minute, then the RPM = 25. If they revolve 200 times in one minute, then the RPM = 200.

You don't have to count all the revolutions for one whole minute. Say that you count 25 revolutions in 30 seconds. You know that 1 minute = 60 seconds. You can figure out that the RPM = 50 because 30 seconds multiplied by 2 equals 60 seconds, and 25 rotations multiplied by 2 equals 50.

$$\frac{25 \text{ revolutions}}{30 \text{ seconds}} \begin{matrix} \times 2 \\ \times 2 \end{matrix} = \frac{50 \text{ revolutions}}{60 \text{ seconds}}$$

If your blades make 500 turns in 2 minutes, then the RPM is 250. If that doesn't make sense to you, then ask a friend or a teacher to help you figure it out so that it does make sense.

> **HEY, TEACHERS / PARENTS!**
> *Visit www.maketolearn.org/wind for a worksheet on calculating RPM.*

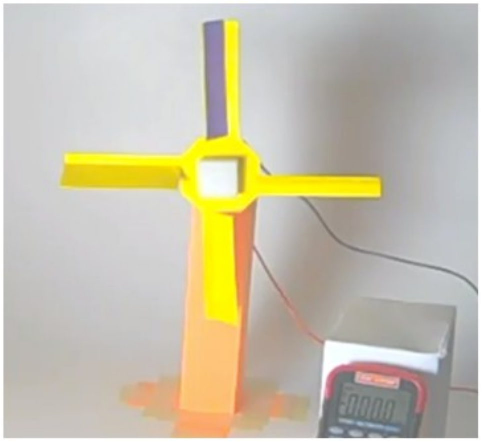
MEASURING RPM

There are two ways to measure the RPM of your windmill blades. You can use a video camera, or you can use an awesome tool called a laser tachometer!

TRICK OF THE TRADE #1: USE A VIDEO CAMERA

One way to measure the RPM of your windmill blades is to use a video camera. You can use a regular video camera for this, or you can use one in a laptop computer, if you have one.

> **HEY, TEACHERS / PARENTS!**
> *At www.maketolearn.org/wind you can find detailed instructions on using video cameras to calculate RPM.*



TRICK OF THE TRADE #2: USE A LASER TACHOMETER

A laser tachometer may seem like a heavy-duty piece of equipment, but actually it is easy to use! It shoots a laser at something that is spinning, like the blades on your turbine. Every time the laser beam hits a shiny sticker that you put on the blades, it reflects back into the tachometer. The tachometer can then count the number of times the blades turn.

> **HEY, TEACHERS / PARENTS!**
>
> *Digital tachometers are easy to order online, and they are not particularly expensive. For example, the Neiko Professional Digital Laser Photo Non-Contact Tachometer sells for less than $30 on amazon.com.*

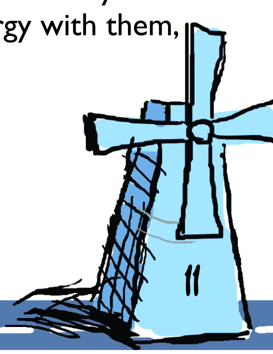
INVENTOR EXPERIMENT #2: CALCULATING RPM

Now you can find out how fast the windmill you made in Invention Experiment #1 spins. We do this by measuring its RPM.

> **HEY, TEACHERS / PARENTS!**
>
> The activity directions, materials list, and worksheets are all available at www.maketolearn.org/wind.

POWER TIME! ALL ABOUT ELECTRICITY...

If you could zoom in to get REALLY close to lightning (which is impossible with the naked eye), you would see very small things called electrons. An electron is a piece of an atom, and atoms are the building blocks for nearly everything. These little electrons are EVERYWHERE—in our hair, in our pizza, and especially in our electricity! When these tiny electrons move, they carry energy with them, and electricity is born!



Electricity is the flow of electrons, often through something like a wire. Metal wire—like everything else—has lots and lots of electrons in it. Some metals allow electrons to move through them more easily than others. If a wire or different object allows electrical current to flow, it is called a conductor. Copper is a particular type of metal that has a gold color. It is a very good conductor of electricity. Sometimes wires are coated with an insulator, which is the name for something that does not conduct electricity. Plastic and wood are examples of insulators.

Electricity needs to follow a path to get from a power supply, like a battery or a generator, to an object like a TV or a computer. The path that electricity follows is called a circuit. When you plug a lamp into a socket on a wall, a circuit is created—you just don't see it because it is hidden within the lamp, lamp cord, and wall socket!

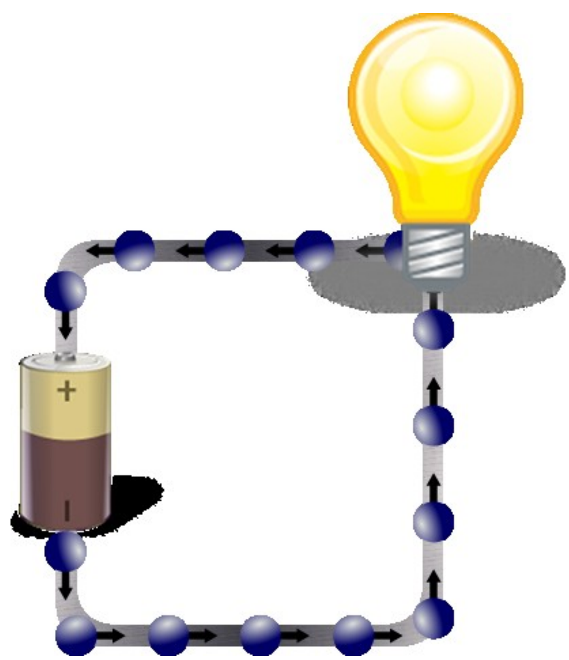
CIRCUITS

A circuit is made up of a number of parts. One necessary part is a power supply. Some examples of a power supply are a socket on a wall or a battery. The power supply provides the "pressure" that pushes the electrons in a steady path. Wall sockets and batteries contain two important sides: the positive side and the negative side. The positive side is labeled with a **+** and the negative side has a – label. Why would you want to know this? Electrons in the wire are pushed through the circuit by the negative side, and return to the battery on the positive side. On the way around the circuit, the electrons use the energy they carry throughout the circuit.

In this picture, the purple balls stand for electrons. Remember that you can't actually see electrons. These electrons in the picture are made really big so you can see the direction they are traveling in.

HEY, KIDS!

Want to see how a model circuit works? Visit www.maketolearn.org/wind, or use this QR code to go to a website that allows you to make your own circuits from batteries, wires, light bulbs, and even paper clips and pencils!



William created a circuit when he built his wind turbine. What is interesting is that he did not use a battery or a wall socket for a power source. Neither was available in Malawi, and this was part of the problem. So, he built a wind turbine that captured wind energy and turned it into electrical energy! He connected the wind turbine to lights using wires, and this formed a circuit.

Now is your chance to make a circuit. Use the following instructions to make a circuit using a wire, copper tape, battery, and a light called an LED.

Inventor Experiment #3: Building Circuits

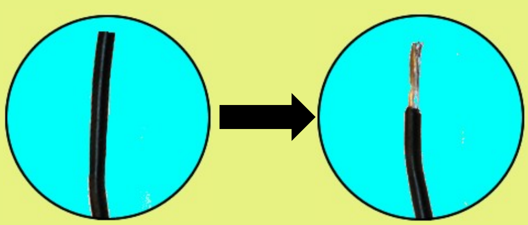
In this Inventor Experiment, you will first create a circuit by following the guide on the next page. Then, you will use the same parts to build your own circuit with an on/off switch to light up a model house!

Part I

You will use two wires to attach a battery to a small light bulb, called an LED. Both wires are made from insulated copper wire. The core of the wire is made out of copper, which, as you know, is a very good conductor. Electricity flows through copper easily. The outside of the wire is made out of either red- or black-colored plastic. Remember that plastic is an insulator—electricity does not pass through it.

Hey, Teachers / Parents!

It is a good idea to strip ½ inch of the insulation from each end of the wires before the activity begins. Stripping wire can be time consuming for younger students. It is very helpful to use a good pair of wire strippers, though you can use scissors as well.



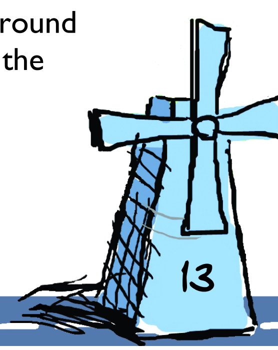
unstripped　　stripped

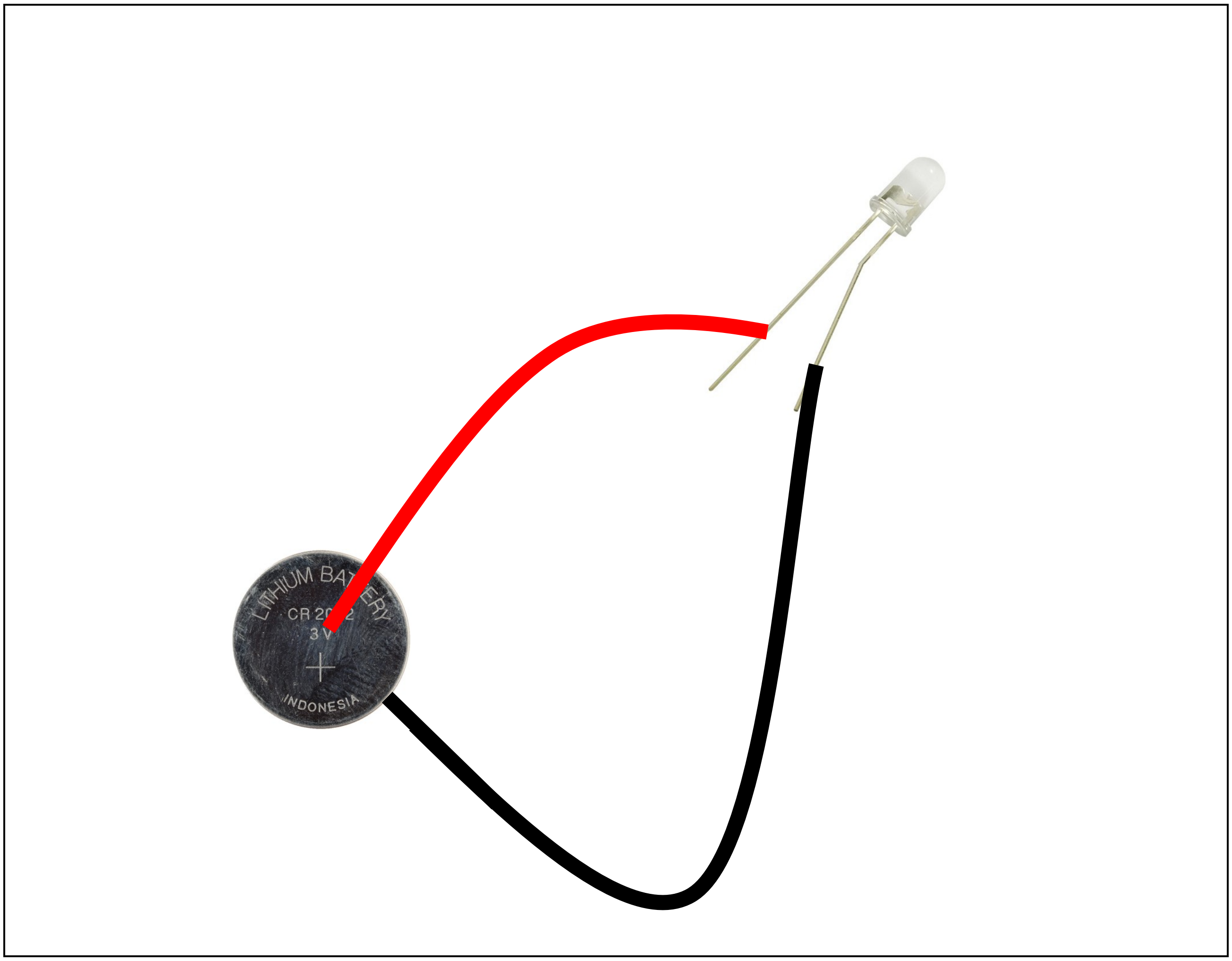
To make this circuit, you will need:

- a 2-inch piece of red wire
- a 4-inch piece of black wire
- a 3V watch battery
- an LED
- tape

Here are the directions:

1. Attach the copper part of the red wire to the positive side of the attached battery (the side with the +). Use regular tape to attach the wire and battery.
2. Attach the copper part of the black wire to the other side of the battery.
3. Tape the battery in the battery circle in the picture on the next page.
4. Find the positive pole of the LED. It is the longer of the two stiff wires attached to the LED. Attach the other copper end of the red wire to it by twisting the copper around the pole. You can use tape to hold the connection together. Use the picture on the next page as a guide.
5. Attach the other copper end of the black negative wire to the other pole of the LED. Use tape if you need to make the wire and pole stay together. The LED should light up!





HEY, KIDS!

If you taped a wire directly to a battery, nothing would happen. This is because the wire is covered in plastic. Plastic is an insulator, which means that electricity can't flow through it. In order to get the electron to flow, the inside of the wire must touch the battery. The inside of the wire is made from copper, which is an excellent conductor. That means that electrons move through it very easily. If your wire doesn't have any copper sticking out of the end, your teacher can help you remove the plastic insulator so that the copper sticks out.

Once you have made the circuit, it is time to practice lighting a house! Move on to Part II on the next page.

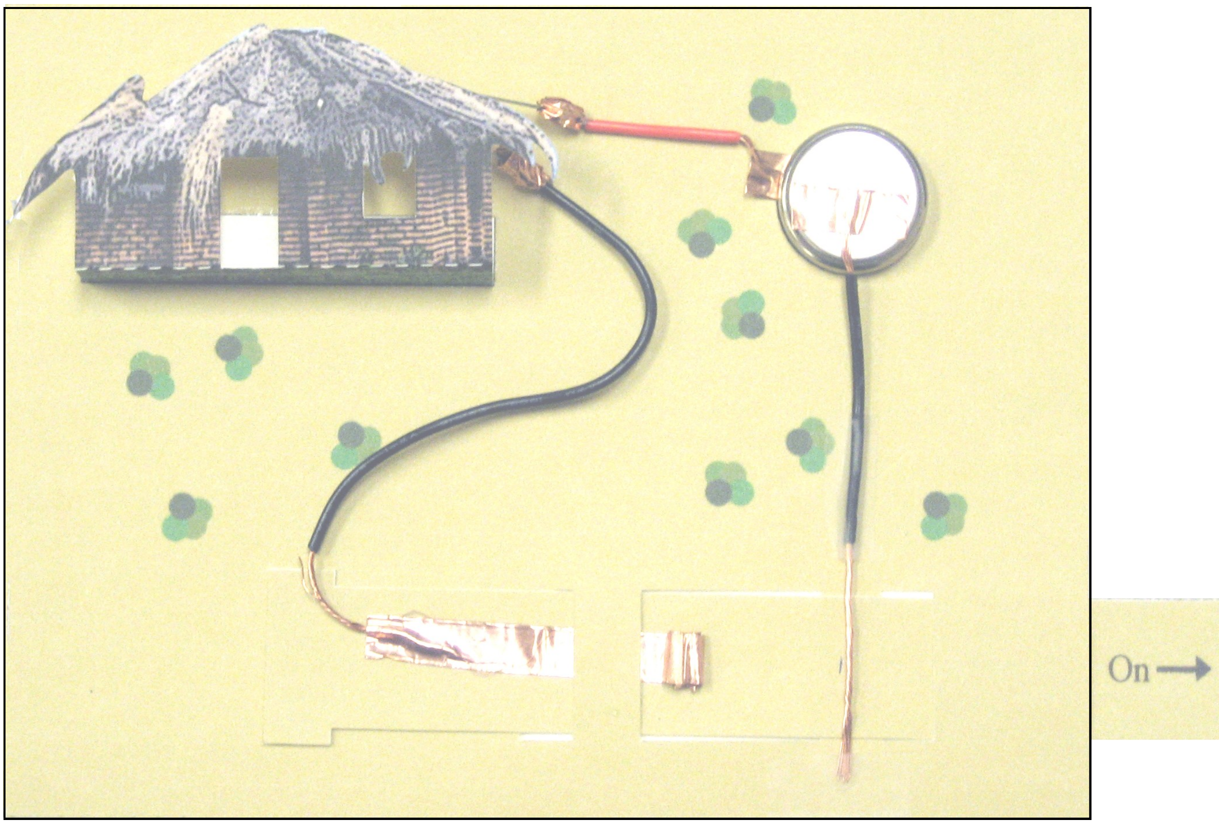
PART II

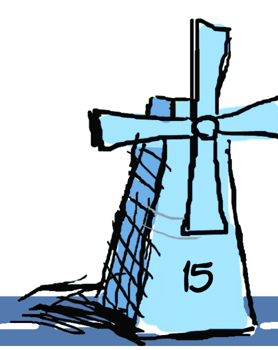
Now, it is time to put a switch into a circuit so you can turn the light in the house on and off.

HEY, TEACHERS / PARENTS!

Go to www.maketolearn.org/wind to download the materials list, activity instructions, and design shapes for this activity.

Once you assemble the circuit and switch, you can glue the card into this box. Make sure when you glue the card down that you can still pull the switch!





SPIN IT! GEARS AND GEAR RATIOS

INTRODUCTION

Remember that a generator produces electricity. As the generator turns faster it generates more electricity.

So, as the wind blows harder, the wind turbine blades turn faster. The faster the blades turn, the faster the generator turns. And the faster the generator turns, the more electricity it produces.

One aspect of electrical energy that we measure is volts. The table below shows what would happen to the RPM and volts at different wind speeds:

In the table below, the first row shows what could happen to a turbine in a 2 miles-per-hour (MPH) wind. The RPM of the turbine would be 100. Remember that an RPM of 100 means that it turns 100 times in 1 minute.

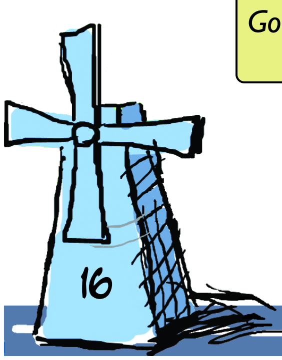
Wind Speed (MPH)	RPM	Volts
2	100	0.5
4	200	1.0
6	300	1.5

- The first row shows that at 2 MPH, the blades revolve at 100 RPM, and the generator produces 0.5 volts.
- The second row shows that at 4 MPH, the blades revolve at 200 RPM, and the generator produces 1.0 volts.
- The third row shows that at 6 MPH, the blades revolve at 300 RPM, and the generator produces 1.5 volts.

Notice that in a 4 MPH wind, the blades revolve at 200 RPM. This is two times the RPM caused by a 2 MPH wind. Because the blades in a 4 MPH wind are spinning two times faster than a 2 MPH wind, the generator produces two times as many volts (1.0 volts) as it does in a 2 MPH wind.

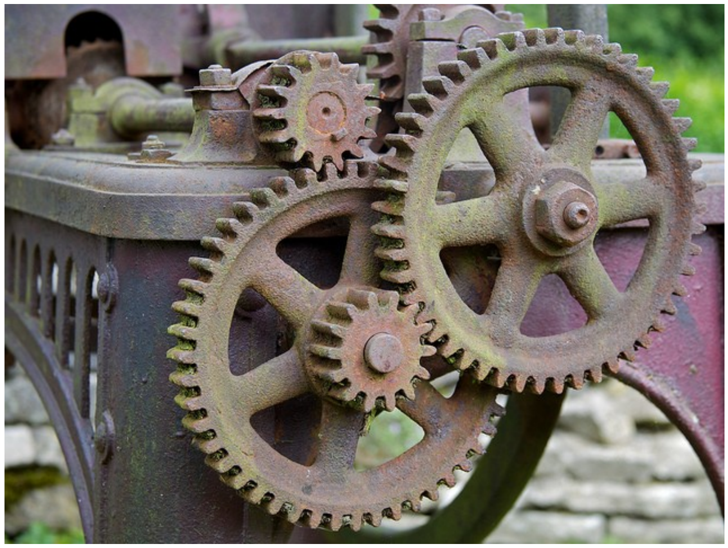
HEY, TEACHERS / PARENTS!

Want to give more opportunities for practice on calculating wind speed, RPM, and volts? Go to www.maketolearn.org/wind for an activity sheet.



SO WHAT DOES THIS HAVE TO DO WITH GEARS?

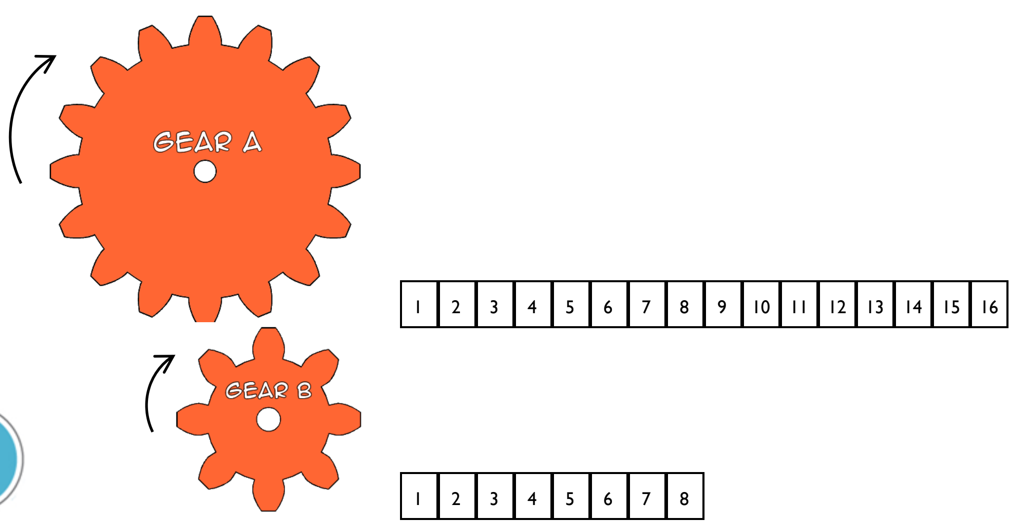
We know that faster wind means that the generator produces more electricity. This is a good thing! But what if we want to make the generator spin faster even if the wind isn't going any faster? We can do this with gears!



The circular shapes in the picture above are gears. The pieces on the outside of each circle are called teeth because, well, they look like teeth! Notice that the teeth of one gear fit in between the teeth of the other gear. When one gear turns, it makes the other gear turn, too.

You can make one of the gears move faster than the other gear by making one of the gears smaller than the other.

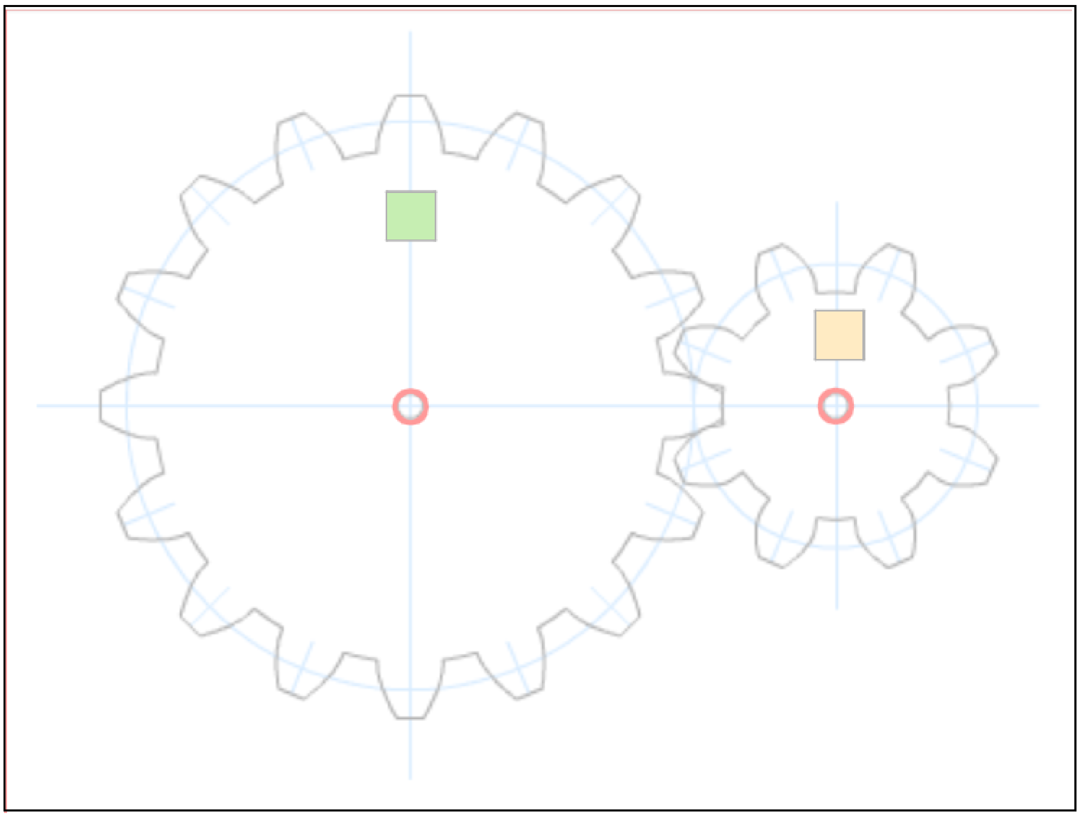
One way to think about it is like this: The circumference of a circle is the distance around its outside. If you were able to roll these two gears out to measure their circumference, you would see that the big gear, Gear A, would roll out further than the little gear, Gear B. In fact, Gear A would roll out twice as far (16 units) as Gear B (8 units).



Check out the gears below. They have the same number of teeth as Gears A and B on the last page. Notice that the teeth on each gear are the same size. Gear A has twice the circumference of Gear B. This is really important because for every one time the Gear A turns, Gear B turns twice!

So, the gear ratio is 1:2, which we say "one to two." For every one time Gear A turns, Gear B turns two times.

See for yourself:



So, imagine that the blades are attached to Gear A and that Gear B is attached to the generator. And now imagine that the blade RPM = 10. Every time Gear A turns once, Gear B turns twice. So, Gear A has an RPM of 10, but Gear B has an RPM of 20.

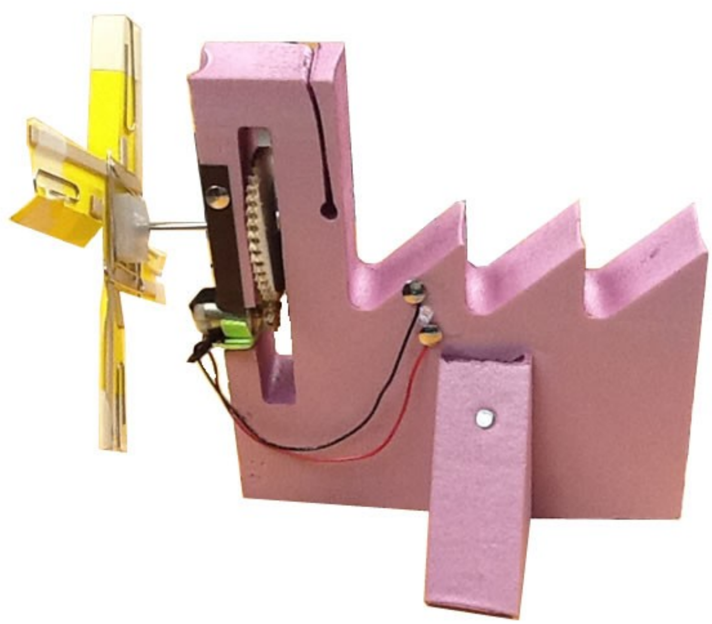
This means that using our gears, the generator will rotate twice as fast as the blades. We have generated more electricity without needing more wind!

Inventor Experiment #4: Put It All Together – Let's Make Electricity!

It's time to make your own wind turbine! You have two choices here. If your classroom has a 3D printer, you can make all the pieces yourself! If your classroom doesn't have a 3D printer, you can order many of the parts from a kit. Read all about 3D printers on page 22.

Hey, Teachers / Parents!

www.maketolearn.org/wind has all the information you need for fabricating your own wind turbine from scratch. If your classroom is equipped with a 3D printer, you can download some of our component templates to help you and your students get started. If you don't have a 3D fabricator, don't worry! You can still build many of the components of the wind turbine, but there are a couple of parts you'll have to purchase.



This turbine was made with a Silhouette 2D fabricator and a Fab@School 3D fabricator! The blades are made from cardstock, and they were cut out with a Silhouette. The gears are made out of wood. The base is made out of foam. Both the gears and the base were made using the Fab@School 3D fabricator.

This is a wind turbine that was made without a 3D fabricator. The base is an empty water bottle. It is filled with gravel so the fan doesn't blow it over. The blades were made using a Silhouette 2D fabricator. The shaft was made from common, everyday materials, such as a plastic straw, drywall anchors, and a kitchen sponge. The gears and the generator came from a kit.

Have you completed your wind turbine? Excellent—now is your chance to be just like William!

William built his own wind turbine and brought electricity to his village. You will now do the same thing with the village that you will set up inside the back cover of this book.

1. Go to www.maketolearn.org/wind and download the picture of the village.
2. Using either a Silhouette 2D fabricator or a pair of scissors, cut out the picture of the village. Make sure you cut out the holes where the LED bulbs will be!
3. Tape or glue the picture over the wiring and LED bulbs.
4. Attach the wires from your generator to the wires in the book. Look for "Hook up here" printed on the village page. You can attach the wires by twisting the end of your wire to the wires in the book. Remember to twist the red wire to the red wire and the black wire to the black wire.
5. Turn on a fan and point it at the wind turbine. Light up the village!

HEY, TEACHERS / PARENTS!

Some generators do not have the positive and negative marked. If your generator does not light up the village, you may have to reverse the two wires attached to the generator. See www.maketolearn.org/wind for more troubleshooting tips.

CONCLUSION

You've done it!

Like William, the boy we met in the introduction, you have figured out how to capture the energy of the wind and turn it into electricity!

William did not wait for electricity to show up on his doorstep. Instead he took a book and a desire to succeed and he built his own wind turbine to power four lights and a well pump at his house.

In fact, that's William's turbine in the picture to the right!

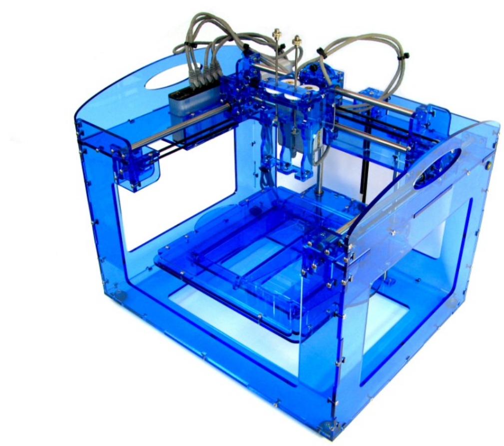
All over the world, people in garages and classrooms and bedrooms are making things. All it takes is a little bit of knowledge, and a lot of energy to succeed. Look around your classroom or house. What can you build to make your life, and the lives of those around you, better?

Good luck, young inventor!

ONE MORE THING... YOUR VERY OWN DESKTOP FACTORY!

When you think of how machines and parts are made, you may think of big factories. Factories churn out hundreds or thousands of parts at a time. Most of the machines, tools, and parts we use come from factories.

However, new technologies are making it possible for people to have their own desktop factories. These machines are called personal fabricators or replicators. They are miniature factories, so small that you can have your own personal factories on your kitchen tables or in your classroom!



This is the Fab@School 3D fabricator. It is about the size of a microwave oven. You can sit at your computer and design a spoon, press "Print," and then, a few minutes later, reach into this machine and pull out your spoon!

The possibilities are endless! Picture this: A girl lives in an apartment that has a leaky faucet in the kitchen sink. In fact, every apartment in her building has a leaky faucet in the kitchen sink. One weekend, she decides to find the problem. She takes apart the faucet and finds that an important part in the faucet does not fit exactly right. So, she takes some measurements, then she sits down at her computer and she designs a new part. She hopes that it will fit perfectly!

She presses "Print," and the desktop fabricator whirrs to life. Minutes later, she has a replacement part that she puts back into the faucet.

Unfortunately, when she turns on the faucet, it still leaks. The part she made still does not fit exactly. After taking a couple more measurements, she returns to her computer and changes the first digital design she had made. Again, she presses "Print," and the fabricator produces another part.

She returns to the faucet for installation and testing. This time, the washer fits perfectly, and the leak is no more!

She is so happy that the part fits that she goes back to her computer and prints out twelve identical parts. She gives one to each of her neighbors, and they all fix their leaky faucets. With the fabricator, our hero could design and make her own part exactly how she wanted it. She was able to adjust her original design with a couple of clicks of her mouse. And, once she was happy with the part, she was able to replicate the part as many times as she wanted.

HEY, KIDS!

To replicate *means to make an exact copy of something. A* replicator *is a machine that can replicate objects. A 3D printer is also called a replicator.*

About This Book

This book is an experimental prototype of a Transmedia Book, or, a T-book. It was developed by the Fab@School team, which includes representatives from the Children's Engineering Group at the University of Virginia's Curry School of Education, the Albemarle County (Virginia) Public Schools, the Computational Synthesis Laboratory at Cornell University, the Society for Technology and Teacher Education, and FableVision Learning.

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Question: How many educators does it take to write a book about a light bulb?

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Answer: 29!

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