How to make GREAT Ideas for INVENTIONS

A Book for Young Inventors

PROJECT FUNDED by the Korea Funds-in-Trust at the World Intellectual Property Organization

[for Mentors]

KIPO
KOREAN INTELLECTUAL PROPERTY OFFICE

01

Understanding Invention

- Discovery and Invention
- The Birth of Invention
- The Value of Invention
- Think about It

02

Creative Thinking Methods

- Divergent and Convergent Thinking
- Further Information
- Think about It

03

Methods of Invention

- Techniques for Brainstorming Ideas
- Think about It

04

Balance and Invention

- Preview- Exploring Principle #1
- Exploring Principle #2
- Exploring Inventions
- Invention Experiment
- Balance

05

Action, Reaction, and Invention

- Preview
- Exploring Principle #1
- Exploring Principle #2
- Exploring Inventions
- Invention Experiment
- Action & Reaction

06

Sound and Invention

- Preview
- Exploring Principle #1
- Exploring Principle #2
- Exploring Inventions
- Invention Experiment
- Sounds

07

Inertia and Invention

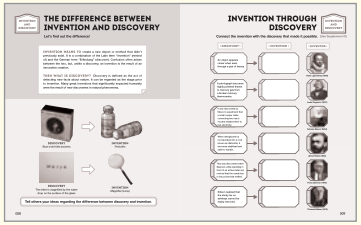
- Preview
- Exploring Principle #1
- Exploring Principle #2
- Exploring Inventions
- Invention Experiment
- Inertia

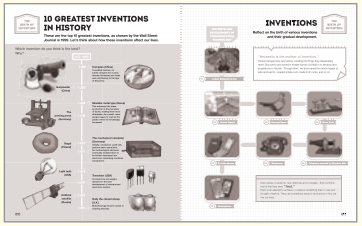
Theme : Creative Problem Solving Projects
1. Make a cup stand on its handle!
2. Grab the rolling object!
3. Create a toy out of a discarded CD!

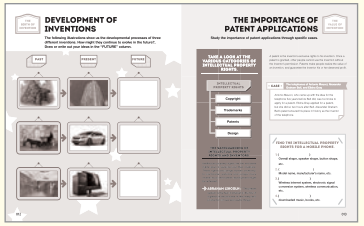
PART 1
UNDERSTANDING INVENTION

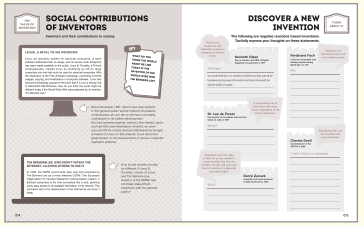
The first invention was perhaps made when a caveman attached a grip to his stone axe to give his chops more power.
Can you believe that running water which is now an indispensable part of modern life, first used in 2,300 B.C.? In the past, buttons were not only used for adjusting clothes, they were treated as jewels.
Pizza originated from soldiers using their shields to bake bread, and high heels originally became popular in Europe because they helped women avoid stepping in filth.

From here on, get ready to learn what is really meant by “invention,” how it has evolved and how it affects our lives.









Understanding Invention

Teacher's guide

1. Examine various inventions and help students distinguish between an invention and a discovery.

2. Examine the birth of a particular invention and let students reflect on the future of this invention.

3. Examine patent cases and let students discuss the value of inventions.

Notable tips for class

Show students various inventions to spark their interest.

Class management

Introduction	Development	Conclusion
• Analyze the invention of tools and the reasons behind them. • Inform them of the learning goal.	• Know the difference between an invention and a discovery. • Compare recent inventions and discoveries by looking at the top 10 inventions of all time. • Predict the future by looking at the past and present. • Know the value of an invention, the importance of patent applications, and the various types of patents.	• Express your thoughts and listen to others' opinions.

Introduction

A primitive man once thought while packing,
"Can these tools I carry be combined?"
"Can I make them lighter?"
Inform the students that most inventions start with an intention to solve a particular problems.

Inform them of the Learning Goal

Find out about inventions that changed our lives, how they have evolved over time, and how they may continue to evolve in the future.

Inform them of the Learning Activity

01 Inventions and discoveries

02 The birth of invention

03 The value of invention

04 Think about it

INVENTION AND DISCOVERY

THE DIFFERENCE BETWEEN INVENTION AND DISCOVERY

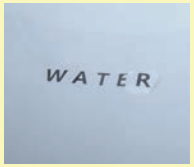
Let's find out the difference!

INVENTION MEANS TO create a new object or method that didn't previously exist. It is a combination of the Latin term "invention" (remind of) and the German term "Erfindung" (discover). Confusion often arises between the two, but, unlike a discovery, an invention is the result of an innovative creation.

THEN WHAT IS DISCOVERY? Discovery is defined as the act of detecting new facts about nature. It can be regarded as the stage prior to invention. Many great inventions that significantly impacted humanity were the result of new discoveries in natural phenomena.

DISCOVERY
Blue mold kills bacteria

INVENTION
Penicillin



DISCOVERY
The letter is magnified by the water drop on the surface of the glass

INVENTION
Magnifier (Lens)

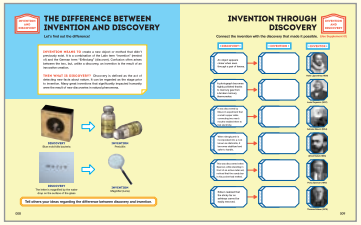
Tell others your ideas regarding the difference between discovery and invention.

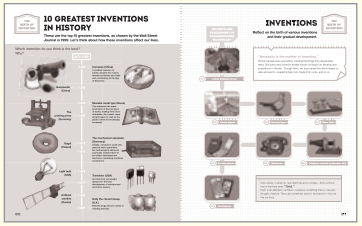
INVENTION THROUGH DISCOVERY

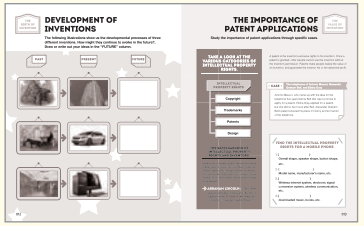
INVENTION AND DISCOVERY

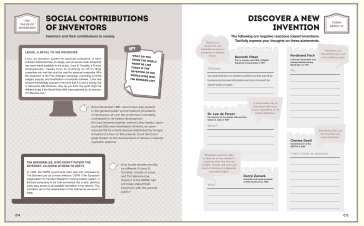
Connect the invention with the discovery that made it possible. (Use Supplement 01)

DISCOVERY	INVENTION	INVENTOR
An object appears closer when seen through a pair of lenses.		 Hans Lippershey (1608)
A photograph becomes highly polished thanks to mercury gas from a broken mercury thermometer.		 Louis Daguerre (1837)
It was discovered by Meucci's experiment that a small copper cable connecting two men's mouths enabled them to feel electricity.		 Antonio Meucci (1854)
When nitroglycerin is incorporated into a rock known as diatomite, it becomes stabilized and safer to handle.		 Alfred Nobel (1866)
This was discovered when Spencer, while standing in front of an active radar set, noticed that the candy bar in his pocket had melted.		 Percy Spencer (1945)
Edison realized that the sticky tar on ashtrays cannot be easily removed.		 Thomas Edison (1879)









01 Teaching point

Help them distinguish between "discovery" and "invention."

What is an invention?

These days, a patent is what protects new inventions. To obtain a patent, your invention must:

- Be new
- Have an inventive step that is not obvious to someone with knowledge and experience in the subject
- Be capable of being made or used in some kind of industry

What is a discovery?

A discovery is "finding something that had previously existed." It is commonly misunderstood as a creative action. But the discovery of things like new stars or animals helps people think in new ways. Of course, things can be discovered by chance. However, most discoveries require a significant amount of effort and study.

The greatest discovery and invention in history

A group of fossil specimens, along with some charcoal and ashes, were discovered near Beijing (Peking) in 1923. This served as evidence that primitive man had used fire. They first discovered fire from natural phenomena, such as thunder or volcano eruptions, 500,000 years ago. 30,000 years ago, human beings discovered how to make fire by rubbing wood together and striking iron pyrites to create flames. Then human beings could cook, hunt wild animals, and create light and heat.

Peking Man Peking Man is an example of a homo-erectus. It was discovered in 1923-1927 during excavations at Zhoukoudian near Beijing, China. These findings have been dated from roughly 750,000 years ago.

02 Teaching point

Understand the relationship between discovery and invention, and that new inventions are made due to the endless efforts of many people.

Discovery and invention of the telescope

In 1608, German-Dutch spectacle-maker Hans Lippershey was observing two children playing with lenses in his shop. The children commented on how they could make a faraway weather-vane seem closer when they looked at it through two lenses. The design of these early refracting telescopes consisted of a convex objective lens and a concave eyepiece. They were used for military purposes for a while, but then Galileo Galilei made an astronomical telescope that was 8 times stronger than Lippershey's. He also discovered Jupiter, Saturn, and spots on the sun. It was an awakening for those who had believed in the Geocentric theory for the past thousands of years.

Modern photographic techniques and the Daguerreotype

Early photographs used to take 8 hours to process (meaning you had to stand in front of the camera for 8 hours). Upon looking in a cabinet, French photographer Louis Daguerreo stumbled upon a clear picture of how to speed up the process. Daguerreo then researched the cause and discovered that there was a broken mercury thermometer in the cabinet. Through this, he invented the Daguerreotype, which took only 30 minutes to create a very clear picture. Taking a photo then became a popular trend because of this invention.

The principle of the telephone : its discovery and invention

Metal plating company owner Antonio Meucci cured people using electricity. He sent electricity through the patient's tongue and used his own tongue to adjust the current's intensity. One day, he heard the sound of a patient's moaning coming through the electric wire. Through this, he discovered how to transmit sounds, and he invented the telephone after conducting various experiments.

Invention of dynamite

Nitroglycerine was very dangerous to carry and use, since it's a colorless liquid that can be exploded by a small shock or temperature change. Alfred Nobel, who was researching safer usage of nitroglycerine, discovered that, when incorporated into diatomaceous soil, it became safer and more convenient to handle. Through this, he invented a form of dynamite that can be used in a much safer manner.

Discovery and invention of a microwave oven

Percy Spencer, a researcher at a military lab, was researching microwave generators that were being used as radars. He noticed that, during the time he stood in front of an active radar, the candy bar in his pocket melted. This gave him the idea for a microwave oven. Microwaves are a form of electromagnetic radiation with wavelengths ranging from as long as one meter to as short as one millimeter. A microwave oven is a kitchen appliance that heats food by bombarding it with electromagnetic radiation in the microwave spectrum and cause polarized molecules in the food to rotate and build up thermal energy in a process known as dielectric heating.

Invention of the light bulb

The earliest light bulb lasted only 10 minutes. Thomas Edison experimented with thousands of different filaments to find just the right materials that would glow brightly and be long-lasting. In 1879, Edison discovered that a carbon filament in an oxygen-free bulb glowed for 40 hours without burning up. Edison eventually produced a bulb that could glow for over 1,500 hours.

Implications

Small discoveries can create a new better future. Thus, discoveries and inventions are the building blocks of human history.

THE BIRTH OF INVENTION

10 GREATEST INVENTIONS IN HISTORY

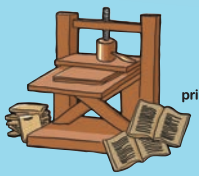
These are the top 10 greatest inventions, as chosen by the Wall Street Journal in 1999. Let's think about how these inventions affect our lives.

Which invention do you think is the best? Why?

A.D. 1,000

1,086 Compass (China)
It enabled mariners to safely navigate the oceans, thereby increasing sea trade and contributing to the Age of Discovery.

Gunpowder (China) **1,250**

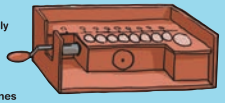


1,329 Movable metal type (Korea)
This enhanced the mass production of diverse types of books, making them more affordable. As a result, more people began to read as the public's thirst for knowledge increased.

The printing press (Germany) **1,450**

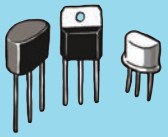
Bagel (Poland) **1,610**

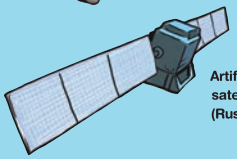
1,671 The mechanical calculator (Germany)
Initially, calculators could only perform basic operations, but technological advances eventually enabled them to be further developed into electronic calculating machines (computers).



Light bulb (USA) **1,879**

1,947 Transistor (USA)
Its small size and weight, allowed for the later development of miniaturized electronic devices.





Artificial satellite (Russia) **1,957**

1,997 Dolly the cloned sheep (U.K.)
Biotechnology became useful in treating diseases.

INVENTIONS

THE BIRTH OF INVENTION

Reflect on the birth of various inventions and their gradual development.

THE BIRTH AND DEVELOPMENT OF COMMUNICATION TECHNOLOGY

01 Letters delivered on foot

"Necessity is the mother of invention."
Human beings have survived by creating the things they desperately need. Discovery and invention enable human civilization to develop and populations to flourish. Through them, we discovered fire (which keeps us safe and warm), created simple tools made from rocks, and so on.

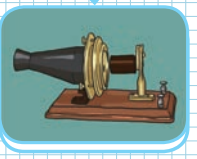
02 Smoke Signals

03 Homing Pigeon

04 Morse Code

07 Portable phones

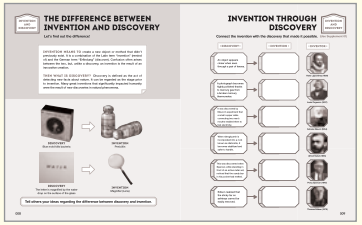
06 Telephones

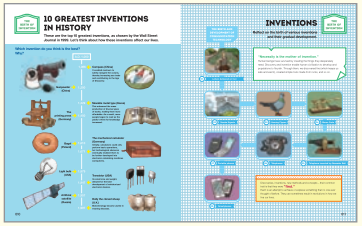


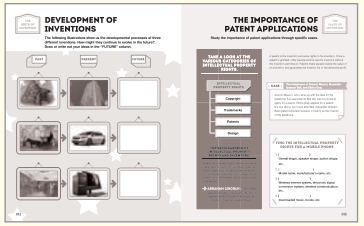
05 Telephone invented by Alexander Bell

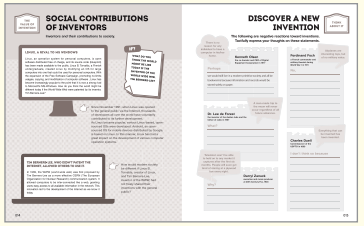
08 Smartphones

Discoveries, inventions, new methods and concepts – their common trait is that they were **"first."**
Each is an attempt to achieve or express something that no one ever thought of before. They can sometimes result in revolutions in how we live our lives.









03 Teaching point

Explain how the 10 greatest inventions affect our lives.

Reasons why these were selected as the 10 greatest inventions in history (in 1999 by the Wall Street Journal)

1. Compass	It enabled mariners to navigate safely away from land, increasing sea trade and contributing to the Age of Discovery.
2. Gun	With the invention of gun powder, the concept of war changed.
3. Metal type	This enhanced the mass production of diverse books at a lower cost. More people began to read books, and the public's desire to acquire new knowledge was stimulated.
4. Metal printing	The printing press and ink were also developed around the same time as the metal type, and the era of mass production began.
5. Mechanical calculator	This calculator had metal spokes, and the wheel dial was only capable of performing addition and subtraction. However, it brought about the revolution of info-communication, including the invention of computers and smart phones.
6. Bagel	Traditional Jewish bread containing wheat flour, salt, water, and yeast leavening was a big help during food shortages.
7. Light bulb	Inventors experimented with thousands of different filaments, including bamboo, to find just the right materials that would glow brightly and be long-lasting.
8. Transistor	Its functions include opening, rectifying, and amplifying an electrical current. It changed the way culture was transmitted, from publications to the application of multi-media.
9. Artificial satellite	Russia's Sputnik 1 launched the era of space exploration.
10. Dolly the cloned sheep	It proved the sensational discovery in biotechnology that a fully grown somatic cell could recreate a whole individual.

TIME magazine selects the best inventions of the year

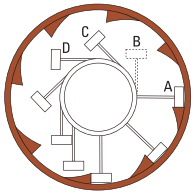
Each December, TIME magazine selects the top 50 inventions of the year. These included a flying automobile, a 130-meter-long space rocket, and an electric car that generates electricity by solar panels and human pedals.
For more information (including photos and stories), please refer to the following website: http://techland.time.com/the-25-best-inventions-of-the-year-2013/

04 Teaching point

Help the students understand the birth of invention and the development process.

Impossible inventions (summarized from Wikipedia)

1) Perpetual motion device



Perpetual motion describes motion that continues indefinitely without any external source of energy. This is impossible in practice because of friction and other sources of energy loss. Furthermore, the term is often used in a stronger sense to describe a perpetual motion machine of the first kind, which is a "hypothetical machine which, once activated, would continue to function and produce work" indefinitely with no input of energy. There is a scientific consensus that perpetual motion is impossible, as it would violate the first and second law of thermodynamics.

2) Alchemy

The ostensible goal of alchemy is often given as the transmutation of common metals into gold, but this goal was never reached. However, alchemists developed a structure of basic laboratory techniques, theories, terminology, and experimental methods, some of which are still in use today. Acid was first discovered in 1669 by the German alchemist, Hennig Brand, who extracted the substance by processing enormous amounts of human urine.

3) Time machine

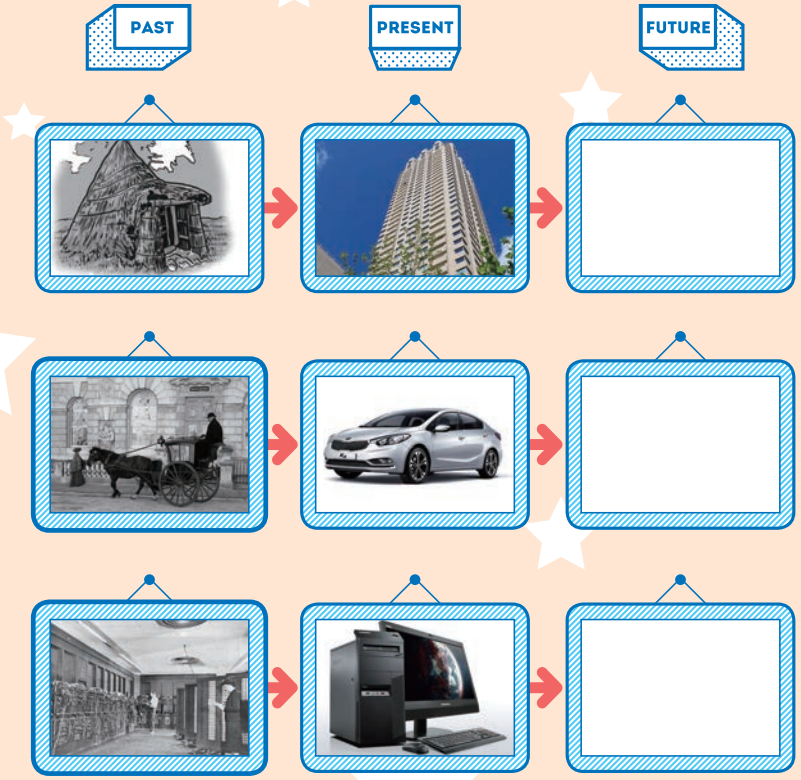
Time travel is permitted in Albert Einstein's special and general theories of relativity. These theories state that, relative to a given observer, time passes more slowly for bodies moving quickly in relation to the observer, or for bodies that are deeper within a gravity well. But no one in history has yet found an energy source that can move an object faster than light or increase its mass.

Signals Human beings have used smoke, light, and flags to deliver information to people far away.
Carrier pigeon Pigeons were used with letters tied to their legs because they could find and return to their nests.
Morse signal Electric signals were used to deliver information, with each letter being replaced by signals of varying lengths.

THE BIRTH OF INVENTION

DEVELOPMENT OF INVENTIONS

The following illustrations show us the developmental processes of three different inventions. How might they continue to evolve in the future?, Draw or write out your ideas in the "FUTURE" column.



THE IMPORTANCE OF PATENT APPLICATIONS

THE VALUE OF INVENTION

Study the importance of patent applications through specific cases.

TAKE A LOOK AT THE VARIOUS CATEGORIES OF INTELLECTUAL PROPERTY RIGHTS.

THE SAFEGUARDING OF INTELLECTUAL PROPERTY RIGHTS AND INVENTORS.

Intellectual property rights are the exclusive rights given to persons over their creations. These rights encourage human creativity. In particular, patents encourage more inventions so that further development might be achieved.

ABRAHAM LINCOLN : "The patent system is the fuel of interest to the fire of a genius in the process of discovery and production of new and useful things."

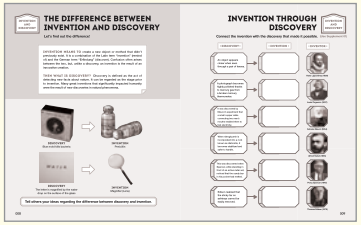
A patent is the inventor's exclusive rights to his invention. Once a patent is granted, other people cannot use the invention without the inventor's permission. Patents make people realize the value of an invention, and guarantee the inventor his or her deserved profit.

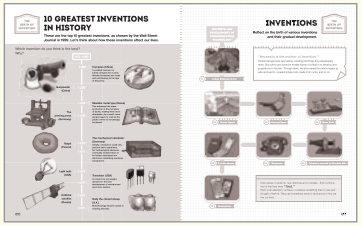
CASE The telephones of Antonio Meucci, Alexander Graham Bell, and Elisha Gray

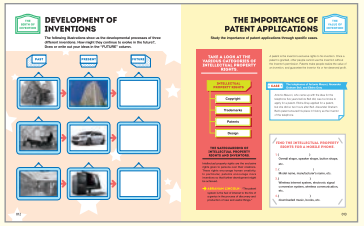
Antonio Meucci, who came up with the idea for the telephone five years before Bell did, was too broke to apply for a patent. Elisha Gray applied for a patent, but she did so two hours after Bell. Alexander Graham Bell's patent ensured his place in history as the inventor of the telephone.

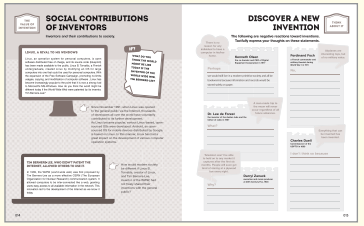
FIND THE INTELLECTUAL PROPERTY RIGHTS FOR A MOBILE PHONE.

1. ( )
   Overall shape, speaker shape, button shape, etc.
2. ( )
   Model name, manufacturer's name, etc.
3. ( )
   Wireless internet system, electronic signal conversion system, wireless communication, etc.
4. ( )
   downloaded music, books, etc.









05 Teaching point

Let them reflect on the developmental process of possible future inventions.

The birth of invention, and development case studies (summarized from Wikipedia)

1) Aspirin extracted from bark

In 400 B.C., the Greek doctor Hippocrates left historical records describing the use of pain-relieving powder made from the bark and leaves of willow trees. In 1893, German chemist Felix Hoffman, who developed Hippocrates' medical treatments, went on to make Aspirin.

2) X-Rays discovered by accident

German physicist Röntgen discovered X-Rays while he was investigating cathode rays using a fluorescent screen painted with barium platinocyanide and a Crookes tube that he had wrapped in black cardboard to keep visible light from interfering.

3) Vacuum cleaner to blow away dust

The first manual model was a kind of bellows to blew away dust. The modern design of the vacuum cleaner was invented in 1901 by Hubert Cecil Booth of England.

4) Microwave ovens used to be weapons

A microwave oven uses electromagnetic waves and humidity to heat things up. Microwave ovens were first developed as weapons. Percy Spencer noticed that microwaves from an active radar set he was working on melted the candy bar in his pocket. In 1947, an American company called Raytheon built the oven and sold it to the public as a cooking device.

5) A blender to mix food

The blender that Stephen Poplawski invented in 1922 was made to mix food rather than grind it.

6) Vaseline came from petroleum residue

In 1859, chemist Robert Chesebrough invented Vaseline using petroleum residue.

7) The world's first postage stamp

In 1804, British printer James Chalmers proposed the idea for a modern postal system that uses stamps. At that time, the person receiving a letter, rather than the person sending it, had to pay the price of the stamp.

8) Soap saved babies' lives

The principle of soap was discovered in ancient Mesopotamia. The world's infant mortality rate decreased rapidly once soap became popularized in the 19th century.

06 Teaching point

Help students understand applications of patents through famous examples and recognize the types of Intellectual Property Rights.

What is a patent dispute?

It's a legal dispute between individuals and companies, or vice versa, over the protection of their rights. Large scale disputes are often called "patent wars." Today's patent disputes among multinational enterprises occur in every economical sector in the world.

Intellectual Property Rights (IPR)

An intellectual property right is a safeguard to protect the intangible property rights of an intellectual creation. They can be classified as industrial property rights–which includes patent rights, trademark rights, and design rights–or copyrights, which protect creative works such as art and literature.

Patent right	A patent right takes effect when an innovative new invention is created, and the right is applied for and registered. The patentee receives exclusive rights for a limited period of time, restricting others from using the patented invention without permission.
Trademark right	Trademark rights take effect when someone applies for and registers a product that can be differentiated by a particular symbol, character, or figure. The trademark right is infringed when someone else copies or uses a similar symbol, character, or figure without permission.
Design right	Design rights take effect when they are applied for and registered as distinctive artwork with distinctive colors or shapes. Design rights are infringed if someone copies the design without permission.
Copyright	Copyrights are rights for inventions that articulate human thought or emotions. These may include books, music, paintings, sculptures, movies, computer software, databases, advertisements, maps, and blueprints.

THE VALUE OF INVENTION

SOCIAL CONTRIBUTIONS OF INVENTORS

Inventors and their contributions to society.

LINUX, A RIVAL TO MS WINDOWS

Linux, an operation system for personal computers, is open software distributed free of charge, and its source code (blueprint) has been made available to the public. Linus B. Torvalds, a Finnish undergraduate, created Linux by modifying an OS for large computers into one that could be used for personal computers. With the expansion of the Free Software Campaign, promoting no-limits usagee, copying, and modification of computer software , Linux has become increasingly popular to the point that it is now a strong rival to Microsoft's MS-Windows. How do you think the world might be different today if the World Wide Web were patented by its inventor, Tim Berners-Lee?

IF?

WHAT DO YOU THINK THE WORLD MIGHT BE LIKE TODAY IF THE INVENTOR OF THE WORLD WIDE WEB, TIM BERNERS-LEE?

Since November 1991, when Linux was opened to the general public via the Internet, thousands of developers all over the world have voluntarily contributed to its further development. As Linux became popular, various Linux-based, open-sourced OSs were developed. Android, an open-sourced OS for mobile devices distributed by Google, is based on Linux. In this manner, Linux has had a great impact on the development of various computer operation systems.

TIM BERNERS-LEE, WHO DIDN'T PATENT THE INTERNET, ALLOWED OTHERS TO USE IT.

In 1989, the WWW (world-wide web) was first proposed by Tim Berners-Lee as a more effective CERN (The European Organization for Nuclear Research) communication system. It allowed computers to be inter-connected like a web, granting users easy access to all available information in the network. This innovation led to the development of the Internet as we know it today.

How would modern society be different if Linus B. Torvalds, creator of Linux, and Tim Berners-Lee, inventor of the WWW, had not freely shared their inventions with the general public?

DISCOVER A NEW INVENTION

THINK ABOUT IT

The following are negative reactions toward inventions. Tactfully express your thoughts on these statements.

There is no reason for any individual to have a computer in his/her home.

Kenneth Olsen
the co-founder and CEO of Digital Equipment Corporation in 1977

Perhaps

we would still live in a modern primitive society and all be bookworms because information and records would be stored solely on paper.

A man-made trip to the moon will never occur regardless of all future advances.

Dr. Lee de Forest
the inventor of the Audion tube and the father of radio in 1967

What?

Television won't be able to hold on to any market it captures after the first six months. People will soon get tired of staring at a plywood box every night.

Darryl Zanuck
executive and movie producer at 20th Century Fox, 1946

Why?

Airplanes are interesting toys, but of no military value.

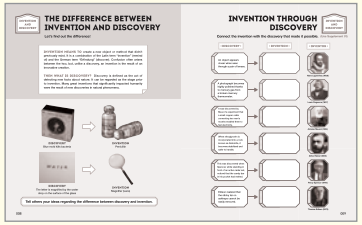
Ferdinand Foch
a French commander and military theorist during World War I in 1911

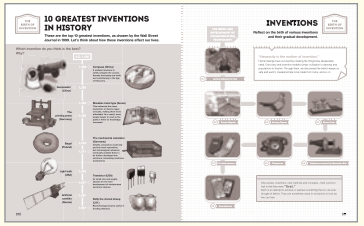
No,

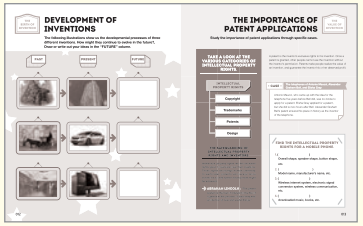
Everything that can be invented has been invented.

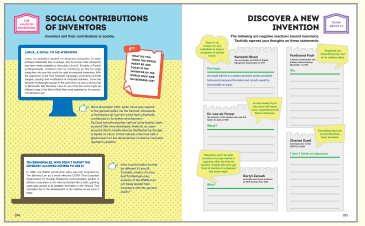
Charles Duell
Commissioner of the USPTO in 1899

I don't think so because









07 Teaching point

Use case studies to help students understand the social contributions of inventors.

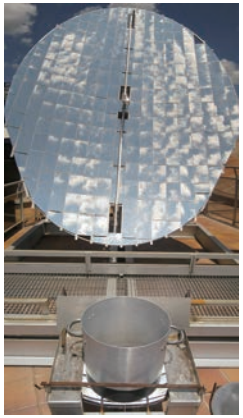
Example of one inventor's social contribution (summarized from Wikipedia)

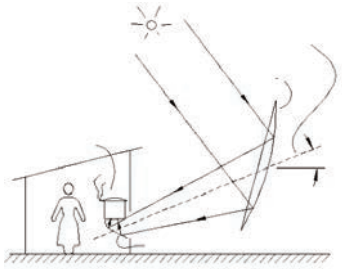
Scheffler's solar cooker for preventing desertification

Trees are used for firewood in many countries. Because of this, mountains have been denuded rapidly, resulting in what is called desertification. This, in turn, has made firewood increasingly difficult for people living in those areas to find. Thankfully, an invention called "Scheffler's cooker," which operates using solar heat, has helped to relieve some of the burden of people living in third world countries.

The cooker, which invented by German inventor Wolfgang Scheffler, looks like a big dish. It has an auto tracking system and can get as hot as 290℃. As much as 2 liters of water can be boiled in 2 minutes on a sunny day.

Solar cookers are very inexpensive and can be used anywhere under the sun. It's the simplest, safest, and most convenient way to cook food without consuming fuel or heating up the kitchen. This innovative invention shows us that solar heat can be used as household energy. This means that it could help preserve trees and prevent desertification. Also, Scheffler made his designs and associated intellectual property available for free in order to create a better, solar-powered world.





Scheffler's solar cooker

desertification The transformation of arable or habitable land to desert, as by a change in climate or destructive land use.

08 Teaching point

Help correct misconceptions about invention.

Notable points

The following extracts are taken from "The 7 Habits of Highly Effective Teens." These comments were made by experts in every field. They may sound quite silly now, but it is easy to understand why they were said, considering the very different circumstances at the time. Therefore, instead of simply refuting these comments, it is important to compare the technology of the past with that of the present. Then, we can begin to predict that of the future. In proceeding with the class, allow students to share their thoughts on existing inventions.

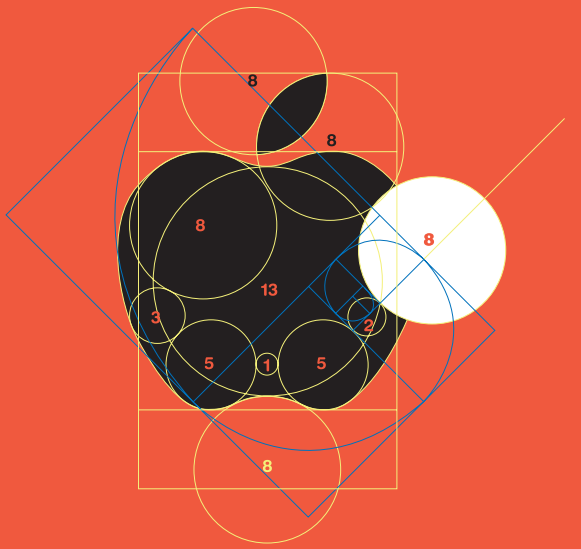
Digital Equipment Corporation A major American company in the computer industry from the 1960s to the 1990s.

Ferdinand Foch A French commander during World War I who also predicted World War II.

Lee de Forest An American inventor who invented the Audion tube and was also called the "father of radio."

Darryl Zanuck An executive and movie producer at 20th Century Fox. Ex.) Jaws, Star Wars, etc.

PART 2
CREATIVE THINKING METHODS

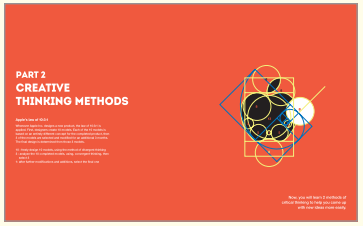


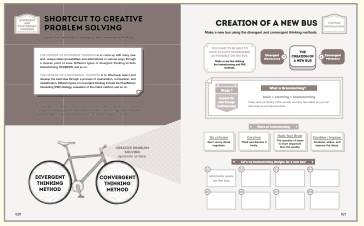
Apple's law of 10:3:1

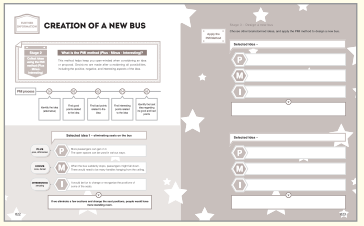
Whenever Apple Inc. designs a new product, the law of 10:3:1 is applied. First, designers create 10 models. Each of the 10 models is based on an entirely different concept for the completed product, then 3 of the models are selected and modified for an additional 3 months. The final design is determined from those 3 models.

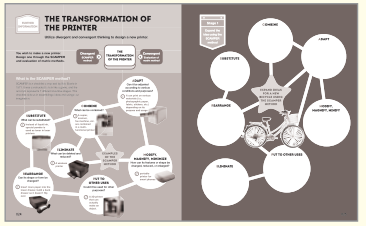
10 : freely design 10 models, using the method of divergent thinking
3 : analyze the 10 completed models, using, convergent thinking, then select 3
1: after further modifications and additions, select the final one

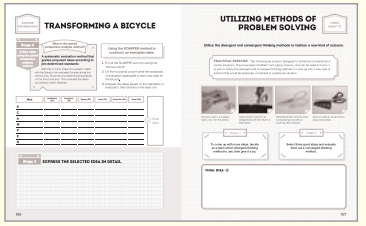
Now, you will learn 2 methods of critical thinking to help you come up with new ideas more easily.











Creative Thinking Methods

Teacher's guide

Help students recognize the two methods of critical thinking – divergent and convergent thinking – and apply these methods in practice.

Notable points in class

Make students aware of the fact that divergent thinking and convergent thinking are not only used to create an idea but may be used in endless repetition to solve problems.

Class management

Introduce	Develop	Conclude
• Look into Apple's law of design in light of the critical thinking method. • Inform them of the learning goal.	• Types of critical thinking methods: recognize the methods of divergent and convergent thinking. • Experience the technique of endlessly repeating divergent and convergent thinking to achieve an easier idea-designing process.	• Identify and resolve any inconvenience with your scissors while applying the critical thinking method in practice.

Introduction

There is usually more than one solution when you try to solve problems using inventions.
However, it's often not possible to experiment with every idea that you come up with. Help students understand that the best idea can be detemined by coming up with as many ideas as possible, then modifying and refining them.
As a point of emphasis, tell students about Apple's law of design and let students know that a good idea does not happen all at once.
Have students learn about the two critical thinking methods and give typical examples.
Then, guide the students to realize that the methods of divergent and convergent thinking are not dealt with separately, but that each method may be applied repeatedly to increase the value of a new idea.

Inform them of the learning goal

Look into the methods of divergent and convergent thinking and apply them in practice.

Inform them of the learning activity

Apple Computer software company was established in the United States by Steve Jobs and others. It is the company that brought you Macintosh computers, iPods, iPhones, etc.

DIVERGENT AND CONVERGENT THINKING

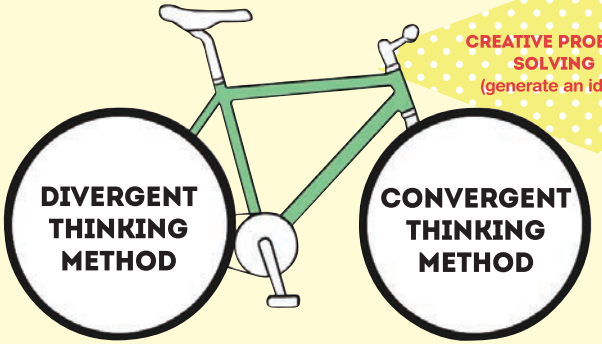
SHORTCUT TO CREATIVE PROBLEM SOLVING

Learn the methods of divergent and convergent thinking.

THE METHOD OF DIVERGENT THINKING is to come up with many new and, unique ideas (possibilities and alternatives) in various ways through a diverse point of view. Different types of divergent thinking include brainstorming, SCAMPER, and so on.

THE METHOD OF CONVERGENT THINKING is to effectively select and develop the best idea through a process of examination, comparison, and classification. Different types of convergent thinking include the Plus/Minus/Interesting (PMI) strategy, evaluation of the matrix method, and so on.

To engage in creative problem-solving, come up with new ideas through the divergent thinking method, then select the best ideas through the convergent thinking method. Finally, take the time to modify and refine your idea.



CREATION OF A NEW BUS

FURTHER INFORMATION

Make a new bus using the divergent and convergent thinking methods.

YOU WANT TO BE ABLE TO HAVE AS MANY PASSENGERS AS POSSIBLE ON THE BUS.

Make a new bus utilizing the brainstorming and PMI methods.

Divergent Brainstorming → **THE CREATION OF A NEW BUS** ← Convergent PMI Method

Stage 1

Expand the idea through brainstorming

What is Brainstorming?

brain + storming = brainstorming

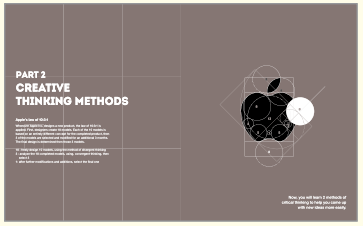
Freely and uncritically come up with as many new ideas as you can, then improve and develop them.

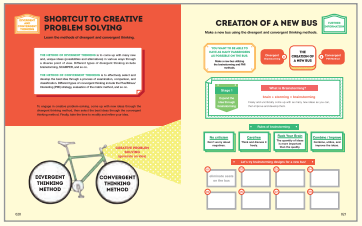
Rules of brainstorming

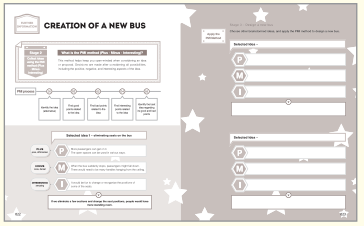
- **No criticism** — Don't worry about negatives.
- **Carefree** — Think and discuss it freely.
- **Rack Your Brain** — The quantity of ideas is more important than the quality.
- **Combine / Improve** — Combine, utilize, and improve the ideas.

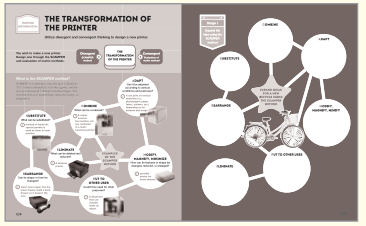
Let's try brainstorming designs for a new bus!

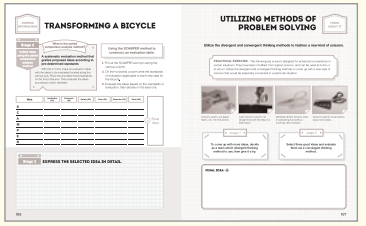
01 eliminate seats on the bus	02	03	04
05	06	07	08











01 Teaching point

Make them aware of the meaning of and relationship between divergent and convergent thinking.

The implication of an endless repetition of divergence and convergence

In solving problems creatively, the methods of divergent thinking (expand and generate) and convergent thinking (focus and criticize) are like two wheels on a bicycle.

"What if one wheel becomes broken?"

A true idea is created when both methods of divergent and convergent thinking supplement each other during the idea formation process.

Other examples of divergence and convergence

category	implication	Critical thinking method
Divergent thinking	• a thinking process that is meaningful, expressive, and leads to a new connection • the process of creating an idea (possibilities and alternatives)	• Brainstorming • Brain writing • Synectics • SCAMPER • Six thinking hats
Convergent thinking	• a thinking process that selects, analyzes, and modifies • the thinking process of selecting and developing an idea (possibilities and alternatives)	• Highlighting • PMI (Plus-Minus-Interesting) • P-P-C (Positive-Possibilities- Concerns) • evaluation of matrix method • paired comparison analysis method

Brain Writing Each member of a group receives a piece of paper with a theme written down on it. Then each member writes down 3 or more ideas on the same piece of paper and leaves it on the desk. Afterwards, each person grabs someone else's piece of paper and then writes down 3 more ideas under what has already been written. Repeat this process until the ideas well runs dry. Prior ideas are referred to and shared by all the members of the group. This activity is carried out in silence, so language barriers will not serve to limit anyone.

02 Teaching point

Lead students to acknowledge the implication of brainstorming (divergent thinking method) and understand its procedure, notable points, and application-to-idea planning.

Steps of Brainstorming

• group size

5-6 people (best to have an odd number, with the maximum being 12)

• group composition

consider gender, age, level, etc. so that there will be a good mixture of students in each group to cover a wide range of problems via different points of view, thereby allowing for a variety of ideas.

• host

host the activity in a carefree environment so students can come up with as many ideas as possible.

• scribe

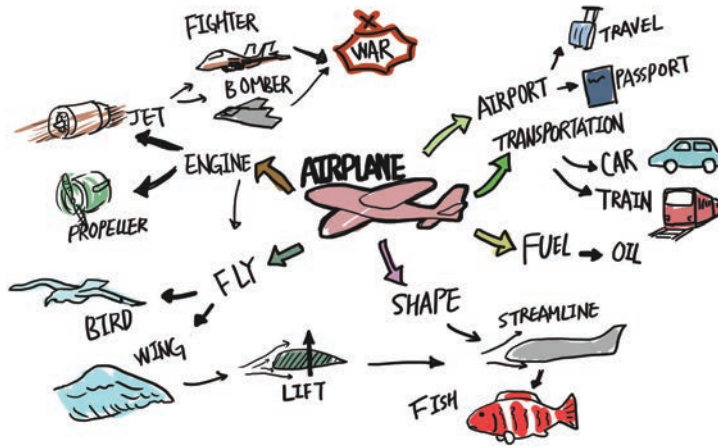
try not to leave anything out from the discussion, but record key words only.

• You may before hand set a time limit and determine the number of ideas to be generated.

• After organizing the ideas, evaluate each one to select the very best.

Beware when applying brainstorming

1) Guide the students to be attentive when other students are presenting their work.
2) If there are many groups of people, ask students to speak quietly so that they don't interfere with other groups.
3) Guide the students in keeping track of the ideas they come up with and in making sure that additional ideas don't overlap with existing ones.



FURTHER INFORMATION

CREATION OF A NEW BUS

Stage 2

Collect ideas using the PMI method (Plus · Minus · Interesting)

What is the PMI method (Plus · Minus · Interesting)?

This method helps keep you open-minded when considering an idea or proposal. Decisions are made after considering all possibilities, including the positive, negative, and interesting aspects of the idea.

PMI process

01 Identify the idea (alternative)

02 Find good points related to the idea

03 Find bad points related to the idea

04 Find interesting points related to the idea

05 Identify the best idea regarding its good and bad points

Selected idea 1 – eliminating seats on the bus

PLUS pros, affirmation — P: More passengers can get on it. The open spaces can be used in various ways.

MINUS cons, denial — M: When the bus suddenly stops, passengers might fall down. There would need to be many handles hanging from the ceiling.

INTERESTING amusing — I: It would be fun to change or reorganize the positions of some of the seats.

If we eliminate a few sections and change the seat positions, people would have more standing room.

Stage 3 – Design a new bus

Apply the PMI Method

Choose other brainstormed ideas, and apply the PMI method to design a new bus.

Selected Idea –

P

M

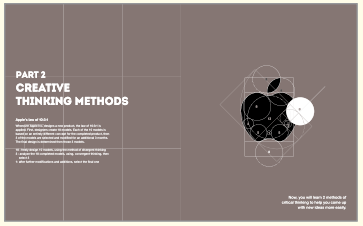
I

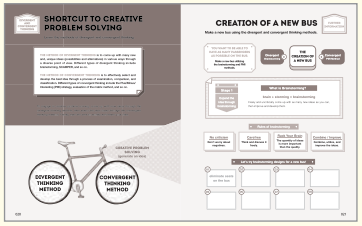
Selected Idea –

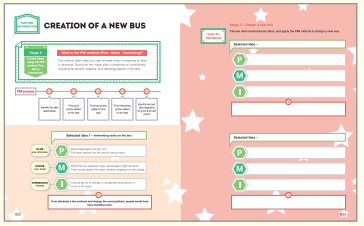
P

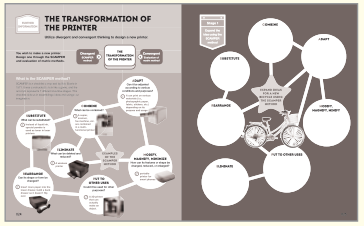
M

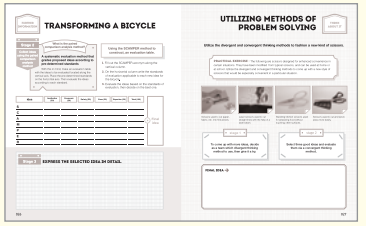
I











03 Teaching point

Recognize the meaning of the PMI convergent method and help students understand the process for applying the method.

PMI Method

This thinking method—part of the meta-cognitive program developed by Edward de Bono—is used to help people keep an open mind when they deal with an idea or suggestion, enabling them to consider all positive, negative, and interesting aspects of an idea before making a final decision.

The procedure for applying the PMI Method

1. Explain the meaning of PMI to the members of the group.
2. In each stage of P, M, and I, make maximum use of the brainstorming method.
3. Generate ideas for each part.
4. Present PMI outcomes.
5. Discuss PMI outcomes.

Something to remember when the PMI method is being applied

1) Concentrate only on the good points when looking for pros, and only on the bad points when looking for cons. When P is considered, concentrate on P, and forget all about M or I. Likewise, when ideas related to M are considered, concentrate only on M.
2) Make learning adjustments to form a collective judgment based on the output of thoughts at each stage. Simply listing out P, M, and I is not feasible.

04 Teaching point

Let students select the idea constructed through brainstorming and apply the PMI method to design a new idea.

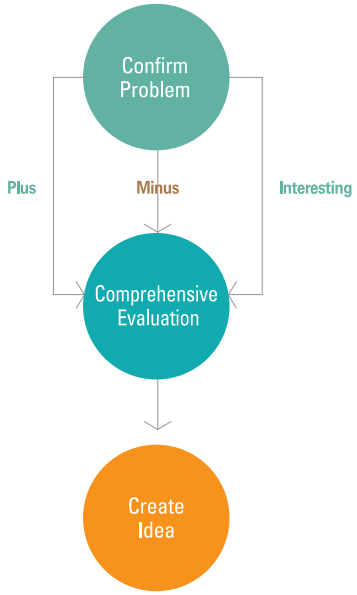
The principle of the PMI method

1) PMI may not seem useful at first. However, it is proven to be effective in helping people remember good ideas.
2) If it wasn't for PMI, you might overlook the bad points of an idea that seems very good at first glance.
3) PMI not only analyzes the good and bad points of the idea, but the interesting ones as well.

Effects of PMI usage

1) It promotes competition between groups so that many perspectives can be gathered within a short period of time, and it allows for active participation.
2) Through the selection of categories, active discussion and the implementation of various thinking methods become possible.
3) Find advantages and disadvantages for each subject, suggest new alternatives, and come up with unique ideas.
4) Creativity grows as participants present their progress, ask questions, find answers, and modify the process.

PMI Process



FURTHER INFORMATION

THE TRANSFORMATION OF THE PRINTER

Utilize divergent and convergent thinking to design a new printer.

You wish to make a new printer. Design one through the SCAMPER and evaluation of matrix methods.

Divergent SCAMPER method → **THE TRANSFORMATION OF THE PRINTER** ← **Convergent** Evaluation of matrix method

What is the SCAMPER method?

SCAMPER is a checklist composed by Bob Eberle in 1971. It was constructed to look like a game, and the acronym represents 7 different inventive stages. This checklist aids us in assemblinge ideas and usinge our imagination.

EXAMPLES OF THE SCAMPER METHOD

ADAPT
Can it be adjusted according to various conditions and purposes?
- It can print on various materials (i.e., photographic paper, fabric, stickers, etc.) depending on its purpose and usage

COMBINE
What can be combined?
- A copier, scanner, fax machine, etc. are combined in a multi-functional printer

SUBSTITUTE
What can be substituted?
- Instead of liquid ink, special powder is used as toner in laser printers.

ELIMINATE
What can be deleted and reduced?
- A wireless printer

MODIFY, MAGNIFY, MINIMIZE
How can its features or shape be changed, reduced, or enlarged?
- portable printer for smart phones

REARRANGE
Can its shape or form be changed?
- Insert more paper into the lower drawer, build a back drawer so it doesn't flip over.

PUT TO OTHER USES
Could it be used for other purposes?
- A 3D printer that can actually make an object.

Stage 1
Expand the idea using the SCAMPER method

EXPAND IDEAS FOR A NEW BICYCLE USING THE SCAMPER METHOD

COMBINE

ADAPT

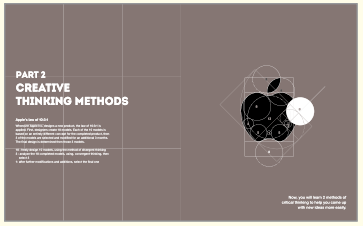
SUBSTITUTE

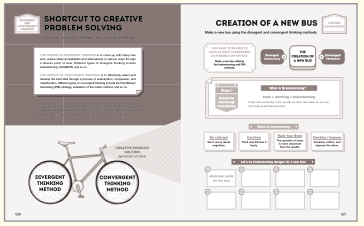
REARRANGE

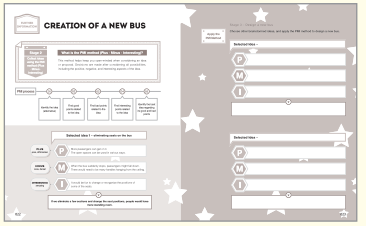
MODIFY, MAGNIFY, MINIFY

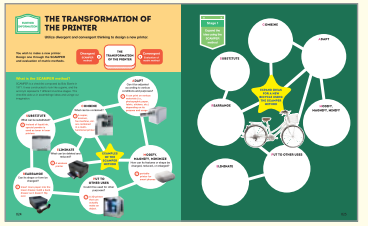
PUT TO OTHER USES

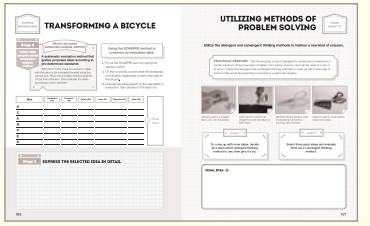
ELIMINATE











05 Teaching point

Recognize the implications of the SCAMPER method in elaborating ideas.

SCAMPER

Bob Eberle's SCAMPER method is the ideal checklist for divergent thinking. SCAMPER is easy to memorize and useful for fostering creativity, so it can be widely used in our daily lives. It is comprised of 8 words abbreviated into a game-like format and designed as a checklist to help assimilate ideas and fuel the imagination.

Other examples of SCAMPER

New Bicycle

- **S** Substitute air-filled tires to airless tires
  → even when the tire is punctured, it can still be used
- **C** Combine a bicycle with a back seat attachment
  → a form of personal vehicle transformed into a transportation means for multiple people
- **A** Adapt auxiliary wheels for safety
  → modified so children may use it
- **M** Modify/Magnify/Minify a bicycle that uses small wheels and is foldable
  → a portable bicycle
- **P** Put in a generator device to produce electricity
  → kinetic energy generated through the rotating wheel is transformed into electric energy
- **E** Eliminate bicycle spokes
  → when the spokes are replaced with round plates, air resistance is reduced (racing bicycle)
- **R** Rearrange a bicycle so that the height of the seat is lowered
  → the bicycle is rendered more aerodynamic

A generator device is attached to produce electricity

Eliminate bicycle spokes

Rearrange a bicycle with the height of the seat lowered

06 Teaching point

Apply the SCAMPER Method to construct an idea related to a new bicycle.

Another divergent thinking method

Six thinking hats

This is a method developed by Edward de Bono, in which six different colored hats direct us to think in distinctive ways. One has to think in terms of the direction of the hat he or she is wearing and the implication of its color. Through this tool, an individual or group can view problematic circumstances constructively and expand their thinking perspectives in order to solve problems.

Note when applying the "six thinking hat" method

1) The yellow and black hats are different from the red hat in the way that reasonable evidence of wearers' ideas must be provided.
2) If hats are inconvenient to use, they may be replaced with ball point pens, necklaces, flags, etc.
3) Order of idea generation White → Green → Yellow → Black → Red → Blue
4) Order of idea discussion White → Red → Yellow → Black → Green → Blue

Ways of utilizing the "six thinking hats" method

Color	Symbol	Type of thinking	Content
White	Purity → Neutral, Objective	Realistic	• Fact • Shame
Red	Blood, Passion, Anger, Love → Emotional, Intuitive	Emotional Intuitive	• Emotion • Feeling
Yellow	Sunlight, Bright → Optimistic, Positive	Logically positive	• Good point • Positive judgment
Black	Darkness, Gloom, Seriousness → Pessimistic, Critical	Logically negative	• Bad point • Negative judgment
Green	Grass, Vegetable, Abundance → Productive, Creative	Creative	• New idea • Interesting thought
Blue	Coldness, Coolness → Rational	Think about thinking	• Comprehensive idea of five different colors

FURTHER INFORMATION

TRANSFORMING A BICYCLE

Stage 2

Collect ideas using the paired comparison analysis method

What is the paired comparison analysis method?

A systematic evaluation method that grades proposed ideas according to pre-determined standards

With this in mind, make an evaluation table with the ideas to be evaluated located along the vertical axis. Place the pre-determined standards on the horizontal axis. Then evaluate the ideas according to each standard.

Using the SCAMPER method to construct, an evaluation table.

1. Fill out the SCAMPER acronym along the vertical column.
2. On the horizontal column write the standards of evaluation applicable to each new idea for the bicycle.
3. Evaluate the ideas based on the standards of evaluation, then decide on the best one.

idea	Aesthetics (20)	Economic (20)	Safety (20)	Ease (20)	Expertise (20)	Total (100)
S						
C						
A						
M						
P						
E						
R						

Final idea

Stage 3 **EXPRESS THE SELECTED IDEA IN DETAIL.**

UTILIZING METHODS OF PROBLEM SOLVING

THINK ABOUT IT

Utilize the divergent and convergent thinking methods to fashion a new kind of scissors.

PRACTICAL EXERCISE : The following are scissors designed for enhanced convenience in certain situations. They have been modified from typical scissors, and can be used at home or at school. Utilize the divergent and convergent thinking methods to come up with a new style of scissors that would be especially convenient in a particular situation.

Scissors used to cut paper, fabric, etc. into fine pieces.

Laser scissors used to cut straight lines with the help of a laser beam.

Standing kitchen scissors used for preparing food without touching other surfaces.

Scissors used to cut and serve pizza more easily.

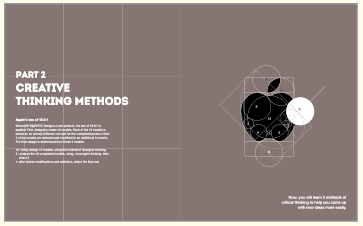
stage 1

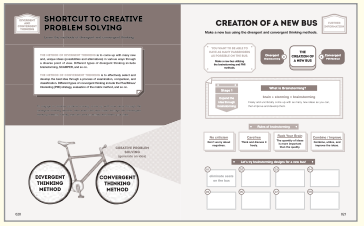
To come up with more ideas, decide as a team which divergent thinking method to use, then give it a try.

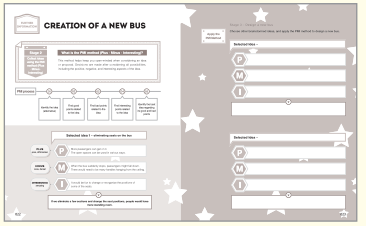
stage 2

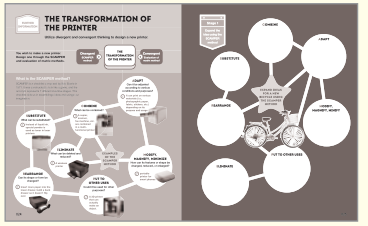
Select three good ideas and evaluate them via a convergent thinking method.

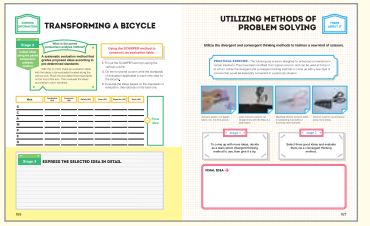
FINAL IDEA











07 Teaching point

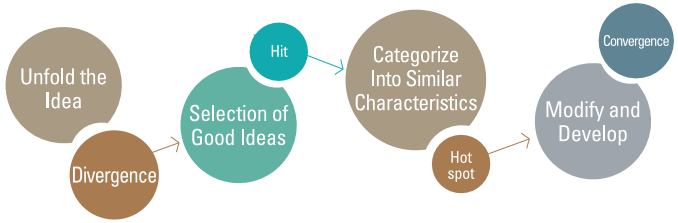
Help students understand the meaning of the evaluation matrix method and Let them collect numerous ideas from SCAMPER by using the evaluation matrix table.

Another convergent thinking method

Highlighting Method

The highlighting method is a convergent thinking method for selecting the best ideas. It then compresses the various ideas into a few basic groups and categorizes them. The highlighting method makes for better alternatives by modifying and developing these concentrated areas into a suitable form for effective problem-solving.

Process of the Highlighting Method



- Sparkling ideas : Hit
- Hit divided into a few categories : Hot spot

Example of using the Highlighting Method

- Choose "Hit" after divergent thinking

08 Teaching point

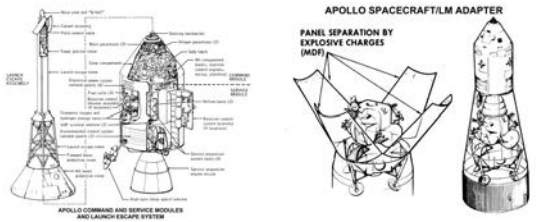
Help students understand the relationship between divergent and convergent thinking through the process of applying each method at each stage. Let them go through the process of generating invention ideas to improve an object's convenience.

Things to keep in mind while using this method

1) Help students recognize the problem first, then select the suitable divergent thinking method.
2) The core element of invention, which is the consideration of innovation, is less important at this stage.
3) When selecting suitable ideas generated through divergent thinking, gradually reduce the number of suitable ideas by applying the convergent thinking method several times rather than cutting down to 2-3 ideas all at once.
4) Guide the students so that, at the last stage of idea construction, they apply the divergent thinking method to contemplate whether any other ideas are superior to the final idea. From among those, select the one that is most suitable.
5) While students are generating new ideas about scissors, help them choose whether to come up with solutions for each different inconvenience, or to select just one inconvenience and give it their full attention.

An example of divergence and convergence

A problem arose when the United States of America invented a manned spacecraft capable of traveling through Earth's gravity despite being incredibly heavy and carrying a large amount of fuel. Its engineers had a dilemma: how to make it arrive safely at the moon despite its excessive weight. One engineer came up with an idea while brainstorming. "What if we only land a partial section of the rocket instead?" This tiny idea provided a break through for solving the problem, and more ideas came about through divergent and convergent thinking. Finally, the outcome was that the Lunar Module was designed to separate from its mother ship.



Lunar Module (summarized from Wikipedia) The Lunar Module was designed after NASA chose to reach the moon via Lunar Orbit Rendezvous (LOR) instead of the direct ascent or Earth Orbit Rendezvous (EOR) methods. Both direct ascent and EOR would have involved landing a much heavier, complete Apollo spacecraft on the moon. Once the decision had been made to proceed using LOR, it became necessary to produce a separate craft capable of reaching the lunar surface and ascending back to lunar orbit.

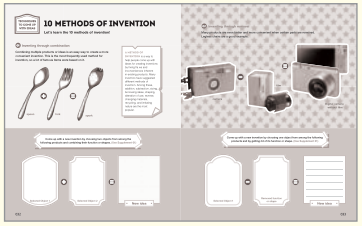
PART 3
METHODS OF INVENTION

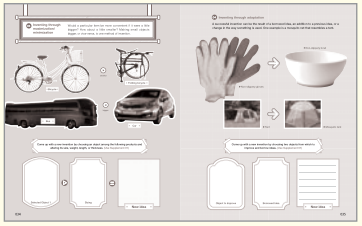
What if we put clothes on a house?

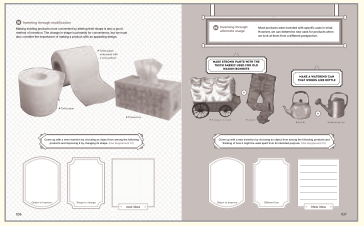
These advertisements show houses wearing warm winter clothing. Are these houses indeed warm?
A famous boiler company in Italy wanted people to know at first glance that these house were warm. After considering what they could do to the houses to give people the impression of warmth, they finally decided to give the houses coats. The advertisements were a huge success.

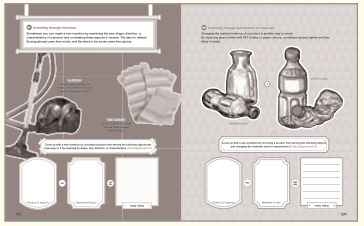
Can you think of other ways to advertise a boiler company? How can you give people the quick impression that a particular house is nice and cool?

Now, we will explore 10 methods of invention. You will see that coming up with new ideas is simple and easy.









Methods of Invention

Teacher's guide
Help the students understand the methods of invention and apply them to their lives.

Something to think about
Methods of invention are organized ways for finding the proper solutions to resolve any inconvenience of past and present inventions, how it was invented, and which methods were used collectively. Hence, they are focused on understanding the biggest differences between existing products and inventions.

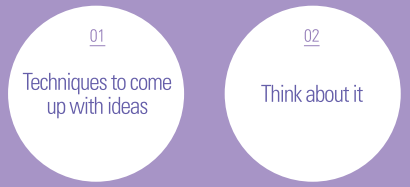
Class management

Introduce	Develop	Conclude
• Guess the methods of invention by analyzing the intent of the ad. • Inform students of the learning goal.	**Techniques for coming up with ideas** • Learn the types of methods of invention • Understand the 10 methods of invention and come up with a new idea using those methods.	• Check out new products using methods of characteristics of past inventions to find a new method for innovative ones.

Introduction
The 10 methods introduced in this stage are not set in stone. Methods of invention can be substituted based on the perspectives of the people analyzing the inventions. For example, one may discover that characteristics of many successful inventions are not only built from changing their shapes or materials, but also from manipulating their colors. This leads to the "changing color" method of invention.The number of methods for invention could vary from 5 to 10.
On top of that, there are famous methods like TRIZ, which was created by Altshuller, and ASIT, which was suggested by Horowitz.
Hence, the teacher should guide students in learning these 10 methods of invention without limiting all methods of invention to just these 10.

Inform students of the learning goal
Learn 10 methods of invention and try to come up with of a new method.

Inform them of the learning activity



TRIZ TRIZ(teoriya resheniya izobretatelskikh zadatch) is a theory consisting of 40 ways to think about a problem in order to achieve the most ideal result and come up with proper solutions for overcoming contradictions. It was developed by the Soviet engineer Genrich Altshuller and his colleagues in the 1600s.

ASIT A method developed as a tool for easily applying the complicated TRIZ method.

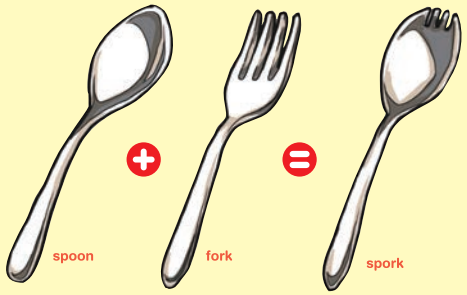
TECHNIQUES TO COME UP WITH IDEAS

10 METHODS OF INVENTION

Let's learn the 10 methods of invention!

01 Inventing through combination

Combining multiple products or ideas is an easy way to create a more convenient invention. This is the most frequently used method for invention, so a lot of famous items were based on it.

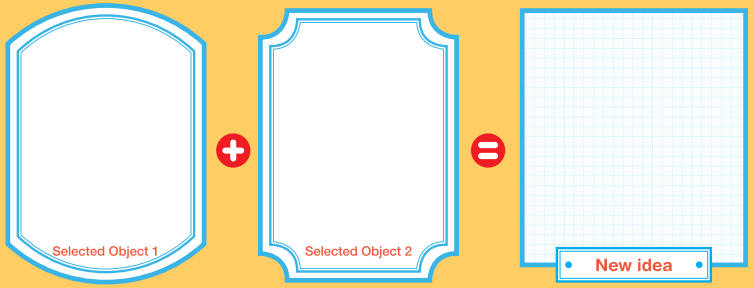


A METHOD OF INVENTION is a way to help people come up with ideas for creating inventions by fixing fla ws and inconveniences inherent in existing products. Many inventors have suggested different methods of invention. Among these, addition, subtraction, sizing, borrowing ideas, shaping, alteration of use, reverse, changing materials, recycling, and imitating nature are the most popular.

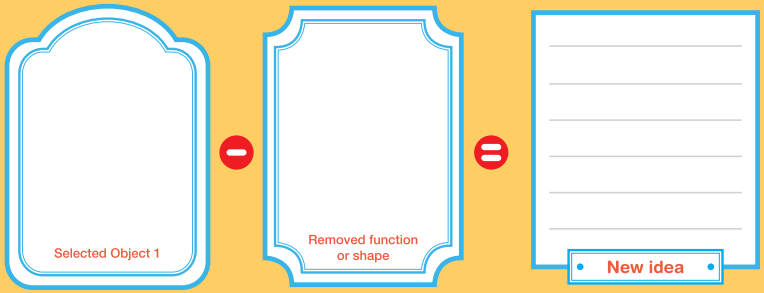
02 Inventing through removal

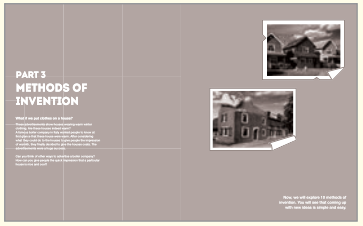
Many products are even better and more convenient when certain parts are removed. Legless chairs are a good example.

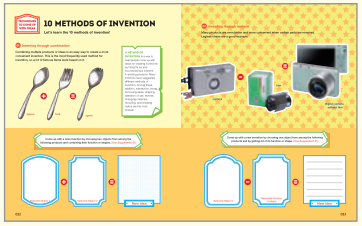
Come up with a new invention by choosing two objects from among the following products and combining their function or shapes. (Use Supplement 01)

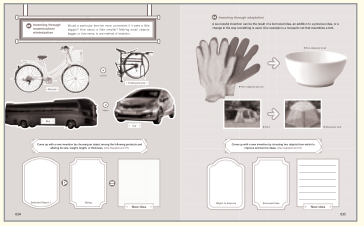


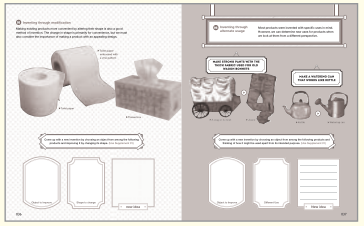
Come up with a new invention by choosing one object from among the following products and by getting rid of its function or shape. (Use Supplement 01)

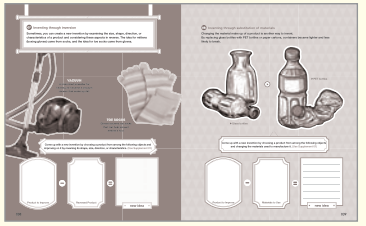












01 Teaching point

Help students understand inventions through combination and design a new invention by using this method.

Inventing through combination

1) Overview

Inventing through combination is adding something onto an existing invention in order to create something new. This method is divided into two types: A+A, which combines two similar things, and A+B, which combines two different things.

2) Examples of inventions

- A disposable toothbrush + toothpaste = A disposable toothbrush that doesn't need toothpaste
- A shoe lift + a bottle opener

Example of a new method of invention
〈Combining Principles〉

01 Humans are always striving for more convenient and comfortable lives. That's why, all things being equal, we prefer those objects that have greater functionality. From this point of view, it is useful to combine the basic principles behind the products instead of combining the products exactly as they are. New functions can be added by assimilating the principle of a different invention.

02 Examples of inventions

- Ruler + Portability = Tape measure (A flexible ruler that is easy to carry and automatically rolls back into its container.)
- Tire + Waterspout = Snow tire (It allows melted snow to flow out easily and increases traction.)
- Air conditioner + Filter technology = Air conditioner with an air-purifying function

02 Teaching point

Help students understand inventions through removal and design a new invention by using this method.

Inventing through removal

1) Overview

Simply removing a random part of the product doesn't make for a new invention. You must be careful to make the product better, lighter, cheaper, or more useful without causing any new problems.

2) Examples of invention

Tubeless tire
Unlike traditional pneumatic tires, tubeless tires have no inner tubes to hold the air. The air fills them entirely in order to prevent flat tires, thereby saving people a lot of time and effort.

Concrete masonry unit
The holes in concrete masonry units, as opposed to traditional bricks, reduce raw materials and decrease their weight.

Steel pipes
An iron bar easily bends when a person hangs on it, but a horizontal steel pipe is lighter, stronger, and uses fewer raw materials.

Digital cameras
Digital cameras encode digital images using digital sensors instead of film. The result is that they can display images on a screen immediately after the images are recorded, without having to develop any film.

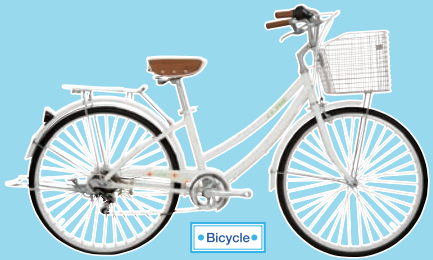
Electric motorcycles
They have electric motors instead of engines and gas tanks, thereby reducing exhaust fumes and noise.


Concrete masonry unit


Electric motorcycles

03 Inventing through maximization/ minimization

Would a particular item be more convenient if it were a little bigger? How about a little smaller? Making small objects bigger, or vice-versa, is one method of invention.



Bicycle

smaller

Folding bicycle

Bus

bigger

Car

Come up with a new invention by choosing an object among the following products and altering its size, weight, length, or thickness. (Use Supplement 01)

Selected Object 1

Sizing

New idea

04 Inventing through adaptation

A successful invention can be the result of a borrowed idea, an addition to a previous idea, or a change in the way something is used. One example is a mosquito net that resembles a tent.

Non-slippery gloves

Non-slippery bowl

Tent

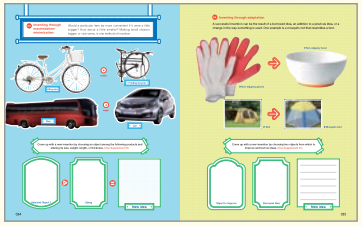
Mosquito tent

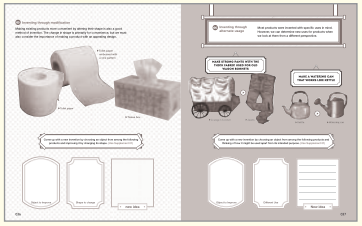
Come up with a new invention by choosing two objects from which to improve and borrow ideas. (Use Supplement 01)

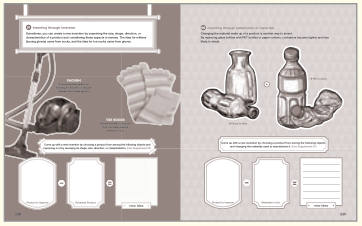
Object to Improve

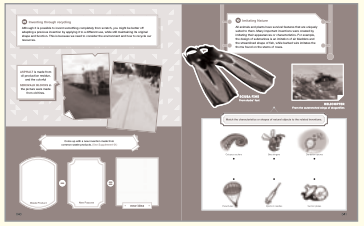
Borrowed Idea

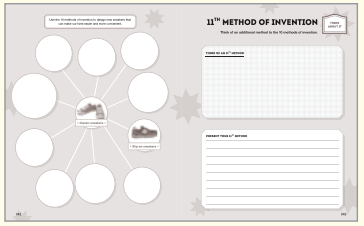
New idea











03 Teaching point

Help students understand inventions through maximization/minimization and design a new invention by using this method.

Inventing through maximization/minimization

1) Overview

Sizing for invention means changing the size of an existing object in order to increase its power, enhance its effects, or make it more convenient and portable. It's important to note that sizing should not lower the previous function of the object or weaken its strength.

2) Examples of inventions

Enlarging

Windmills

Windmills, which came from the idea of a spinning pinwheel, help people thresh crops, easily pump large amounts of water, and produce electricity via a generator.

Large refrigerators, large washing machines, large TVs

Downsizing

Folding umbrellas

Nowadays, umbrellas can be folded up until they are small enough to fit inside a purse.

Earphones

Huge radio speakers have been miniaturized to the point that they can fit directly in our ears.

Collapsible water jugs

Collapsible water jugs contain large amounts of water, but their volume can be reduced once they are emptied, making them easy to carry.

Collapsible water jugs

04 Teaching point

Help students understand inventions through adaptation and think of a new invention by using this method.

Inventing through adaptation

1) Borrowing ideas for invention

Look for clues in existing inventions in order to come up with unexpected ideas. The goal is not to reinvent things that already exist, but to consider how they can be improved. Your invention should be something that has a unique feature or can be sold at reduced cost.

2) Thinking process

1. What is the best way to borrow other people's ideas?
2. What are the advantages of borrowed ideas?

05 Inventing through modification

Making existing products more convenient by altering their shape is also a good method of invention. The change in shape is primarily for convenience, but we must also consider the importance of making a product with an appealing design.

Come up with a new invention by choosing an object from among the following products and improving it by changing its shape. (Use Supplement 01)

Object to Improve

Shape to change

new idea

06 Inventing through alternate usage

Most products were invented with specific uses in mind. However, we can determine new uses for products when we look at them from a different perspective.

MAKE STRONG PANTS WITH THE THICK FABRIC USED FOR OLD WAGON BONNETS

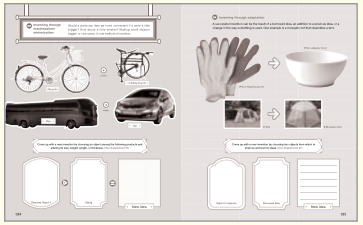
MAKE A WATERING CAN THAT WORKS LIKE KETTLE

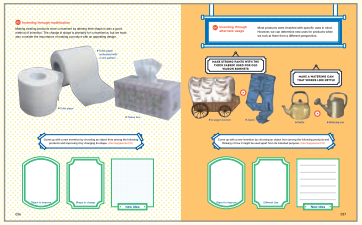
Come up with a new invention by choosing an object from among the following products and thinking of how it might be used apart from its intended purpose. (Use Supplement 01)

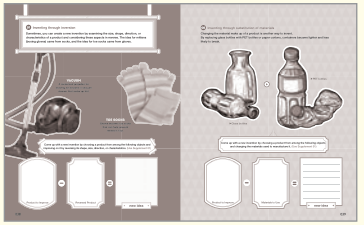
Object to Improve

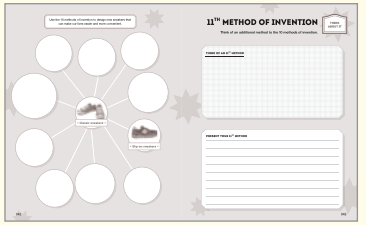
Different Use

New idea









05 Teaching point

Help students understand inventions through modification and design a new invention by using this method.

Inventing through maximization/ minimization

1) Overview

It is important not to weaken a product's function or diminish its ease of use. In other words, shaping should achieve a certain goal, whether it is making the product look better, enhancing its convenience, or creating financial profit.

2) Examples of inventions

Cola bottles

At one times, their surfaces were flat, just like common bottles. However, once curves were added to the shape, they became easier and safer to hold onto. They also looked better, resulting in increased financial profit.

Bendy straws

After a bendy part was added to regular straws, people could drink through them even while lying down.

Granton edge knives

Granton edge knives have hollowed out grooves on the sides of the blades. These grooves fill with air whenever a cucumber is being cut, making it easier to remove the cucumber slices from the surface of the blade.

Granton edge knife

Bendy straws

06 Teaching point

Help students understand inventions through alternate usage and design a new invention by using this method.

Inventing through alternate usage

1) Alteration of use for invention

George Stephenson invented the steam locomotive using the steam engine that James Watt invented for operating machines in factories. Chalk is also a good example of alteration of use, since it is not only useful for writing on a blackboard but also for making plaster statues after it is ground down and mixed with water.

2) Examples of invention

Electric motors

They're widely used for fans, refrigerators, vacuums, etc.

Aspirin

Invented as a fever remedy, it is also used as a growth accelerator for pigs.

07 Inventing through inversion

Sometimes, you can create a new invention by examining the size, shape, direction, or characteristics of a product and considering these aspects in reverse. The idea for mittens (boxing gloves) came from socks, and the idea for toe socks came from gloves.

VACUUM
A motorized propeller for blowing air became a vacuum cleaner that sucks up dirt.

TOE SOCKS
Gloves became toe socks that can help prevent athlete's foot.

Come up with a new invention by choosing a product from among the following objects and improving on it by reversing its shape, size, direction, or characteristics. (Use Supplement 01)

Product to Improve − Reversed Product = new idea

08 Inventing through substitution of materials

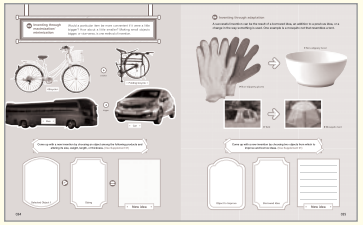
Changing the material make up of a product is another way to invent.
By replacing glass bottles with PET bottles or paper cartons, containers became lighter and less likely to break.

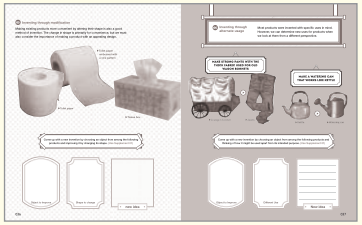
▶Glass bottles

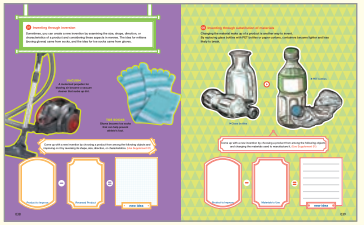
▶PET bottles

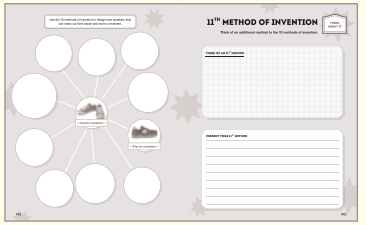
Come up with a new invention by choosing a product from among the following objects and changing the materials used to manufacture it. (Use Supplement 01)

Product to Improve − Materials to Use = new idea









07 Teaching point

Help students understand inventions through inversion and design a new invention by using this method.

Inventing through inversion

1) Overview

Stopping an object in motion, moving an object that is lying still, or reversing a design so that it appears back- to- front these are all good ways to improve an existing product and make it more convenient without altering its original purpose.

2) Examples of inventions

- The invention of the generator is based on the principle of the motor, but in reverse.
- Escalators were invented based on the interesting concept that stairs could be the ones moving up and down instead of people moving up and down.
- A tricycle with pedals for changing directions was invented because someone thought it might be possible to control a bicycle using pedals instead of handles.
- When cosmetic containers with the lids on top are almost empty, they must be placed upside down and tapped on before the contents can escape. However, if the opening were located at the bottom of the container, this would no longer be necessary.

08 Teaching point

Help students understand inventions through substitution of materials and design a new invention by using this method.

Inventing through substitution of materials

1) Changing materials for invention

Great inventions were sometimes made when the materials used to make a particular object were changed. However, the new invention should display the distinctive characteristics of the new material used. For example, a paper cup doesn't break easily and is lighter and cheaper than glass, due to its being made from paper.

2) Examples of invention

Synthetic billiard balls

Billiard balls used to be made of ivory and were very expensive, but they are affordable now that they are being made out of synthetic resins.

Transparent umbrellas

Walking with an umbrella while leaning forward to block the wind and rain can cause a person crash into a car or tree. Umbrellas made of transparent material can help people avoid such accidents.

Gloves made of various materials

Gloves are made of different materials depending on their uses. For example, cotton gloves for working, rubber gloves for washing dishes, and fur gloves for keeping warm.

09 Inventing through recycling

Although it is possible to invent something completely from scratch, you might be better off adapting a previous invention by applying it to a different use, while still maintaining its original shape and function. This is because we need to consider the environment and how to recycle our resources.

ASPHALT is made from oil production residue, and the colorful **SIDEWALK BLOCKS** in the picture were made from old tires.

Come up with a new invention made from common waste products. (Use Supplement 01)

Waste Product − New Purpose = new idea

10 Imitating Nature

All animals and plants have survival features that are uniquely suited to them. Many important inventions were created by imitating their appearances or characteristics. For example, the design of submarines is an imitation of air bladders and the streamlined shape of fish, while barbed wire imitates the thorns found on the stems of roses.

SCUBA FINS
From ducks' feet

HELICOPTER
From the outstretched wings of dragonflies

Match the characteristics or shapes of natural objects to the related inventions.

Octopus suckers

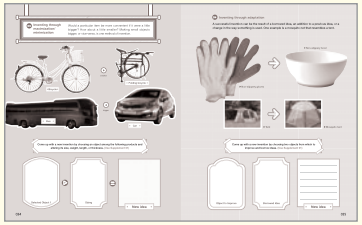
Bee stingers

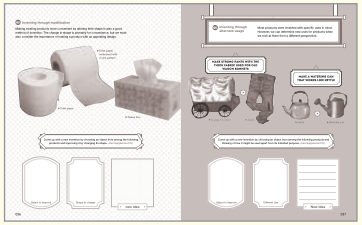
Dandelion spores

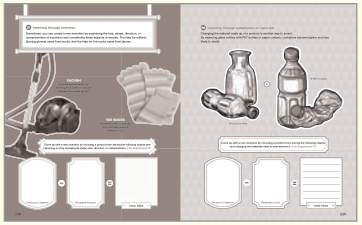
Parachutes

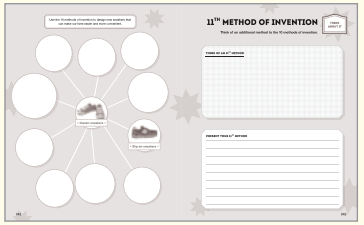
Injection needles

Suction plates









09 Teaching point

Help students understand inventions through recycling and design a new invention by using this method.

Inventing through recycling

1) Overview

Creating an invention is obviously different from just recycling waste products. We are not talking about reusing a notebook after erasing everything written on it. Recycling for invention means creating a product that can be adapted for different purposes, whether by grinding it, cutting it, soaking it in water, or even hanging it on the wall like wallpaper.

2) Examples of invention

Food waste animal feed

Food waste can be processed into animal feed, once it has been chemically treated.

Used coal briquette bricks

Bricks made from used coal briquettes are used for interior decorations because they're light and have a nice color.

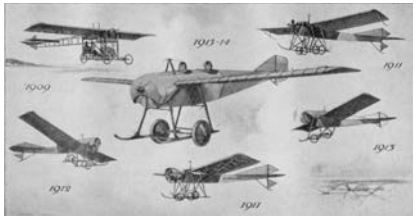
10 Teaching point

Help students understand imitating nature for invention and design a new invention by using this method.

Imitating nature for invention

1) Something to remember

It is crucial to constantly observe and study the characteristics and behavior of animals and plants in order to discover the principles that allow them to do things that humans cannot. A bird flaps its wings while it flies, but there is no airplane that moves its wings to fly. Once scientists learned that a bird's secret to being able to fly is its light bones and lift force, they were able to invent the airplane along similar principles.



Use the 10 methods of invention to design new sneakers that can make our lives easier and more convenient.

• Classic sneakers •

• Slip-on sneakers •

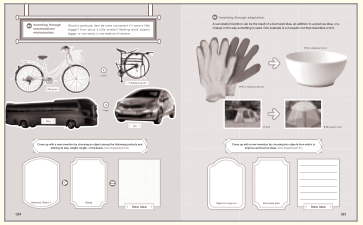
11TH METHOD OF INVENTION

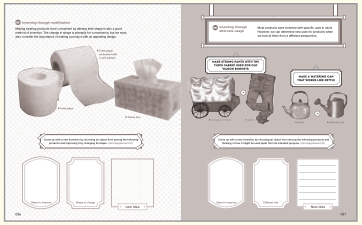
THINK ABOUT IT

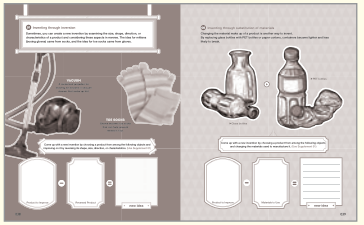
Think of an additional method to the 10 methods of invention.

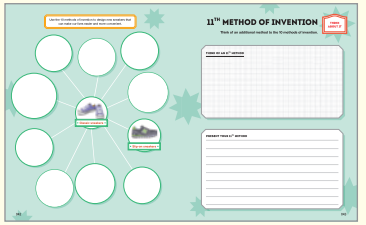
THINK OF AN 11TH METHOD

PRESENT YOUR 11TH METHOD









11 Teaching point

Help students understand the 10 methods of invention they learned and come up with a new method involving sneakers.

Example of a new method of invention #1

See-through Invention

In the past, we used X-rays to find lesions on the human body. Nowadays, doctors can use an endoscope to see inside the human body and diagnose diseases. Patients and their families can view those same images on a screen. Making something see-through can eliminate certain mysteries and boost people's confidence.

Suggestions for a successful activity

- In addition to the suggested method of subtraction for invention, we recommend letting students use the other methods of invention they have learned.
- They can choose either to come up with several different products using one method of invention or to design one product using various methods of invention.
- It would be best to notify students of the preparation materials in advance, so they can keep those materials in mind when thinking of ideas for the new sneakers.
- Allow them to imitate other people's ideas when concluding and presenting the activity.

Exampleof a newmethodof invention #2

Making a hole for invention

Making a hole allows you to reduce costs in materials while also enabling the object to be hung upon something. Many products are more effective with a hole in them. For example, stamps became easier to rip off from a sticker sheet after holes were inserted between each stamp. Also, making a hole on the handle of a comb may seem like nothing, but it was a successful invention because it allowed us to finally be able to hang them up when not being used.

Examples of inventions

- An insurance company agent once made a hole on the tip of a pen so the flow of the ink inside would be partially obstructed. His creation was a big success.
- About 150 years ago, American captain Hanson Gregory was trying to figure out how to eat bread while sailing, since the wheel was too big to control with one hand. After thinking for a long time, he finally found a way. He made a hole in the middle of the piece of bread so he could put it on the handle of the wheel! The hole also made the entire bread evenly baked and taste better.

PART 4
BALANCE AND INVENTION

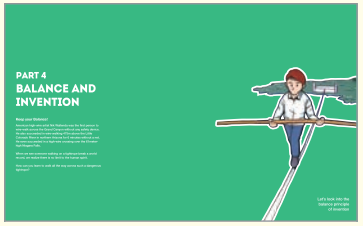
Keep your Balance!

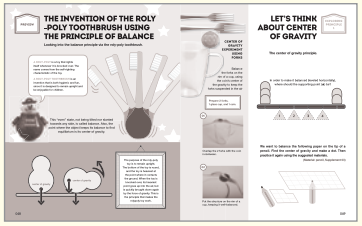
American high-wire artist Nik Wallenda was the first person to wire-walk across the Grand Canyon without any safety device. He also succeeded in wire-walking 475m above the Little Colorado River in northern Arizona for 6 minutes without a net. He even succeeded in a high-wire crossing over the 61meter-high Niagara Falls.

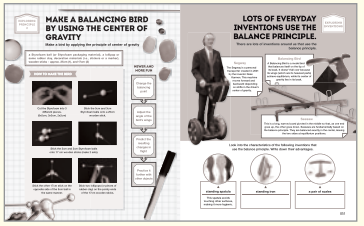
When we see someone walking on a tightrope break a world record, we realize there is no limit to the human spirit.

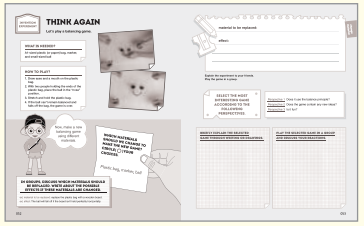
How can you learn to walk all the way across such a dangerous tightrope?

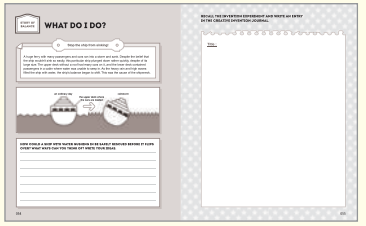
Let's look into the balance principle of invention











Balance and Invention

Teacher's guide

1. Let students know that balance is the stability of the center of gravity of an object and the equal distribution of weight between objects.
2. Let students explore inventions that use the principle of balance in our daily lives.
3. Let students make various toys that use the principle of balance.
4. Apply the invention technique to come up with various balancing games. Let students participate in these activities.

Class management

Introduce	Develop	Conclude
• Understand the reasoning behind using a long pole while tightrope walking. • Inform students of the learning goal.	• Let's look into inventions that use the balance principle in our daily lives. • Let's look into the principle of the center of gravity. • Make a simple invention that uses the center of gravity. • Search for more inventions that use the balance principle. • Play a balancing game.	• Review the principle of balance and the center of gravity. • Solve everyday problems by applying the balance principle.

Introduction

Why is it that we hold onto an umbrella or a long pole when we walk on a tightrope?
When people walk across a tightrope with nothing in their hands, their bodies tilt more easily, making them more liable to fall. It is easier to remain balanced while holding onto an umbrella or a long pole. Furthermore, a long pole has half of the pole's center of gravity weighing down both ends of the pole, thus increasing the rotational inertia and helping acrobats remain well-balanced when walking the tightrope.

Inform students of the learning goal

Let's look into the usage of the balance principle in invention.

Inform them of the learning activity

Rotational Inertia An object that rotates will continue its course, whereas an object that doesn't will stay as it is. Without any external influence, a top that rotates will continue to rotate, and a resting top will continue to remain at rest. A tightrope walker balancing with a long pole uses this rotational inertia to keep his/her balance. A long pole's center of gravity is distant from the center of the pole, which serves as the axis of rotation. Thus, a long pole's rotational inertia is very great. When an acrobat walking on a tightrope starts to tilt, he/she will rotate the pole from its center, the spot onto which he/she is tightly holding. However, due to the long pole's great rotational inertia, it takes a long time for the pole to complete that rotation. The acrobat will use this time to find his/her balance. Therefore, it is favorable to have a longer pole, since the longer the pole, the greater the rotational inertia and the longer an acrobat has to find his/her balance.

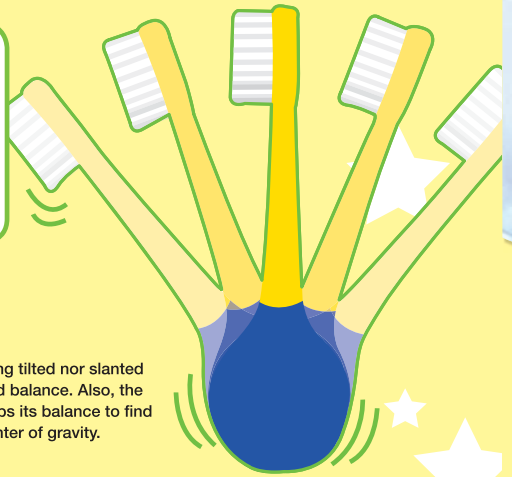
PREVIEW

THE INVENTION OF THE ROLY -POLY TOOTHBRUSH USING THE PRINCIPLE OF BALANCE

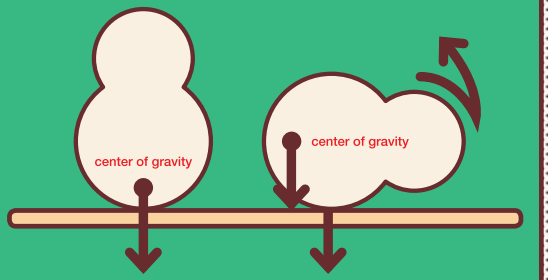
Looking into the balance principle via the roly-poly toothbrush.

A ROLY-POLY is a toy that rights itself whenever it is knocked over. The name comes from the self-righting characteristic of the toy.

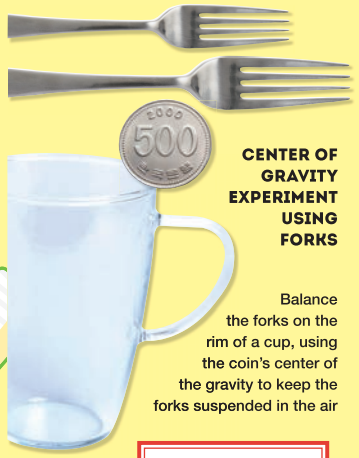
A ROLY-POLY TOOTHBRUSH is an invention that is both hygienic and fun, since it is designed to remain upright and be enjoyable for children.



This "even" state, not being tilted nor slanted towards any side, is called balance. Also, the point where the object keeps its balance to find equilibrium is its center of gravity.



The purpose of the roly-poly toy is to remain upright. The bottom of the toy is round, and the toy is heaviest at the point where it contacts the ground. When the toy is knocked over, its heaviest point goes up into the air, but is quickly brought down again by the force of gravity. This is the principle that makes the rolypoly toy work.



CENTER OF GRAVITY EXPERIMENT USING FORKS

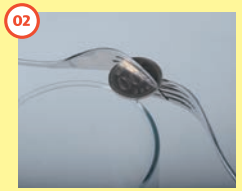
Balance the forks on the rim of a cup, using the coin's center of the gravity to keep the forks suspended in the air

Prepare 2 forks, 1 glass cup, and 1 coin.

01

Overlap the 2 forks with the coin in-between.

02



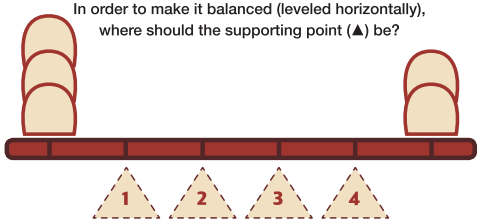
Put the structure on the rim of a cup, keeping it well-balanced.

LET'S THINK ABOUT CENTER OF GRAVITY

EXPLORING PRINCIPLE 1

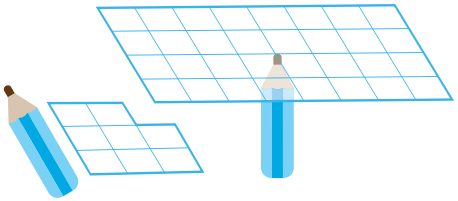
The center of gravity principle.

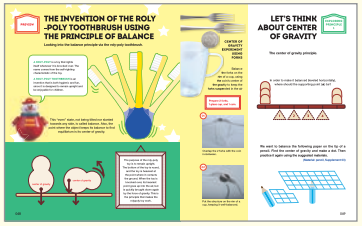
In order to make it balanced (leveled horizontally), where should the supporting point (▲) be?

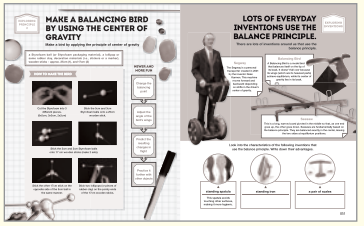


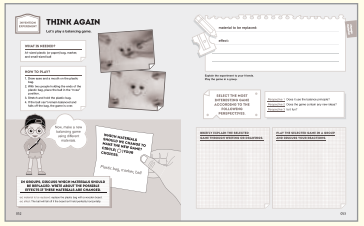
We want to balance the following paper on the tip of a pencil. Find the center of gravity and make a dot. Then practice it again using the suggested materials.

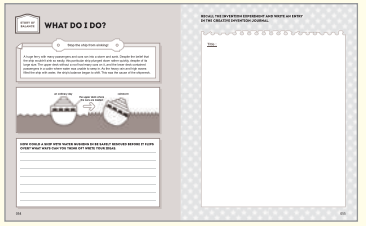
(Material: pencil, Supplement 03)











01 Teaching point

Understand the center of gravity principle, and then get to know the precise concept of balance and center of gravity.

Preview

Demonstrating the balance principle through the roly-poly toothbrush

Use the roly-poly toothbrush to learn about the center of gravity.
Demonstrate the center of gravity using the roly-poly toothbrush. Then apply the concept to various hands-on activities.

1) Why won't a roly-poly toothbrush fall over?
- It won't fall over because its center of gravity is at the bottom.
- It uses the roly-poly principle.

2) What is good about a roly-poly toothbrush?
- It always stands upright, so the brush part doesn't touch any surface, making it hygienic.
- Even when it falls over, it rights itself again. Children will find it fun, and brushing becomes more enjoyable.

3) Balance
- A perfectly even state, not tilted nor slanted towards any side.

4) Center of gravity
- The point of equilibrium.
  Guide students with illustrations to give them a precise understanding of the concepts of balance and the center of gravity.

5) What other daily objects use the roly-poly principle?
- Look for things that use the roly-poly principle and then think about what keeps those objects from falling over.

roly-poly toy

lamp that doesn't fall over

02 Teaching point

The principles of the center of gravity and of balance should be taught with interesting experiments.

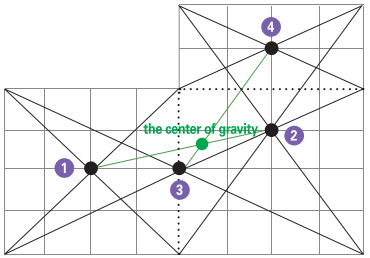
Exploring Principle #1

Explore the center of gravity principle

Experience horizontality by finding the center of gravity through simple experiments

1) Pay attention to:
- predict→experience→discover are the required steps in developing this learning activity.
- Let students physically experiment on balance and the center of gravity on their own.

2) Finding the center of gravity for a figure



- Draw diagonal lines through the figures on the left and right side. Then find the center of gravity for ① and ②.
- Connect the center of gravity for ① and ② in a straight line.
- Make diagonal lines separating the figures on the top and bottom. Then find the center of gravity for ③ and ④.
- Connect the center of gravity for ③ and ④. The point where lines ①/② and ③/④ meet becomes the center of gravity for the whole figure.

3) Flying fork center of gravity experiment
- After interlocking the tines on the forks, place them opposite of each other and set a coin on them.
- Place one side of the coin on the rim of a cup, keeping it well balanced according to its center of gravity.
- Through the experiment, illustrate the principles of balance and the center of gravity and balance at work in our daily lives.

※The instructing will be more effective if the teacher practices the experiment on his/her own before class.

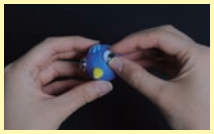
EXPLORING PRINCIPLE 2

MAKE A BALANCING BIRD BY USING THE CENTER OF GRAVITY

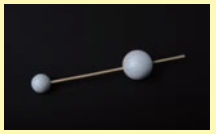
Make a bird by applying the principle of center of gravity

a Styrofoam ball (or Styrofoam packaging material), a lollipop or some rubber clay, decoration materials (i.e., stickers or a marker), wooden sticks – approx. 25cm (1), and 17cm (2)

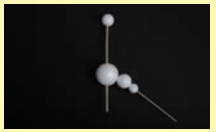
HOW TO MAKE THE BIRD



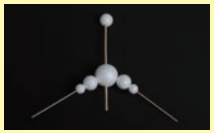
Cut the Styrofoam into 3 different pieces. (5x5cm, 3x3cm, 2x2cm)



Stick the 5cm and 3cm Styrofoam balls onto a 25cm wooden stick.



Stick the 3cm and 2cm Styrofoam balls onto 17 cm wooden sticks (make 2 sets).

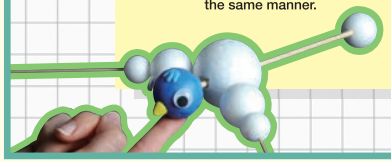


Stick the other 17cm stick on the opposite side of the 5cm ball in the same manner.

Stick two lollipops (or pieces of rubber clay) on the pointy ends of the 17cm wooden sticks.

NEWER AND MORE FUN

- Change the balancing point
- Adjust the angle of the bird's wings
- Predict the resulting changes in flight
- Practice it further with other objects



EXPLORING INVENTIONS

LOTS OF EVERYDAY INVENTIONS USE THE BALANCE PRINCIPLE.

There are lots of inventions around us that use the balance principle.

Segway

The Segway is a personal transporter created in 2001 by the inventor Dean Karmen. This machine moves forward and backward depending on shifts in the driver's center of gravity.

Balancing Bird

A Balancing Bird is a model bird that balances itself on the tip of its beak. It doesn't fall over because its wings (which are its heaviest parts) achieve equilibrium, while its center of gravity lies in its beak.

Seesaw

This is a long, narrow board pivoted in the middle so that, as one end goes up, the other goes down. Seesaws are fundamentally based on the balance principle. They are balanced exactly in the center, leaving the two sides at equilibrium positions.

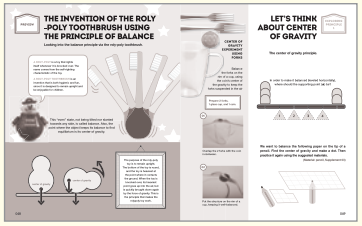
Look into the characteristics of the following inventions that use the balance principle. Write down their advantages.

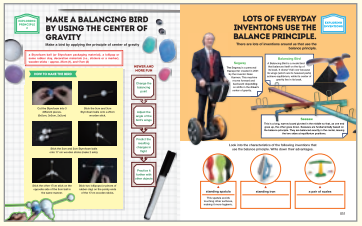
standing spatula

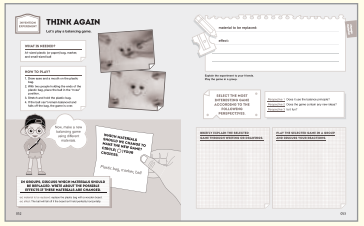
This spatula avoids touching other surfaces, making it more hygienic.

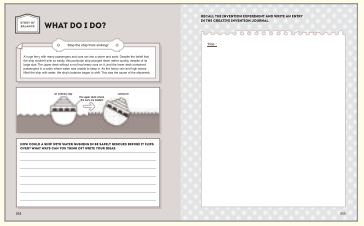
standing iron

a pair of scales









03 Teaching point

Understand the center of balance principle and find new interesting ways to explore it.

Exploring Principle #2

Use centerof gravity to construct a bird

Make a "roly-poly bird" and explore how the center of gravity principle applies.

1) Pay attention to the following things when constructing it:

- Properly adjust the angles of the wooden sticks (wings).
- Be careful of the sharp ends of the wooden sticks, as they may be cause injury.
- While crafting, emphasize locating the center of gravity rather than decoration.

2) Note for teachers

- Encourage awareness of the center of gravity principle when making the roly-poly bird.
- In the "Newer and More Fun" section, let students explore the center of gravity principle through various experiments.
- If there is insufficient class time, the "Newer and More Fun" part can be assigned as homework.

04 Teaching point

Look for inventions that use the balance principle.

Exploring Inventions

Inventions that use the balance principle

Various everyday inventions that use the balance principle.

1) Exploring the Segway

Just like the commonly used posture sensor in a Smartphone, an equilibrium sensor allows the Segway to maintain its balance. The Segway recalibrates its balance approximately 100 times per second. Also, once fully charged, the battery lasts for about 6 hours of driving.

2) Things to keep in mind when exploring inventions

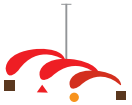
- Present students with an enlarged mechanical drawing of the center of gravity in chosen inventions.
- Let students find the center of gravity on their own, then help them understand the balance principle.
- Let students think about the advantages of inventions that use the balance principle.
- Lead the class to consider why we create inventions like these, encouraging them to think about how inventions have helped eliminate discomfort in our lives.

3) The advantages of inventions that use the balance principle

standing cellular phone
It doesn't fall because its center of gravity is at the bottom.

standing iron
It doesn't fall over, so it is not prone to burning clothes or causing fires.

scale
It weighs objects by using the balance principle.

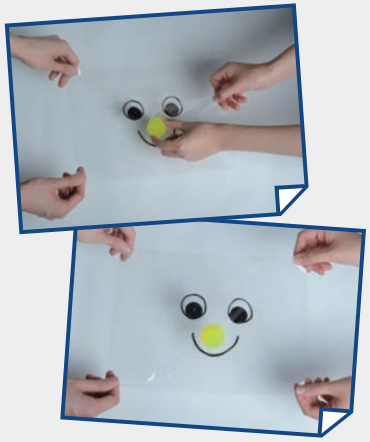


mobile
It hangs steadily without tilting.

INVENTION EXPERIMENT

THINK AGAIN

Let's play a balancing game.



WHAT IS NEEDED?

A1-sized plastic (or paper) bag, marker, and small-sized ball

HOW TO PLAY?

1. Draw eyes and a mouth on the plastic bag.
2. With two people holding the ends of the plastic bag, place the ball in the "nose" position.
3. Stretch and hold the plastic bag.
4. If the ball can't remain balanced and falls off the bag, the game is over.

IN GROUPS, DISCUSS WHICH MATERIALS SHOULD BE REPLACED. WRITE ABOUT THE POSSIBLE EFFECTS IF THESE MATERIALS ARE CHANGED.

ex) material to be replaced: replace the plastic bag with a wooden board.
ex) effect: The ball will fall off if the board isn't held perfectly horizontally.

change material

material to be replaced:

effect:

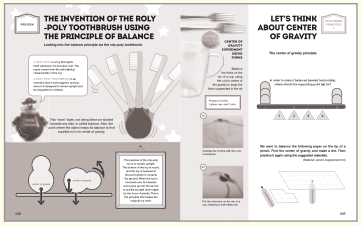
Explain the experiment to your friends.
Play the game in a group.

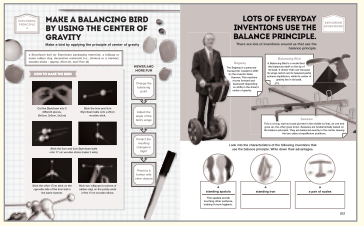
SELECT THE MOST INTERESTING GAME ACCORDING TO THE FOLLOWING PERSPECTIVES.

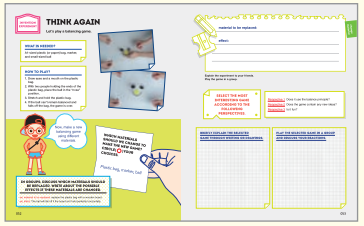
Perspective 1 Does it use the balance principle?
Perspective 2 Does the game contain any new ideas?
Perspective 3 Is it fun?

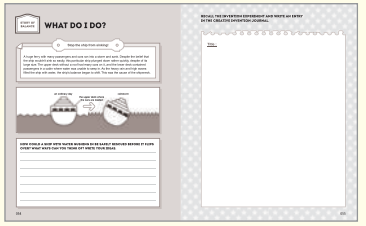
BRIEFLY EXPLAIN THE SELECTED GAME THROUGH WRITING OR DRAWINGS.

PLAY THE SELECTED GAME IN A GROUP AND DISCUSS YOUR REACTIONS.









05 Teaching point

Apply the invention method to the balancing game and plan out a new game.

Invention experiment

Plan out a balancing game

Make a game tool that uses the balance principle. Then make plans for a new and fun balancing game by using the invention method.

1) Altering materials

This is a method for coming up with newer, better inventions by altering the materials used for the selected objects.

Example 1 _ **Gloves**

After knitted gloves were invented to keep people warm, gloves made from other materials–such as rubber, cotton, leather, and plastic–were soon created.


Rubber gloves


Leather gloves


Cotton gloves


Knitted gloves

Example 2 _ **Cup**

Cups that were once made from plastic, glass, and soil can now be made from paper, making the cups light and inexpensive. Also, brands can be printed on the paper cups as a form of advertising.


Mug


Paper cup

Example 3 _ **Shoe fasteners**

Shoe fasteners have also evolved and changed. Laces are often replaced with variousmaterials such as zippers and Velcro.


Lace sneakers


Velcro sneakers

2) Notable points when playing the balancing game

- The plastic bag needs to be stretched tightly in order to maintain good balance.
- Help students keep the balance principle in mind as they think about how to keep the ball from falling.
- Handle the plastic bag with care so that it doesn't rip.

06 Teaching point

Through the method of altering materials, think of new invention ideas.

1) Things to keep in mind when planning out a newbalancing game

- From among the plastic bag, permanent marker, and ball, select the material that should be changed.
- Once thematerial is changed, the object should be improved.
- Look for reusable materials that are easy to find.
- Lead the class so that new inventive ideas using the balance principle are introduced.

2) Things to keep in mind when selecting a new idea and game

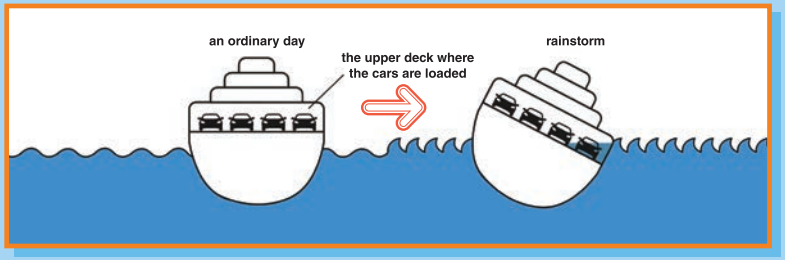
- Help students select a game after careful evaluation has been made.
- If time is limited, allowstudents to apply the concept during a break time or after school has finished.

STORY OF BALANCE

WHAT DO I DO?

Stop the ship from sinking!

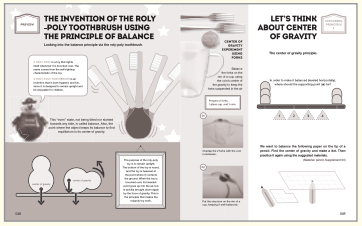
A huge ferry with many passengers and cars ran into a storm and sank. Despite the belief that the ship wouldn't sink so easily, this particular ship plunged down rather quickly, despite of its large size. The upper deck without a roof had many cars on it, and the lower deck contained passengers in a cabin where water was unable to seep in. As the heavy rain and high waves filled the ship with water, the ship's balance began to shift. This was the cause of the shipwreck.

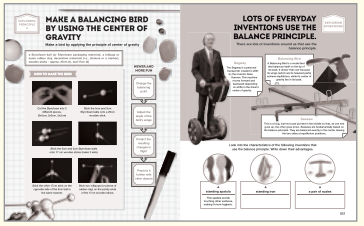


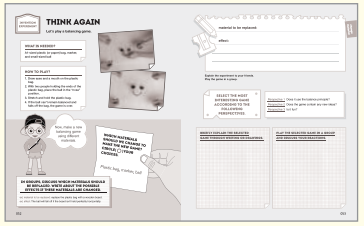
HOW COULD A SHIP WITH WATER GUSHING IN BE SAFELY RESCUED BEFORE IT FLIPS OVER? WHAT WAYS CAN YOU THINK OF? WRITE YOUR IDEAS.

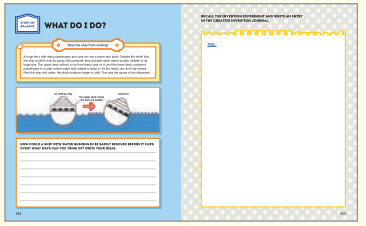
RECALL THE INVENTION EXPERIMENT AND WRITE AN ENTRY IN THE CREATIVE INVENTION JOURNAL.

Title :









07 Teaching point

Solve problems in various ways by using the balance principle.

Balance

Read the story and use the balance principle to solve problems.

1) What is the problem?

- A large ferrymet a stormand was capsized.

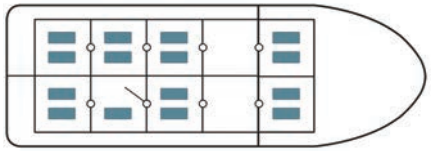
2) Why did it capsize?

- The upper deck, where the cars were kept, had water pouring in. This made the ferry tilt to one side and eventually capsize.
- The interior of the ferry, where the ship was balanced, had water pouring in. The water broke the ferry's balance and made it tilt to one side before capsizing.

3) Possible Solutions

- Separate the upper deck, where the cars are loaded, so that even if there is water pouring in from the storm, each enclosed compartment prevents water leakage.
- Build a roof over the deck where the cars are loaded.
- Make a hole in the lower deck, which would allow the water to drain from the bottom of the ferry and into the sea. By doing this, the center of gravity will be pulled down even further so that it can more effectively ride the wind and waves, as in the roly-poly principle.

Separate the upper deck



Make a hole in the lower deck

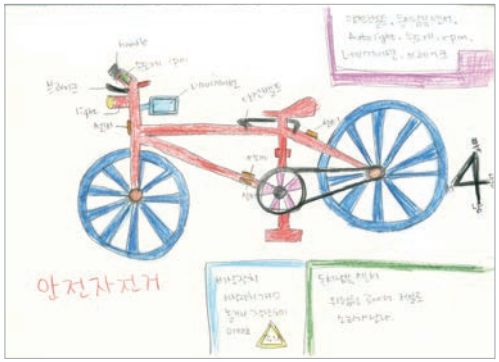
08 Teaching point

Guide students to express their ideas in the invention journal.

Invention Journal

Encourage students to express in the invention journal what they felt during the "Balance and Invention" experiment.

1) Invention Journal example



2) Tips for journal writing

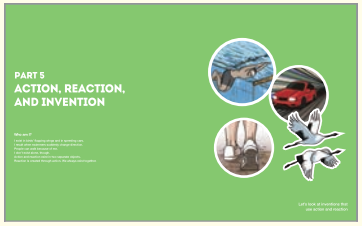
- Guide students to express the things they learned and felt. Let them use the invention journal to introduce inventions that they would like to make, and to write down any ideas that theymight have had.
- Let students freely express themselves through pictures, mind maps, and othermeans, without any restriction in format.
- Use their journals to reinforce and clarify the theme of the chapter.

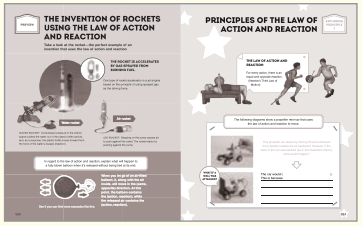
PART 5
ACTION, REACTION, AND INVENTION

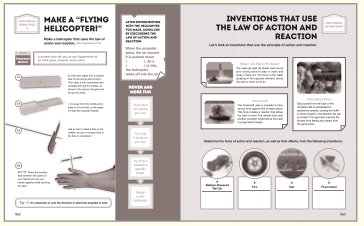
Who am I?

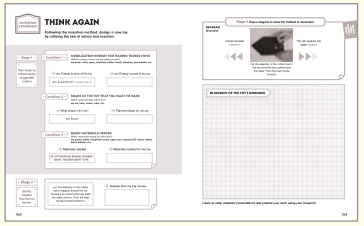
I exist in birds' flapping wings and in speeding cars.
I result when swimmers suddenly change direction.
People can walk because of me.
I don't exist alone, though.
Action and reaction exist in two separate objects.
Reaction is created through action. We always exist together.

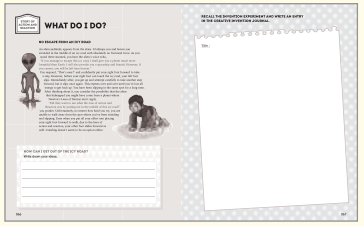
Let's look at inventions that use action and reaction











Action, Reaction, and Invention

Teacher's Guide

1. Let students freely discuss the states of action and reaction.
2. Let students know that there are many common inventions that use the phenomenon of action and reaction.
3. Experience and understand the law of action and reaction through everyday inventions.
4. Help students apply the invention method and plan out new ideas.

Class management

Introduce	Develop	Conclude
• Understand the meaning of "Who am I?" through action and reaction. • Inform students of the learning goal.	• Understand the invention of rockets through the law of action and reaction. • Make "Fly, Helicopter!" after understanding the law of action and reaction. • Search for more inventions that use the law of action and reaction. • Create a toy using the law of action and reaction. Afterwards, design a new science-related toy.	• Review the law of action and reaction. • Solve problems using the action and reaction story.

Introduction

Think about what "I" could be and examine the meaning of action and reaction. What do the students understand action and reaction to be? Furthermore, stimulate the students' curiosity by connecting the law of action and reaction to everyday inventions.

Inform students of the Learning Goal

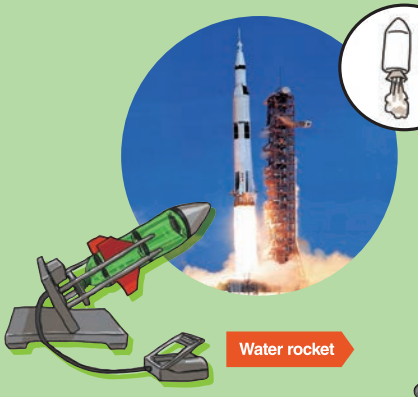
Use various experiments to examine inventions that use action and reaction.

Inform students of the Learning Activity

PREVIEW

THE INVENTION OF ROCKETS USING THE LAW OF ACTION AND REACTION

Take a look at the rocket—the perfect example of an invention that uses the law of action and reaction



THE ROCKET IS ACCELERATED BY GAS SPRAYED FROM BURNING FUEL.

One type of rocket accelerator is a jet engine based on the principle of using sprayed gas as the driving force.

WATER ROCKET: Compressed pressure in the interior space pushes the water out of the plastic bottle (action), and, as a response, the plastic bottle moves forward from the force of the water's escape (reaction).

AIR ROCKET: Stepping on the pump causes air to push against the rocket. The rocket reacts by pushing against the pump.

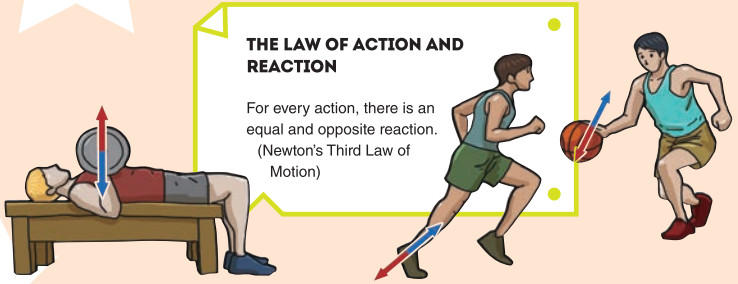
In regard to the law of action and reaction, explain what will happen to a fully blown balloon when it's released without being tied at its end.

When you let go of an air-filled balloon, it, along with the air inside, will move in the (same, opposite) direction. At this point, the balloon contains the (action, reaction), while the released air contains the (action, reaction).

See if you can find more examples like this.

PRINCIPLES OF THE LAW OF ACTION AND REACTION

EXPLORING PRINCIPLE 1



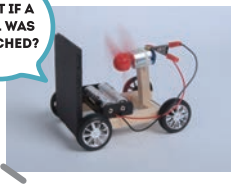
THE LAW OF ACTION AND REACTION

For every action, there is an equal and opposite reaction. (Newton's Third Law of Motion)

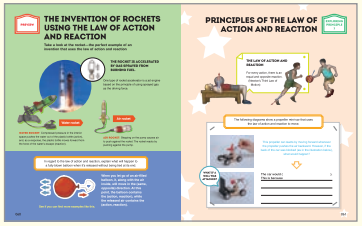
The following diagrams show a propeller mini-car that uses the law of action and reaction to move.

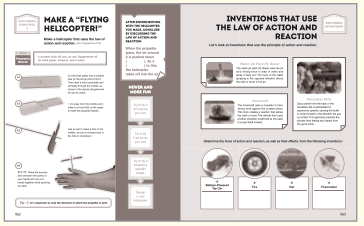
This propeller car reacts by moving forward whenever the propeller pushes the air backward. However, if the back of the car was blocked (as in the illustration below), what would happen?

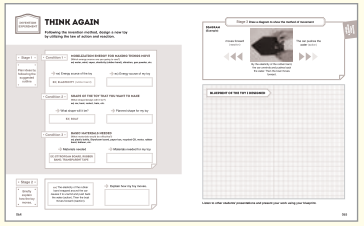
WHAT IF A WALL WAS ATTACHED?

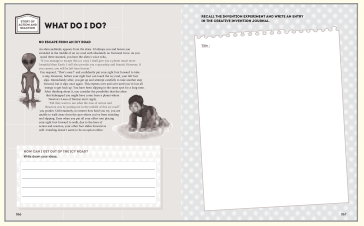


The car would ( ).
This is because









01 Teaching point

Introduce various kinds of rockets, and then lead the students to explain the principle behind the usage of action and reaction.

Preview

The law of action and reaction via a rocket

- By highlighting inventions from our daily lives, help students understand the law of action and reaction
- Talk about various other examples around us.

1) The physical meaning of action and reaction

Action Some physical cause or body contributes to another cause or body (or any similar phenomenon).

Reaction When object A exerts an energy force onto object B, how object B exerts the same force in the opposite direction onto object A.

2) The misconception that students easily fall into

Usually because of how a rocket or balloon moves forward, students often assume the frontal direction of a moving object to be the action. However, scientifically, the force at the back that pushes away from the rocket or balloon is the action, and the movement of going forward is the reaction. This should be pointed out so that students know how to distinguish between the two.

Things to read: "The Birth of a Rocket"

A rocket is a cutting edge transportation tool that lets us fly anywhere in the world. It is the only powered vehicle that can travel in water, air, and even in space. However, rockets were first introduced to the world a lot earlier than you might think. During the 13th century in China, and the 15th century in Korea, the principle of rocketry was used to make a weapon that shot out arrows or spears. Also, during the 16th century, rockets were attached to a chair in an attempt to create a flying chair.

02 Teaching point

Search for the hidden law of action and reaction from among everyday inventions.

Exploring Principle #1

The action and reaction principle through a case study

1) An example of action and reaction in our lives

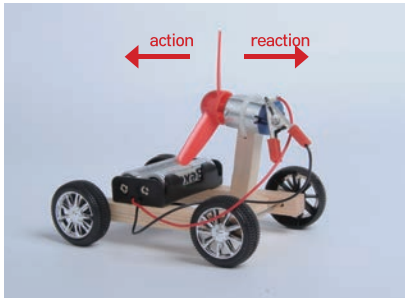
When a person's foot pushes the ground, the ground also pushes the foot. This allows a person to move forward.

2) What is the "Law of Action and Reaction"?

For every action, there is always an equal and opposite reaction. Therefore, both objects give off equal energy to each other in opposite directions. This concept of mutual action is called Newton's Third Law of Motion.

3) The law of action and reaction hidden inside the propeller car

- After reading the story of the first propeller car, mark the action and reaction with an arrow (→).



- **The reason why the second propeller car doesn't move**
  When the wind blows (action 1), it propels the car forward in the opposite direction (reaction 1). The car gains momentum by heading in the opposite direction as the wind. If the wind is blown towards the wall (action 2), the wind would lose its momentum, and the lost momentum (reaction 2) of the wind (air) would be returned to the car. Hence, the momentum of the forces would balance out, and the car would barely move. If the angle of the propeller or the wall is changed even only by a bit, the direction of the force would change.

EXPLORING PRINCIPLE 2

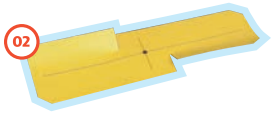
MAKE A "FLYING HELICOPTER!"

Make a helicopter that uses the law of action and reaction. (Use Supplement 05)

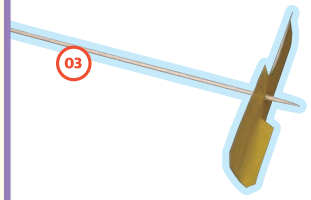
Preparation Material

a wooden stick (15 cm), an awl, Supplement 05 (or thick paper, scissors, and a ruler).

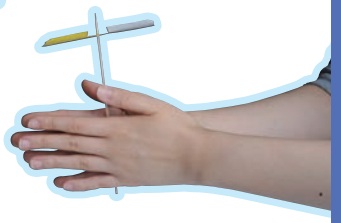
01 Cut the thick paper into a suitable size for the wings (3cm×10cm). Then draw a line horizontally and vertically through the middle, as shown in the picture (Supplement 05 can be used).



02 1 cm away from the middle point, make a cut and fold up the paper to make the propeller blades.



03 Use an awl to make a hole in the middle, and put a wooden stick in the hole to complete it.



04 **FLY IT:** Place the wooden stick between the palms of your hands and rub your hands together while spinning the stick.

Tip ➔ It is important to note the direction in which the propeller is bent.

AFTER EXPERIMENTING WITH THE HELICOPTER YOU MADE, CONCLUDE BY DISCUSSING THE LAW OF ACTION AND REACTION.

When the propeller spins, the air around it is pushed down ( ). As a ( ) to this, the helicopter takes off into the air.

NEWER AND MORE FUN

- Try to fly it as high as you can.
- Try to fly it as far as you can.
- Try to fly it towards a specific target.
- Design a new helicopter.

INVENTIONS THAT USE THE LAW OF ACTION AND REACTION

EXPLORING INVENTIONS

Let's look at inventions that use the principle of action and reaction.

Water Jet Pack *Fly Board*

The water jet pack *Fly Board* uses the jet ski's driving force to draw in water and spray it back out. The force of the water spraying in the opposite direction allows the rider to hover in the air.

Hovercraft

The hovercraft uses a propeller to blow strong wind against the surface below. This force creates a reaction that allows the craft to hover. The vehicle then uses another propeller positioned at the back to propel itself forward.

Recoilless Rifle

Gas pushed from the back of the recoilless rifle is accelerated to supersonic speeds, causing the bullet to move forward in the direction the gun is pointed. This approach prevents the shooter from feeling any impact from the gun's recoil.

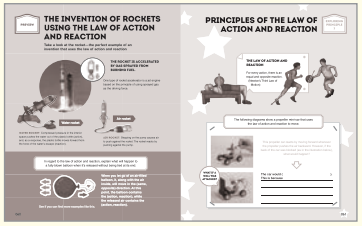
Determine the force of action and reaction, as well as their effects, from the following inventions:

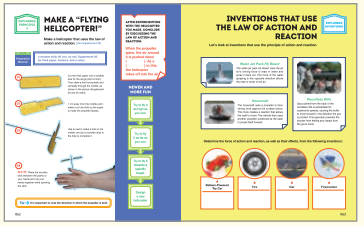
Balloon-Powered Toy Car

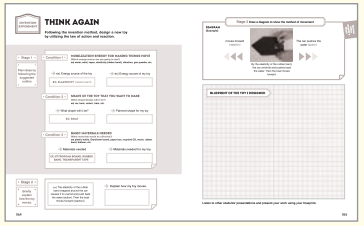
Tire

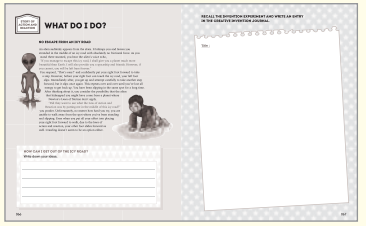
Oar

Firecracker









03 Teaching point

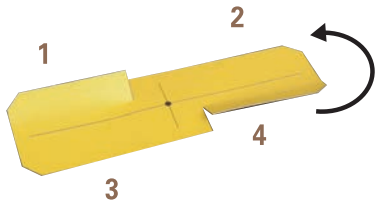
Help students understand the law of action and reaction by making a helicopter toy.

Exploring Principle #2

Making a helicopter toy

Bend the propeller wings in various directions

ex) bend down wings ① and ④ → the helicopter moves up
bend up wings ② and ③ → the helicopter moves down



The hole needs to bemade right in themiddle, with the wings bent symmetrically.

1) Substitutionary Material

It is a good idea to let the students find othermaterials to substitute.

2) Note for Teachers

- In the "Newer and More Fun" section, design a better invention through multiple attempts. It is advised for teachers to praise and encourage students when they come up with new methods of exploration.
- It is also recommended that students have a chance to work independently on these experiments after school.

04 Teaching point

Search for other inventions that apply the law of action and reaction.

Exploring Inventions

Inventions are all around us. Let students find and discuss inventions other than the onesmentioned in the textbook.

1) Preliminary guide

It is advisable to let students think about inventions that use the principle of action and reaction, and to talk about these thoroughly before introducing the inventions in the textbook.

2) Things to keep in mind when exploring inventions

- It is advisable to show students' examples while taking into consideration their backgrounds and level, so that the concept may be more easily understood.
- Instead of finding the results of action and reaction in these inventions, concentrate on their effectiveness. It is more important to consider the purpose and process of such a creation.

INVENTION EXPERIMENT

THINK AGAIN

Following the invention method, design a new toy by utilizing the law of action and reaction.

Stage 1

Plan ideas by following the suggested outline

Condition 1 — **MOBILIZATION ENERGY FOR MAKING THINGS MOVE**

(Which energy source are you going to use?)

ex) water, wind, vapor, elasticity (rubber band), vibration, gun powder, etc.

ex) Energy source of the toy

EX) ELASTICITY (rubber band)

ex) Energy source of my toy

Condition 2 — **SHAPE OF THE TOY THAT YOU WANT TO MAKE**

(What shape/design will it be?)

ex) car, boat, rocket, train, etc.

What shape will it be?

EX) BOAT

Planned shape for my toy

Condition 3 — **BASIC MATERIALS NEEDED**

(What materials would be effective?)

ex) plastic bottle, Styrofoam board, paper box, recycled CD, motor, rubber band, balloon, etc.

Materials needed

EX) STYROFOAM BOARD, RUBBER BAND, TRANSPARENT TAPE

Materials needed for my toy

Stage 2

Briefly explain how the toy moves.

ex) The elasticity of the rubber band wrapped around the oar causes it to unwind and push back the water (action). Then the boat moves forward (reaction).

Explain how my toy moves.

Stage 3 Draw a diagram to show the method of movement

borrow other people's ideas

DIAGRAM (Example)

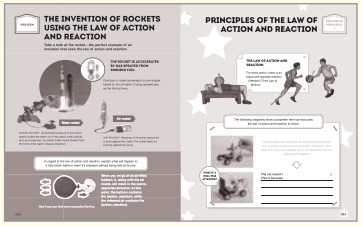
moves forward (reaction)

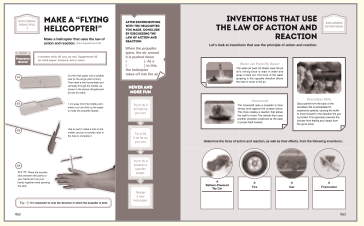
The car pushes the water (action)

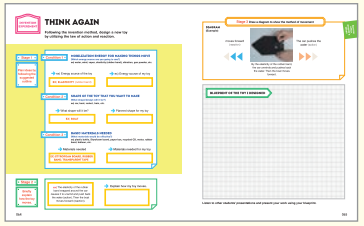
By the elasticity of the rubber band, the oar unwinds and pushes back the water. Then the boat moves forward.

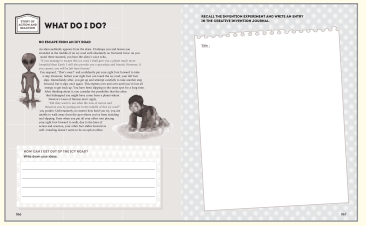
BLUEPRINT OF THE TOY I DESIGNED

Listen to other students' presentations and present your work using your blueprint.









05 Teaching point

Design a new toy by applying the action and reaction principle to the invention method.

Invention Experiment

Make a science-related toy by utilizing the action and reaction principle

Create the illustrated toy by utilizing the law of action and reaction.

1) Something to remember when designing a new toy
- Remind students of the invention method and help them design their own ideas.

2) Emphasis when following the stages of designing an idea
- Encourage students to study and employ other people's ideas in the invention to practice the stages of invention.
- Support students who may have difficulties.
- Encourage students to come up with their own designs ideas so that their designs can come to completion through hands-on experience.

06 Teaching point

Have students express their own ideas through diagrams.

1) Emphasis when selecting and working on a new idea
- Give students the evaluation criteria for their invention ideas and help them set clear goals in creating such inventions.
- It is advised for students to peer-evaluate each other's new ideas rather than for the teacher to do so.

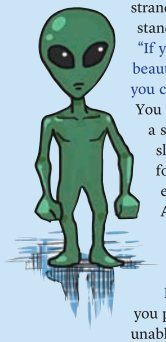
2) Methods for evaluating new ideas
- **Perspective 1**: Does your idea apply the law of action and reaction?
- **Perspective 2**: Did you glean any new ideas fromthis scientific toy?
- **Perspective 3**: Is it fun?

3) Emphasis when exploring the selected idea
- If students are unable realize their own inventions, an oral explanation with an illustration is enough for them to express their inventions' potential.
- It is important to explore the results after creating the selected invention. Since there is a possibility that the idea will become an actual invention, the teacher's active participation is required. The teacher should intervene in this process with the intent of increasing the idea's value as an invention, rather than intervening merely to criticize it.

STORY OF ACTION AND REACTION

WHAT DO I DO?

NO ESCAPE FROM AN ICY ROAD



An alien suddenly appears from the skies. It kidnaps you and leaves you stranded in the middle of an icy road with absolutely no frictional force. As you stand there stunned, you hear the alien's voice echo,

"If you manage to escape this icy road, I shall give you a planet much more beautiful than Earth. I will also provide you a spaceship and friends. However, if you cannot, you will be left here forever."

You respond, "That's easy!" and confidently put your right foot forward to take a step. However, before your right foot can touch the icy road, your left foot slips. Immediately after, you get up and attempt carefully to take another step forward, but it slips once again. This repeats over and over until you've lost all energy to get back up. You have been slipping in the same spot for a long time.

After thinking about it, you consider the possibility that the alien that kidnapped you might have come from a planet where Newton's Laws of Motion don't apply.

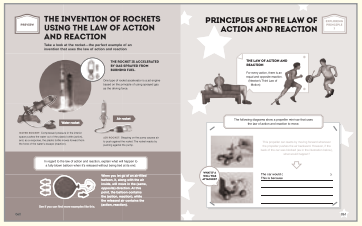
"Did they want to see what the Law of Action and Reaction was by putting me in the middle of this icy road?" you ponder. Unfortunately, no matter how hard you try, you are unable to walk away from the spot where you've been standing and slipping. Even when you put all your effort into placing your right foot forward to walk, due to the laws of action and reaction, your other foot slides forward as well. Crawling doesn't seem to be an option either.

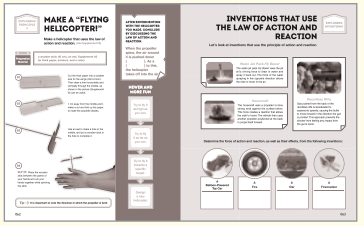
HOW CAN I GET OUT OF THE ICY ROAD?

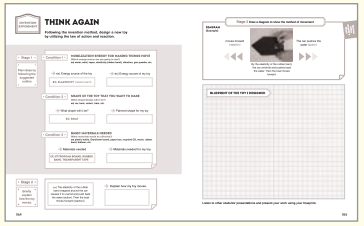
Write down your ideas.

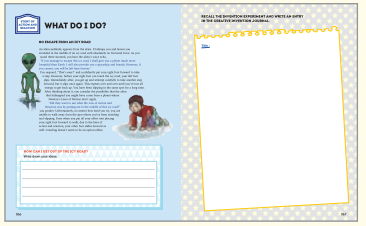
RECALL THE INVENTION EXPERIMENT AND WRITE AN ENTRY IN THE CREATIVE INVENTION JOURNAL.

Title :









07 Teaching point

Let the students read the story and apply the law of action and reaction to solving the problem.

Action & Reaction

1) Action and reaction in movies

In the movie "Gravity," which premiered in 2013, the main character must fly over to a space station all the way from her crew's destroyed Soyuz Space Shuttle, which lacked the necessary fuel. While thinking about what to do, she discovers a fire extinguisher, which she then uses to get to the space station safely. She manages to do this by shooting the fire extinguisher in the opposite direction of where she wants to go.

2) Invention story guidelines

- Let the students read the story first, then ask questions to guide them in understanding the nature of the problem to be solved.

  Ex) What needs to be solved? What (which principle) do you need to understand in order to solve this problem?

- Let students discuss and elaborate on their thoughts.
- Help students to freely engage their thoughts in an open environment.

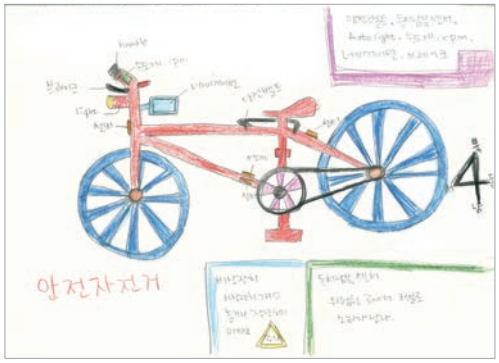
08 Teaching point

Guide students to express their ideas in the invention journal.

Invention Journal

Encourage students to express in the invention journal what they felt during the "Action, Reaction, and Invention" experiment.

1) Examples of invention journals



2) Tips for journal writing

- Guide students to express the things they learned and felt. Let them use the invention journal to introduce inventions that they would like to make, and to record any ideas that theymight have had.
- Let students freely express themselves through pictures, mind maps, and othermeans, without any restriction in format.
- Use their journals to reinforce and clarify the theme of the chapter.

PART 6

SOUND AND INVENTION

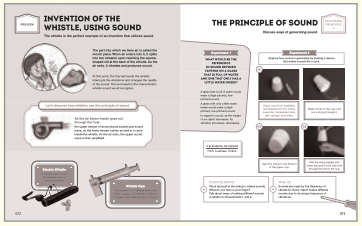
Can an unborn baby hear his or her mother's voice?

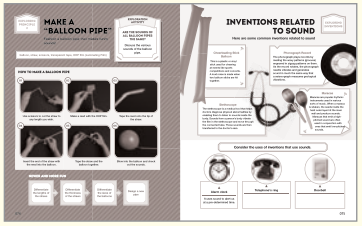
What kind of sound would an unborn baby make? Fetuses feel safest when they hear their mother's voice and can recognize it. They can also listen to music from inside the belly and dance along with the beat. For these reasons, during pregnancy, parents often tell stories and play music as a form of prenatal education.

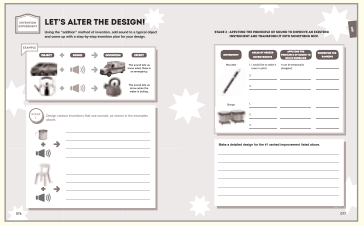
How can an unborn baby hear sound?
Not only can a fetus hear its mother's voice through sound waves in the air, but, while in the womb, it "hears" the vibrations that pass through the mother's body.

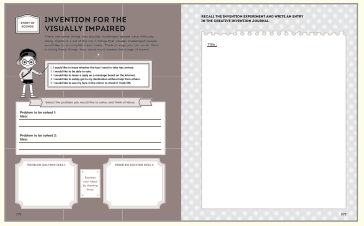
How can we help unborn babies hear the voices of their parents more clearly?

Let's look into inventions that use sound









Sound and Invention

Teacher's guide

1. Help students understand that vibrations generate sounds. Additionally, depending on the vibration frequency, each object produces a different sound.
2. Help students understand the principle of sound and construct a balloon pipe that makes funny noises.
3. Explore everyday inventions related to sound.
4. Apply the method of invention to design a new invention and improve existing musical instrumentsby using the principle of sound.

Class management

Introduce	Develop	Conclude
• Understand how an unborn baby in its mother's tummy can hear sounds. • Inform students of the learning goal.	• Read the invention story of a whistle that uses sound. • Explore the principle of sound. • Make a "balloon pipe." • Find inventions related to sound. • Design a new invention related to sound.	• Solve problems using the principle of sound.

Introduction

The Invention of the Prenatal Sound System

An expecting mom and dad can let their unborn baby listen to stories and music.

Inform students of the learning goal

Let's look into inventions that use sound.

Inform students of the learning activity

01 Preview

02 Exploring Principle

03 Exploring Inventions

04 Invention Experiment

05 Sounds

PREVIEW

INVENTION OF THE WHISTLE, USING SOUND

The whistle is the perfect example of an invention that utilizes sound.

The part into which we blow air is called the mouth piece. When air enters into it, it splits into two streams upon reaching the square-shaped slit at the back of the whistle. As the air exits, it vibrates and produces sound.

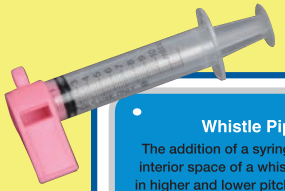
At this point, the tiny ball inside the whistle interrupts the vibrations and changes the quality of the sound. The end result is the characteristic whistle sound we all recognize.

Let's discover how whistles use the principle of sound.

As the air blown inside goes out through the hole,

the upper stream of air produces a particular sound wave, as the lower stream rushes around in a circle inside the whistle. As the air exits, the upper sound wave is then amplified.

Electric Whistle
A whistle that is used by pressing upon it with your hands.



Whistle Pipe
The addition of a syringe alters the interior space of a whistle, resulting in higher and lower pitches in sound.

THE PRINCIPLE OF SOUND

EXPLORING PRINCIPLE 1

Discuss ways of generating sound.

Experiment 1

WHAT WOULD BE THE DIFFERENCE IN SOUND BETWEEN TAPPING ON A GLASS THAT IS FULL OF WATER AND ONE THAT ONLY HAS A LITTLE WATER INSIDE?

A glass that is full of water would make a (high-pitched, low-pitched) sound.

A glass with only a little water inside would make a (high-pitched, low-pitched) sound.

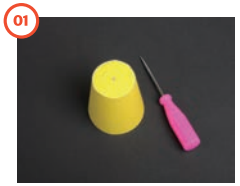
In regard to sound, as the weight of an object decreases, its vibration (increases, decreases).

3 ELEMENTS OF SOUND
Pitch, Loudness, Timbre,

Experiment 2

Explore how sound is generated by making a device that makes sounds like a duck.

01



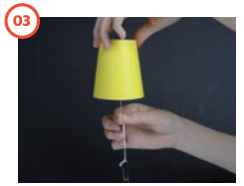
Paper cup (if not available, use Supplement 07), string, paperclip, transparent tape, awl, sponge, and water.

Make a hole in the cup, and run a string through it.

03

Tape the string to the bottom of the paper cup.

03



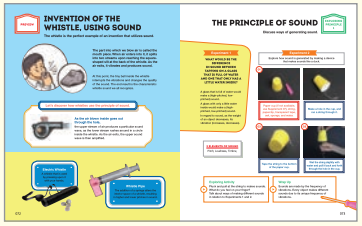
Wet the string slightly with water and pull it back and forth through the hole in the cup.

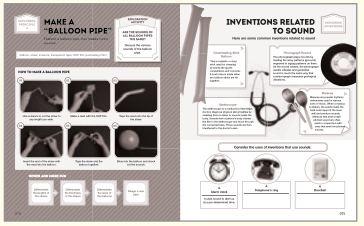
Exploring Activity

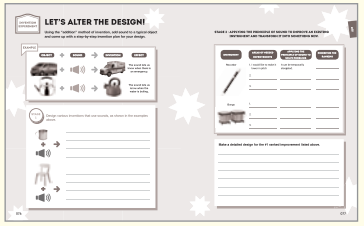
Pluck and pull at the string to makes sounds. What do you feel on your finger?
Talk about ways of making different sounds in relation to Experiments 1 and 2.

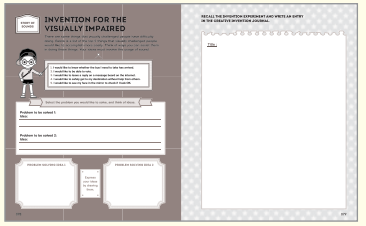
Wrap Up

Sounds are made by the frequency of vibrations. Every object makes different sounds due to its unique frequency of vibrations.









01 Teaching point

Go over various types of whistles and intrigue students with invention experiments that use sounds.

Preview

Using whistles to recognize the principle of sound

Recognize the principle of sound and intrigue students with invention experiments that use sound.

1) Whistle Pipe

- Pull or push on the top of the syringe to expand or contract the space inside the whistle pipe.
- Depending on the amount of air inside, the frequency changes, resulting in a change in pitch (high or lowsound).

2) Things to keep in mind during the activity

- Blow the whistle in class, and explore (study) the principle of sound.
- Go over various types of whistles other than the ones proposed in the text.

3) Check this out!

electric whistle interconnected with an LED electric score board

- It is a tool that combines the electric whistle and a radiofrequency transceiver (walkie-talkie) to signal the start of a game. When the game is over, the final results are immediately displayed on the LED electric score board.
  (Work of Korea's Bronze PrizeWinner, 2013, at TheNational Student Science Invention Contest)

02 Teaching point

Use experiments to help students understand the principle of sound.

Exploring Principle #1

Explore the principle of sound

Explore the actual occurrence of sound via some simple experiments.

1) Something to keep in mind

- Make different sounds in class and study the reasoning and principle behind the actual occurrence of sound.

2) 3 elements of sound

High and low pitches

It depends on the frequency. The higher the frequency, the higher the sound. The measurement unit is "Hz."

Strength (Volume)

It depends on the width of the vibration. The wider the vibration, the louder the sound. Themeasurement unit is "dB."

Sensible distinction (Timbre)

It is the ripple shape of the sound. There is a different feel when a violin plays a musical note, as opposed to when a piano plays that same note. This is due to the timbre of the sound.

3) The reason why different sounds are made, depending on the quantity of water in a wine glass.

The more water in the glass, the lower the sound.
When the glass is tapped, the glass itself vibrates. The more water inside the glass, the more it interferes with the vibrations. The result is that the frequency is reduced and a lower sound is made.

4) Making a song using glasses of water

- Fill different quantities of water in each identical glass. Then, make sounds by tapping on them.
- Adjust the water level to make sounds similar to a musical scale.
- Play a simple tune.

EXPLORING PRINCIPLE 2

MAKE A "BALLOON PIPE"

Fashion a balloon pipe that makes funny sounds!

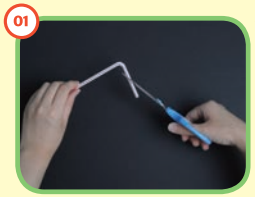
balloon, straw, scissors, transparent tape, OHP film (Laminating Film)

EXPLORATION ACTIVITY

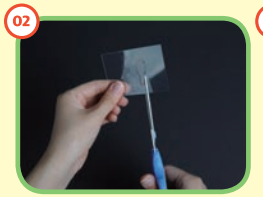
ARE THE SOUNDS OF ALL BALLOON PIPES THE SAME?

Discuss the various sounds of the balloon pipe.

HOW TO MAKE A BALLOON PIPE


01

Use scissors to cut the straw to any length you wish.


02

Make a reed with the OHP film.


03

Tape the reed onto the tip of the straw.


04

Insert the end of the straw with the reed into the balloon.


05

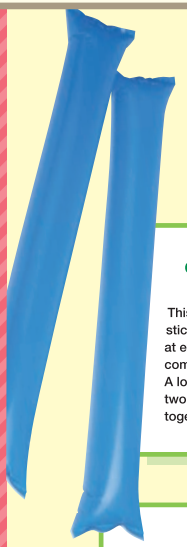
Tape the straw and the balloon together.


06

Blow into the balloon and check out the sounds.

NEWER AND MORE FUN

Differentiate the lengths of the straws → Differentiate the thickness of the straws → Differentiate the sizes of the balloons → Design a new pipe



EXPLORING INVENTIONS

INVENTIONS RELATED TO SOUND

Here are some common inventions related to sound

Cheerleading Stick Balloon

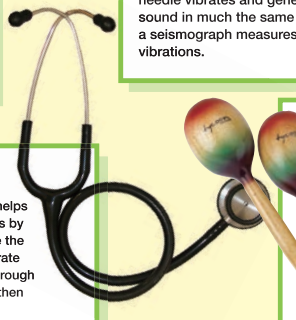
This is a plastic or vinyl stick used for cheering at events like sports competitions and concerts. A loud noise is made when two balloon sticks are hit together.

Phonograph Record

The phonograph plays records by reading the wavy patterns (grooves) engraved in zigzag patterns on them. As the record rotates, the phonograph needle vibrates and generates sound in much the same way that a seismograph measures geological vibrations.

Stethoscope

The stethoscope is a medical tool that helps doctors diagnose physical abnormalities by enabling them to listen to sounds inside the body. Sounds from a person's body vibrate the film in the stethoscope and move through the connected tube. Those sounds are then transferred to the doctor's ears.



Maracas

Maracas are popular rhythmic instruments used in various sorts of music. When a maraca is shaken, the seeds inside the hard outer layer hit the inner wall and produce sounds. Maracas that emit a high-pitched sound are often used in conjunction with ones that emit low-pitched sounds.

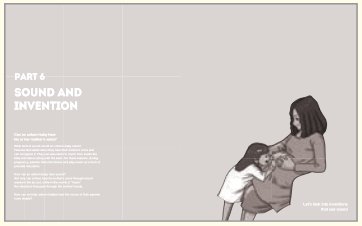
Consider the uses of inventions that use sounds.

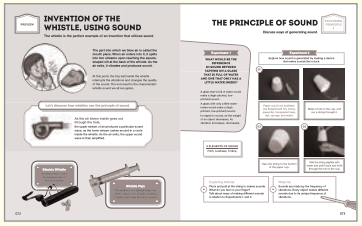
Alarm clock

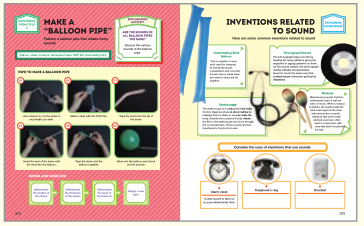
It uses sound to alert us at a pre-determined time.

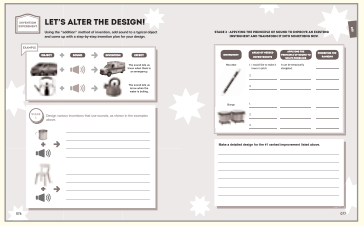
Telephone's ring

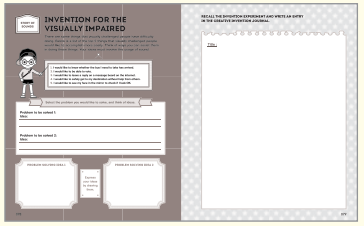
Doorbell











03 Teaching point

Make a "Balloon Pipe" and explore how the principle of sound is applied.

Exploring Principle #2

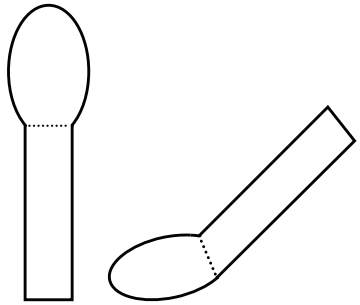
Check out the principle of sound using the balloon pipe.

1) Things to remember when making the balloon pipe

- Securely tape the lid onto the tip of the straw.
- Pucker your lips when blowing air into the straw. Sound can only be made when enough air enters the straw.
- In addition to blowing on the pipe, explore other ways to make sounds.

2) Things to keep in mind while teaching

- While experimenting with the balloon pipe, allow students to explore the principle of sound unguided.
- Use the activity "Newer and More Fun" to foster the students' interest in the principle of sound.
- If time is limited, "Newer and More Fun" can be assigned as homework.



balloon pipe reed

04 Teaching point

Let students examine various inventions related to sound and help them to understand the inventions' principles.

Exploring Inventions

Various inventions related to sound

Inventions exist all around us. Find some that are related to sound, then try to understand their effects.

1) Things to remember when exploring inventions

- Instead of focusing on the principle of a particular sound, concentrate on its effects.
- Let students explore other inventions than just the onesmentioned in the text.

2) The Progression of Records

Phonograph Record

The needle tracks the sound groove and vibrates in the pattern of a wave. If we amplify this vibration, it becomes audible.

CD

The wavy patterns are encoded digitally for the laser beam to scan. A needle is no longer necessary to decode the information.

MP3

This is a computer file that stores music or sound data. "MP3" stands for "MPEG-1 Audio Layer 3."

INVENTION EXPERIMENT

LET'S ALTER THE DESIGN!

Using the "addition" method of invention, add sound to a typical object and come up with a step-by-step invention plan for your design.

EXAMPLE

OBJECT	+	SOUND	→	INVENTION	EFFECT
	+		→		The sound lets us know when there is an emergency.
	+		→		The sound lets us know when the water is boiling.

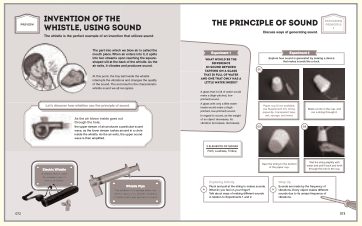
STAGE 1

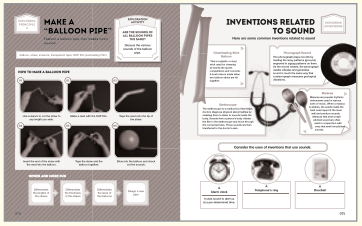
Design various inventions that use sounds, as shown in the examples above.

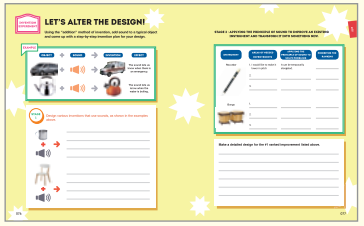
STAGE 2 : APPLYING THE PRINCIPLE OF SOUND TO IMPROVE AN EXISTING INSTRUMENT AND TRANSFORM IT INTO SOMETHING NEW.

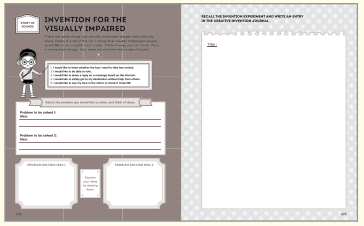
INSTRUMENT	AREAS OF NEEDED IMPROVEMENTS	APPLYING THE PRINCIPLE OF SOUND TO SOLVE PROBLEMS	PRIORITIZE THE RANKING
Recorder 	1. I would like to make it lower in pitch	It can be temporarily elongated.	
	2.		
	3.		
Bongo 	1.		
	2.		
	3.		

Make a detailed design for the #1 ranked improvement listed above.









05 Teaching point

Help students use the combination method to design inventions that combine the principle of sound with existing objects.

Exploring inventions

Design inventions combined with sound by using the "addition" invention method

1) "Addition" invention method

This is the method for creating new inventions by combining objects or methods.

- object + object : combine two objects with different functions
- method + method : combine two different methods

Musical Greeting Card

card ⊕ sound (music, message)

Record music or messages to be sent in the card.

Alarm Clock

alarm ⊕ clock

An alarm is installed inside the clock to wake people up.

Musical books

book ⊕ sound

A picture of an instrument is shown in a book, and, when the button is pressed, a corresponding sound is made.

2) Something to think about when designing new inventions using the "addition" invention method.

- What may be added together?
- What might be the strength (advantage) of the idea?
- What could be the weakness (disadvantage) of the object?
- What materials are required tomake it?

06 Teaching point

Let students design new and improved instruments by using the principle of sound on their own.

Invention Experiment

1) Design a new instrument

- Can it make a higher pitched sound?
- Can it make a lower pitched sound?
- Can it make a different sound?
- Can it make a louder sound?
- Can it make any other sounds?

2) Apply the principle of sound in order to solve problems

- How about elongating it?
- How about changing the location of the holes?
- How about changing the number of holes?
- How about changing the size of the bongo?
- How about changing the materials used?

3) Things to remember when designing a new idea.

- Examine different ways to alter the timbre, pitch, and volume of sounds.
- When pressed for time, let students apply and utilize the concept during break time or after school.

4) Various kinds of recorders

① Sopranino Recorder

Can perform sounds from the upper register, as well as musical pieces that require brilliant techniques. It is often used in concertos.

② Soprano Recorder

Usually responsible for keeping the melody, either by itself or as part of an ensemble.

③ Alto Recorder

Often used in solo performances, and responsible for notes in themiddle register.

STORY OF SOUNDS

INVENTION FOR THE VISUALLY IMPAIRED

There are some things that visually challenged people have difficulty doing. Below is a list of the top 5 things that visually challenged people would like to accomplish more easily. Think of ways you can assist them in doing these things. Your ideas must involve the usage of sound.

1. I would like to know whether the bus I need to take has arrived.
2. I would like to be able to vote.
3. I would like to leave a reply on a message board on the internet.
4. I would like to safely get to my destination without help from others.
5. I would like to see my face in the mirror to check if I look OK.

Select the problem you would like to solve, and think of ideas.

Problem to be solved 1:
Idea:

Problem to be solved 2:
Idea:

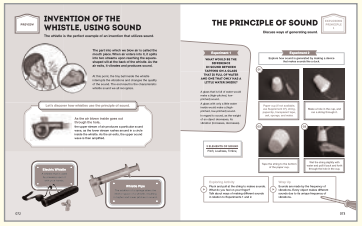
PROBLEM SOLVING IDEA 1

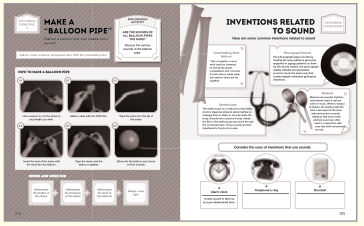
Express your ideas by drawing them.

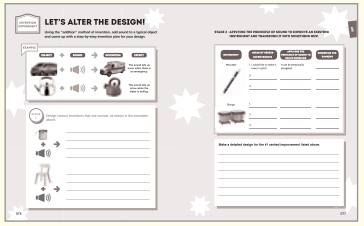
PROBLEM SOLVING IDEA 2

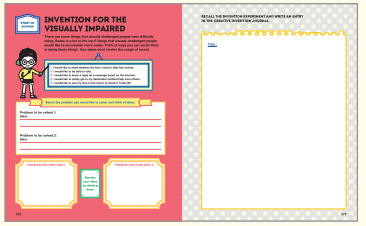
RECALL THE INVENTION EXPERIMENT AND WRITE AN ENTRY IN THE CREATIVE INVENTION JOURNAL.

Title :









07 Teaching point

Let students design an invention that uses sound for people who are visually challenged.

Sound

Design an invention for people who are visually challenged.

1) What do you want to invent?

- An invention for the visually challenged
- An invention using sound

2) Methods for problem-solving

- Think about the problem to be solved, ask questions related to sound, and come up with a method for solving the problem.
- Problem to be solved **Ex 1**: "I would like to know if the bus I want to take has arrived." → What about making a bus that produces specific sounds?
- Problem to be solved **Ex 2**: "I would like to vote." → How about a machine that verbally records the name of the person you want to vote for?

3) Inventions for the visually challenged

Cellular phone for the visually challenged
Instead of a display screen, a key pad with distinctive buttons is installed. Also, a touch sensor is attached so that each key audibly identifies itself when touched.

Portable text message recognition voice changeover device
Scan the content of a book and use TTS (Text to Speech) technology to read back the scanned data.

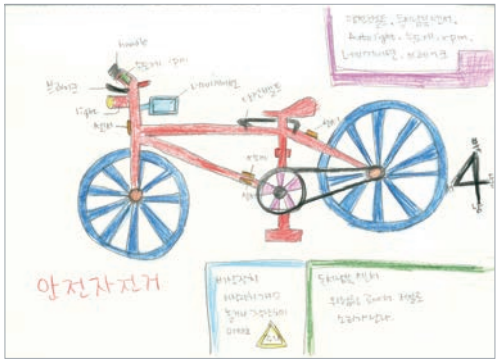
08 Teaching point

Guide students to express their ideas in the invention journal.

Invention Journal

Encourage students to express in the invention journal what they felt during the "Sound and Invention" experiment.

1) Examples of invention journals



2) Tips for journal writing

- Guide students to express the things they learned and felt. Let them use the invention journal to introduce inventions that they would like to make, and to record any ideas that they might have had.
- Let students freely express themselves through pictures, mind maps, and othermeans, without any restriction in format.
- Use their journals to reinforce and clarify the theme of the chapter.

PART 7
INERTIA AND INVENTION

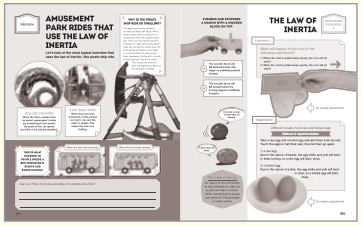
“When I was no longer nervous, the ice rink became a new world.”
“After watching footage of Michelle Kwon, I used the living room as an ice rink to skate all over.”

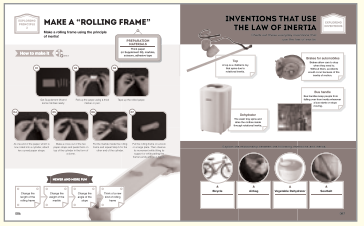
Yuna Kim, Olympic champion skater in 2009 and 2013, wrote the above as part of her journal.

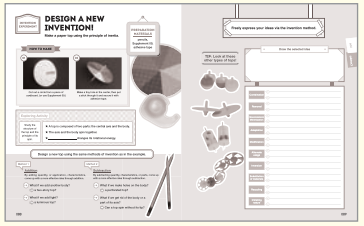
Yuna Kim has been crowned “Queen of the Ice Rink,” and she is an athlete who can jump high and perform amazing feats in mid-air. Her specialty is the Triple Lutz, a move in which she does three full 360° turns before her skates return to the ice.

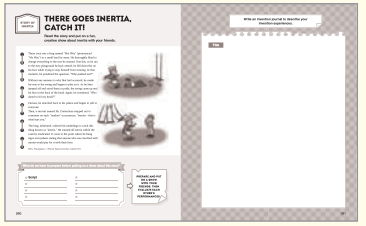
How can Yuna Kim accomplish such impressive feats?

Let’s look into inventions that take advantage of the laws of inertia

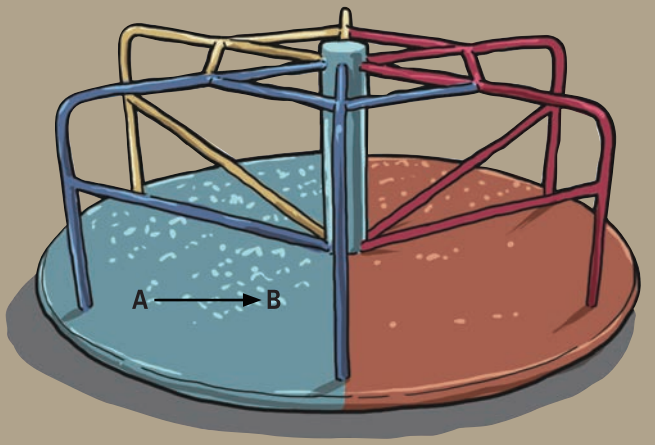








Inertia and Invention



As you move fromthe outer edge (A) of amerry-go-round towards the center (B), the speed of rotation increases.

Teacher's guide

1. Guide the students to freely discuss the phenomena of inertia.
2. Help students recognize that there are many common inventions that use inertia.
3. Help students understand the law of inertia by examining common inventions.
4. Help students use the invention method to design a new invention that use inertia.

Class management

Introduce	Develop	Conclude
• Recognize the meaning of inertia through "the rotating performance of Yuna Kim." • Inform students of the learning goal.	• Examine the playground ride invented through the use of the law of inertia. • Learn about the law of inertia and make a "Rolling Frame." • Examine various inventions that use the law of inertia. • Make a top that uses the law of inertia, and design a new invention.	• Review the law of inertia. • Solve problems by applying the inertia story.

Introduction

The rotating performance of Yuna Kim

When a figure skating athlete opens his/her arms, the moment of inertia of the rotational axis increases, so ultimately the speed of rotation slows down. When his/her arms are folded, the moment of inertia of the rotational axis decreases, hence the speed becomes faster.

※ What is the moment of inertia?
It is a physical quantity that measures the degree of suppression. If there isn't any outside force, the rotating speed slows down as the moment of inertia becomes larger.

Inform students of the learning goal

Use various experiments to explore inventions that use inertia.

Inform students of the learning activity

01 Preview
02 Exploring Principle
03 Exploring Inventions
04 Invention Experiment
05 Inertia

PREVIEW

AMUSEMENT PARK RIDES THAT USE THE LAW OF INERTIA

Let's look at the most typical invention that uses the law of inertia—the pirate ship ride.

ROLLER COASTER

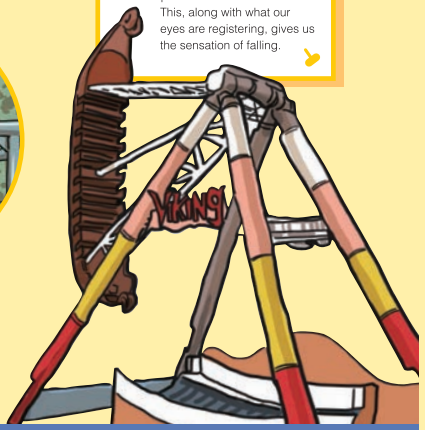
When the roller coaster picks up speed, passengers' bodies are pushed back from inertia. Because of this, the speed and thrill of the ride are amplified.

FAST BOAT RIDE

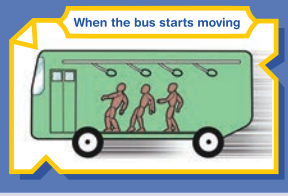
When the boat races downward, inertia causes our hair to rise and the water to splash. This makes the ride more thrilling.

WHY IS THE PIRATE SHIP RIDE SO THRILLING?

The three semicircular canals in our ears are filled with liquid. While these canals shift according to our movements, the inner liquids remain still. This is how we sense rotations. Likewise, on rides such as the pirate ship, we can feel the incline when the boat swings up thanks to the liquid in our ears. When the ride swings back downward, the liquid in our ears moves up due to the law of inertia. This, along with what our eyes are registering, gives us the sensation of falling.



THIS IS WHAT HAPPENS TO PEOPLE INSIDE A BUS WHENEVER IT STARTS AND STOPS MOVING.

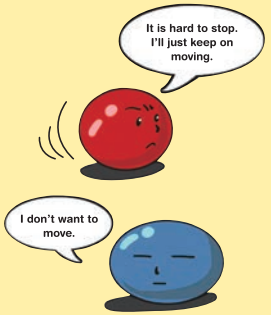


Can you think of more examples of incidents like this?

PUSHING AND STOPPING A WAGON WITH A WOODEN BLOCK ON TOP.

01 The wooden block will fall backward when the wagon is suddenly pushed forward.

02 The wooden block will fall forward when the moving wagon is suddenly stopped.



The Law of Inertia

An object at rest will remain at rest, whereas an object in motion will stay in motion, while maintaining its speed and direction.This principle is called inertia.

THE LAW OF INERTIA

EXPLORING PRINCIPLE 1

Experiment 1

What will happen to the coin in the following experiment?

1: When the card is pulled away slowly, the coin will do what?
2: When the card is pulled away quickly, the coin will do what?

An inertia experiment

Experiment 2

Different results from raw and boiled eggs

Method of experimentation

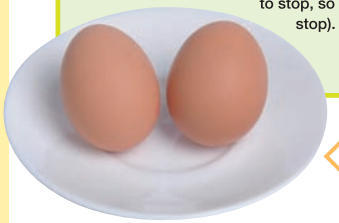
Take a raw egg and a boiled egg and spin them both around. Touch the eggs to halt their spin, then let them go again.

1: a raw egg

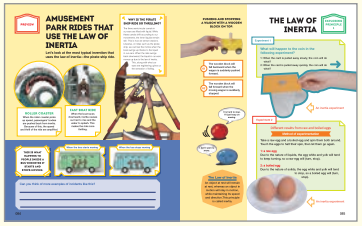
Due to the nature of liquids, the egg white and yolk will tend to keep turning, so a raw egg will (turn, stop).

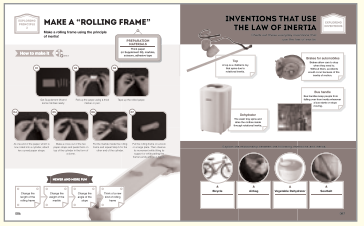
2: a boiled egg

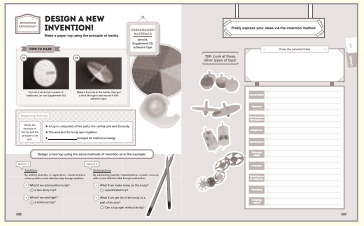
Due to the nature of solids, the egg white and yolk will tend to stop, so a boiled egg will (turn, stop).

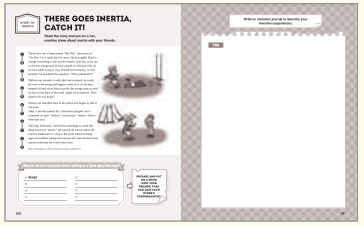


An inertia experiment









01 Teaching point

Let the students study the principles of amusement park rides using the law of inertia.

Preview

Study the law of inertia through the pirate ship ride

1) Overview

Rather than give them a fundamental lesson on inertia, encourage them to take an interest in inertia by discussing the sensation they feel when riding amusement park rides.

2) Top 10 Amusement Parks in the World

1. Magic Kingdom Park of Walt Disney World (The United States of America)
2. Tokyo Disneyland (Japan)
3. Disneyland Paris (France)
4. Everland (The Republic of Korea)
5. Blackpool Pleasure Beach (The United Kingdom)
6. The Tivoli Gardens (Denmark)
7. Ocean Park (Hong Kong)
8. Europa-Park (Germany)
9. Paramount Canada's Wonderland (Canada)
10. Port Adventura (Spain)

3) Common examples related to inertia

1. A person's body leans forward when he or she trips over a jagged stone or falls down while running.
2. When you hit blankets and clothing, dust flies off the fabric.
3. A passenger's body is pulled slightly to one side anytime a car takes a curve.
4. Water is extracted by a spinning laundry wringer.
5. When digging, a shovel moves and then stops, flinging the soil onto the ground.
6. Only the middle section of a pile of objects moves forward if the pile is hit in the middle.
7. A loose hammerhead can be properly refitted by hitting the handle vertically against the ground.
8. A space rocket reaches the moon after breaking through the earth's gravitational sphere.

02 Teaching point

Help students understand the law of inertia through experiments.

Exploring Principle #1

Study the law of inertia by conducting experiments

- Let students explore the law of inertia using common items like a cup, a coin, or an egg.
- Encourage them to focus on common situations related to inertia rather than the specific scientific principles.

1) What is the law of inertia?

"Inertia" is the tendency for an object to stay inmotion when the total amount of all forces acting on that object is 0. Inertia is an object's resistance to change, unless its state of motion is first altered.
The word "inertia" is derived from the Latin word "iners" which means "idleness" or "laziness." Isaac Newton defined the law of inertia as the first law of motion in his book *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy).

2) The law of inertia hidden in raw and boiled eggs

A boiled egg rotates as a single object when it undergoes rotational force. A rotating boiled egg keeps rotating until it's stopped by friction with whatever surfaces it is resting on. On the other hand, a raw egg doesn't rotate nearly as well when it undergoes the same amount of rotational force.

- What obstructs the rotation of a raw egg?

  A raw egg consists of sticky liquid inside and a solid shell outside, and the two parts move separately. When the egg rotates, the shell outside moves but the liquid inside tends to remain still due to inertia. Therefore, the rotational force is gradually delivered to the liquid inside rather than all at once. At first, the shell rotates along with the white of the egg. Then the rotational force is passed down to the yolk inside. Hence, when a raw egg rotates, the outside spins quickly but the inside turns slowly. Eventually, the different layers inside the egg cause friction among themselves and burn up the rotational force as internal energy. Thus, the white and the yolk of the egg are unable to rotate well, since they only receive a small amount of the total rotational force.

- When you try to stop it from spinning by pressing down on it softly and then releasing it again, a boiled egg stops immediately and completely, but a raw egg will resume its spin after it has been stopped. How is this possible?

  The force that occurs when you grab a rotating boiled egg rapidly passes itself down to the entire egg so that it stops completely. The reason why a raw egg will start rotating again is simple. When a raw egg rotates for the first time, the external force on the raw egg is very weak compared to that on a boiled egg. Therefore, even if you grab onto a raw egg while it spins, only the shell ceases its rotation whereas the inside keeps spinning because of inertia. Once you let go, the inner liquid still spinning inside the egg creates friction with the shell, and the entire egg begins to rotate again.

EXPLORING PRINCIPLE 2

MAKE A "ROLLING FRAME"

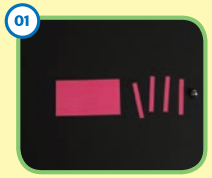
Make a rolling frame using the principle of inertia!

PREPARATION MATERIALS

Thick paper
(or Supplement 08), marbles, scissors, adhesive tape

How to make it

DVD 01

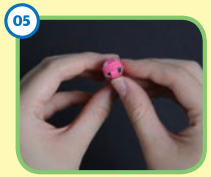


01 Get Supplement 08 and some marbles ready.

02 Roll up the paper using a thick marker or pen.

03 Tape up the rolled paper.

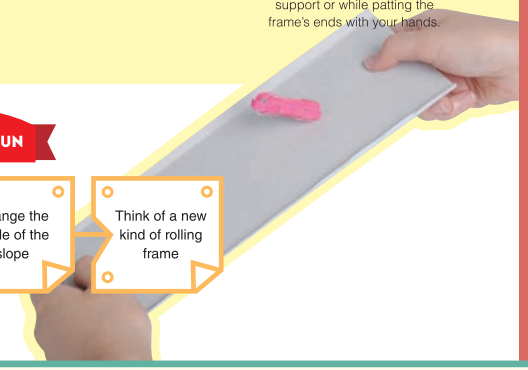
04 At one end of the paper, which is now rolled into a cylinder, attach two curved paper straps.



05 Make a cross out of the two paper straps and paste them on top of the cylinder in the form of a dome.

06 Put the marble inside the rolling frame and repeat Step 5 for the other end of the cylinder.

07 Put the rolling frame on a book or a large plate. Then observe its movement while tilting its support or while patting the frame's ends with your hands.



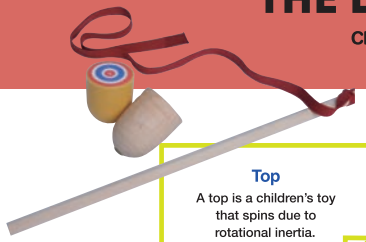
NEWER AND MORE FUN

- Change the length of the rolling frame
- Change the weight of the marble
- Change the angle of the slope
- Think of a new kind of rolling frame

INVENTIONS THAT USE THE LAW OF INERTIA

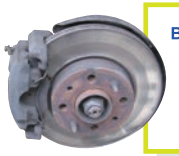
EXPLORING INVENTIONS

Check out these everyday inventions that use the law of inertia.



Top

A top is a children's toy that spins due to rotational inertia.



Brakes for automobiles

Brakes allow cars to stop when they need to. Without them, accidents would occur because of the inertia of motion.

Dehydrator

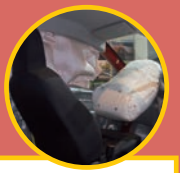
The wash tray spins and dries the clothes inside through rotational inertia.

Bus handle

Bus handles keep people from falling over from inertia whenever a bus starts or stops moving.

Explain the relationship between the following inventions and inertia.

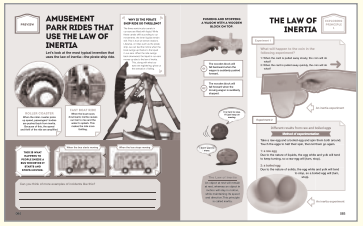
▲ Bicycle

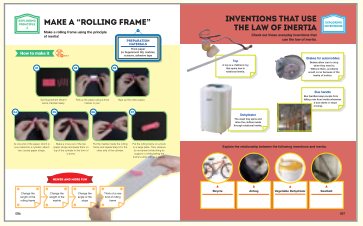


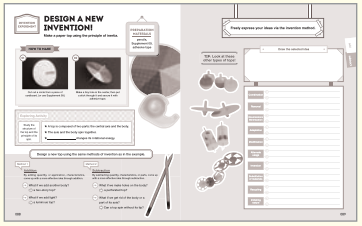
▲ Airbag

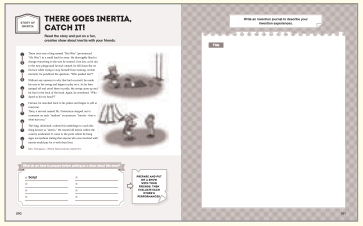
▲ Vegetable Dehydrator

▲ Seatbelt









03 Teaching point

Help students to become more interested in the law of inertia and explore new methods of making a rolling frame.

Exploring Principle #2

Explore students principle of inertia while making a rolling frame.

Help students understand the principle of inertia by making a rolling frame.

1) Things to keep in mind while making it

- It is important to complete the cylinder properly in order for it to roll effectively.
  ※ It is more fun if they compose different surfaces for the frame to roll on.
  e.g.) zigzag rail, hemisphere, spiral structure, etc.

2) Alternative preparation materials

- It is recommended that students seek out alternative preparation materials on their own.
  e.g.) paper or corrugated cardboard

3) Things to remember while teaching

- Encourage the students to come up with better inventions through various scenarios along the lines of "Newer and More Fun." The teacher should reward and compliment students for their creativity.
- Encourage them to carry out the initiative and complete the activities outside of class.

04 Teaching point

Help students find inventions that use the law of inertia, and help them to recognize the relationship between these inventions and inertia.

Exploring inventions

Inventions that use the law of inertia

Inventions are all around us. Students should find ones that use the principle of inertia, then try to understand their effects.

1) Prior information notice

It's advisable to introduce the inventions in the textbook only after allowing the students to come up with and discuss existing inventions that harness the power of inertia.

2) Things to remember while exploring inertia-related inventions

- It is advisable, while showing students many common examples, to take into consideration their backgrounds and levels, so that the concept may be understood more clearly.
- Instead of determining how the law of inertia is applied in the inventions, concentrate instead on inertia's effects. It is more important to consider the purpose and process of such inventions.

INVENTION EXPERIMENT

DESIGN A NEW INVENTION!

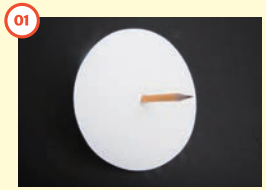
Make a paper top using the principle of inertia.

PREPARATION MATERIALS

pencils, Supplement 09, adhesive tape

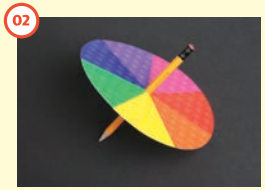
HOW TO MAKE

01



Cut out a circle from a piece of cardboard. (or use Supplement 09.)

02



Make a tiny hole in the center, then put a stick through it and secure it with adhesive tape.

Exploring Activity

Study the structure of the top and the principle of its spin.

★ A top is composed of two parts: the central axis and the body.

★ The axis and the body spin together.

★ _____changes its rotational energy.

Design a new top using the same methods of invention as in the example.

Method 1

Addition

By adding quantity, or application, characteristics, come up with a more effective idea through addition.

e.g. What if we add another body?
⇨ a two-story top?

e.g. What if we add light?
⇨ a luminous top?

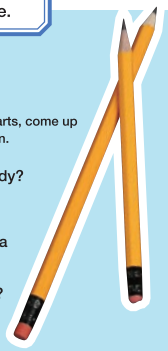
Method 2

Subtraction

By subtracting quantity, characteristics, or parts, come up with a more effective idea through subtraction.

e.g. What if we make holes on the body?
⇨ a perforated top?

e.g. What if we get rid of the body or a part of its axis?
⇨ Can a top spin without its tip?



Freely express your ideas via the invention method.

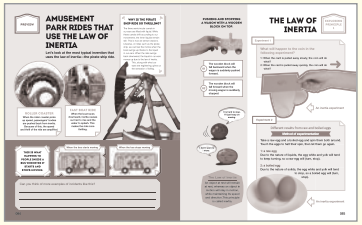
TIP: Look at these other types of tops!

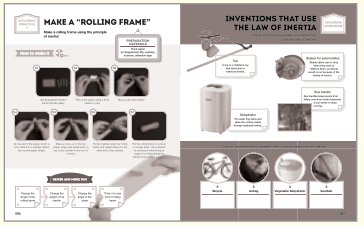
Draw the selected idea

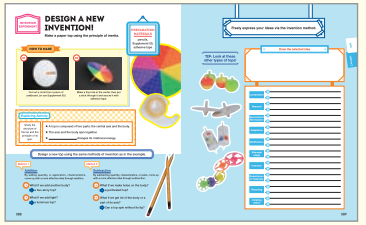
add

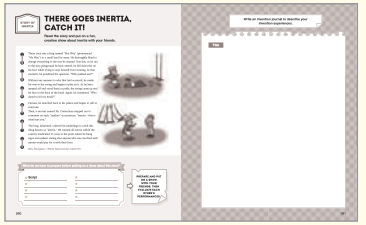
subtract

- Combination 01 02
- Removal 01 02
- Maximization/ Minimization 01 02
- Adaptation 01 02
- Modification 01 02
- Alternate usage 01 02
- Inversion 01 02
- Substitution of materials 01 02
- Recycling 01 02
- Imitating nature 01 02









05 Teaching point

Help students make a paper top and then explore its structure and the principle of its spin.

Invention Experiment

Make a paper top

01 Help students make a top out of cardboard. By analyzing the principle behind its spin, come up with a new style of top from new ideas.

02 Students should understand the key structure of a top.

1) Things to keep in mind when coming up with a new top

- Help them use various invention methods to come up with new ideas based on the key structure of a top.
- Give them examples to help them better understand the process of coming up with new ideas.

2) Points of focus when going through the stages of coming up with new ideas.

- Help them experience the stages of invention by using addition and subtraction.
- The teacher should help struggling students by going over each stage with them individually.
- It is recommended that students create models rather than just come up with ideas, so that their designs can come to completion through hands-on experience.

06 Teaching point

Let students freely display and express their new ideas.

Display ideas by using various methods of invention.

1) Thinking of and choosing ideas

- Explain the standard of evaluation and let students set a specific goal.
- It is advisable for the students to cross-evaluate each other's ideas, rather than for the teacher to evaluate them.
- Help students better understand the blueprint by drawing or writing out their ideas in a simple fashion.

2) Evaluation perspectives for new ideas

- **Perspective 1**: Does it use the principle of inertia?
- **Perspective 2**: Does it include a new idea?
- **Perspective 3**: Is it fun?

※ Displays of examples should be short and simple to help students think effectively

3) Points of focus during the exploring activity for the selected ideas

- If the students have trouble realizing their own invention ideas, oral explanations with illustrations, either as in a class or in groups, is recommended for sharing the ideas with other.
- It is important to explore the actual results of following through with the selected idea. Each idea has the potential to become an actual invention, so the teacher's active participation is required. The teacher should consider each idea's value as an invention, rather than evaluate them in a straight-forward manner.

STORY OF INERTIA

THERE GOES INERTIA, CATCH IT!

Read the story and put on a fun, creative show about inertia with your friends.

There once was a king named "Mai Wey" (pronounced "My Way") in a small land far away. He thoroughly liked to change everything to the way he wanted. One day, as he ran to the new playground he had created, he fell down flat on his face while trying to stop himself from running. At that moment, he pondered the question, "Who pushed me?!"

Without any answers to why that had occurred, he made his way to the swing and began to play on it. As he later jumped off and stood there in pride, the swing came up and hit him in the back of the head. Again, he wondered, "Who dared to hit my head?!"

Furious, he marched back to his palace and began to yell at everyone.
Then, a servant named Mr. Pretentious stepped out to comment on such "random" occurrences, "Inertia – that is what hurt you."

The king, infuriated, ordered his underlings to catch this thing known as "inertia." He wanted all inertia within the country eradicated. It come to the point where he hung signs everywhere stating that anyone who was involved with inertia would pay for it with their lives.

Kim, Youngsoo, <There Goes Inertia, Catch It!>

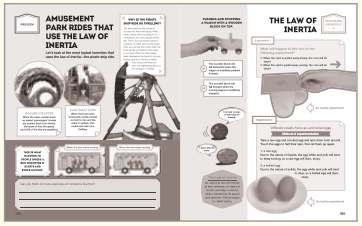
What do we have to prepare before putting on a show about this story?

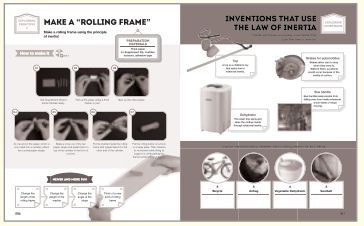
- ★ Script
- ★
- ★
- ★
- ★
- ★
- ★
- ★

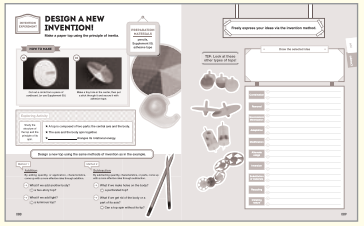
PREPARE AND PUT ON A SHOW WITH YOUR FRIENDS. THEN EVALUATE EACH OTHER'S PERFORMANCES.

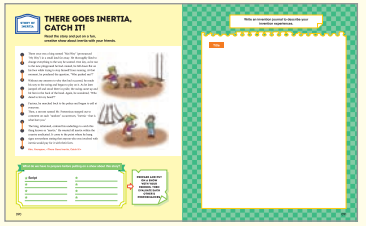
Write an invention journal to describe your invention experiences.

Title









07 Teaching point

Let the students resolve the problem in various ways using the principle of inertia.

Inertia

Perform a creative skit related to the principle of inertia.

01 Let the students read the story and resolve the problem by applying the principles of invention and inertia.
02 Induce comprehensive thinking by helping them put on interesting skits one they have grasped the scientific principles.

1) Example of how to put on a skit

1. Organize the students into teams.
2. Choose a team leader and a name for each team.
   (It possible, make a slogan and a sign for each team as well)
3. Under the supervision of their team leader, have each team write out a scenario.
4. Conduct a simple backdrop and collect any props you might need.
5. Practice with a script.
6. Determine the order of the skits, and let each team perform their skit on stage.
7. Have the teams evaluated each other's performances.

2) Teaching strategies

- The teacher should let the students read the story first, then ask questions to help them determine the exact nature of the problem to be solved.
  e.g)What problem needs to be solved? What (which scientific principle) do we need to knowin order to resolve it?
- Encourage the students to use divergent thinking to examine the problem thoroughly.
- Let students talk freely about how to resolve the problem.

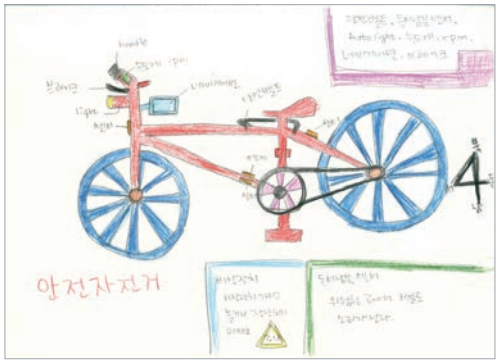
08 Teaching point

Guide students to express their ideas in the invention journal.

Invention Journal

Encourage students to express in the invention journal what they felt during the "Inertia and Invention" experiment.

1) Example of an invention journal



2) Tips for journal writing

- Guide students to express the things they learned and what they felt. Let them use their invention journals to introduce inventions that they would like to make, and to record any ideas they might have had.
- Let students freely express themselves through pictures, mind maps, or various other means without any restriction in format.
- Use the invention journals to reinforce and clarify the theme of the chapter.

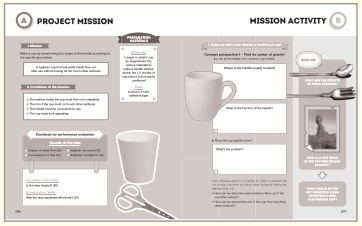
CREATIVE PROBLEM-SOLVING PROJECT

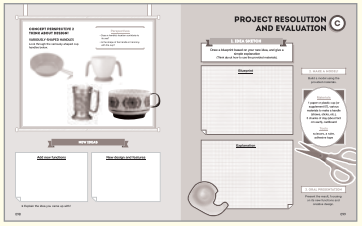
TOPIC 1

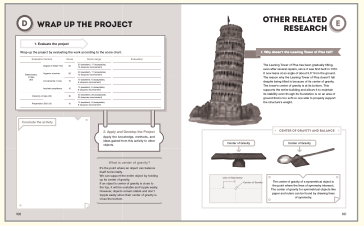
MAKE A CUP STAND ON ITS HANDLE!

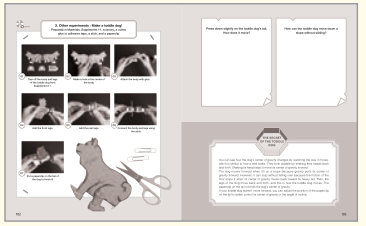
When you put down your toothbrush cup after brushing your teeth, the remaining water stays inside the cup.
This increases the possibility of bacteria propagating. Furthermore, bacteria might multiply rapidly inside the cup since bathrooms are usually not ventilated properly. However, for hygienic reasons, we cannot place the cup upside down, since the rim would come in contact with dirty surfaces. Wouldn't it be great if we could use a toothbrush cup that allowed residue to flow out after usage, without the rim touching any unclean surfaces?

This project allows you to make a convenient and hygienic toothbrush cup. Check out the problem and come up with ideas for completing the mission.









Make a cup stand on its handle!

Teacher's Guide

Help students understand the principle of center of gravity and assist them in making a hygienic cup using this principle.

Class management

Introduce	Develop	Conclude
• Discuss the process of brushing one's teeth. • Give the background information for the mission. • Inform students of the learning goal.	• Suggest methods for preparing the materials for the activity, and give standards by which the students can evaluate their success. • Explain the learning activity. • Explore the mission and related inventions. • Come up with various ideas for completing the mission, then choose the best idea from among them.	• Wrap up the project. • Other related research.

Introduction

- Ask the students about their teeth-brushing habits
  - "Who didn't brush their teeth before coming to school?" is a better question than "Who brushed their teeth before coming to school?", because it will likely encourage laughter and other strong reactions, thereby gaining their attention better.
- Let the students be the ones to bring up the topic of toothbrush holders by asking them about the tools they use while brushing their teeth in the morning.
- Provide the background for the mission by asking them what they do with their toothbrush holders after they use them.

Inform them of the learning goal

Help them construct a convenient and hygienic toothbrush holder.

Inform them of the learning activity

Clearly explain the entire procedure for the day's class, then help the students to understand the activity and prepare for it.

A PROJECT MISSION

1. Mission

Make a cup by transforming the shape of the handle according to the specification below.

A hygienic cup that lets water inside flow out after use without having its rim touch other surfaces

2. Conditions of the mission

- ★ The residue inside the cup must flow out completely.
- ★ The rim of the cup must not touch other surfaces.
- ★ The handle must be convenient to use.
- ★ The cup must look appealing.

Standards for performance evaluation

Results of the idea

- ★ Degree of water flow (20)
- ★ Hygienic structure (20)
- ★ Convenience of Use (10)
- ★ Aesthetic excellence (10)

Creativity of the Idea

Is the idea original? (30)

Presentation Skills

Was the idea explained effectively? (10)

PREPARATION MATERIALS

Materials

1 paper or plastic cup (or Supplement 07), various materials to make a handle (straws, sticks, etc.), 5 chunks of clay (about 5x3cm each), cardboard

Tools

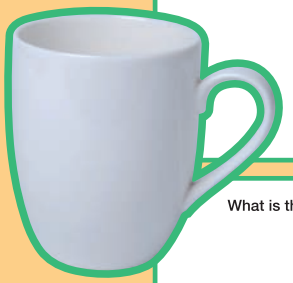
scissors, a ruler, adhesive tape

MISSION ACTIVITY B

1. Come up with a new idea for a toothbrush cup!

Concept perspective 1 – Find its center of gravity!

▶ Look at the shape of a common cup handle.



Where is the handle usually located?

What is the function of the handle?

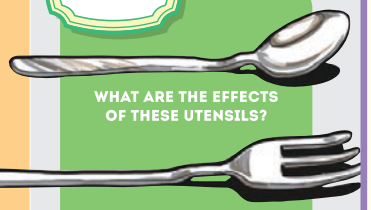
▶ Place the cup upside down!

What's the problem?

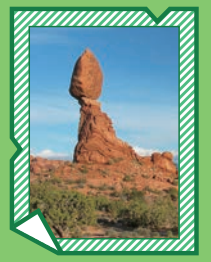
Let's discuss what to consider in order to prevent the rim of the cup from touching other surfaces letting the residue flow out.

- How can we allow the water inside to flow out of the cup after using it?
- How can we prevent the rim of the cup from touching other surfaces?

HOLD ON!

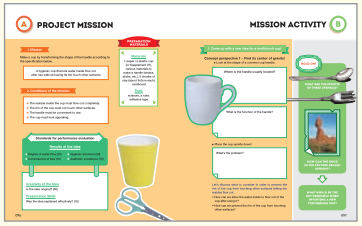


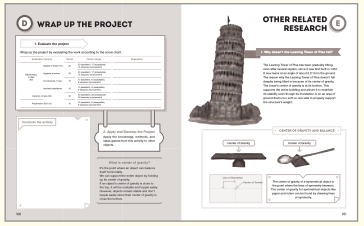
WHAT ARE THE EFFECTS OF THESE UTENSILS?

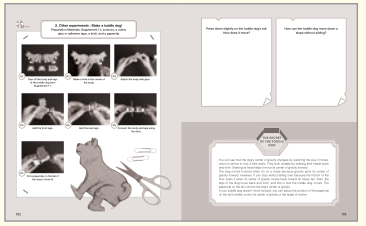


HOW CAN THE ROCK IN THE PICTURE REMAIN UPRIGHT?

WHAT WOULD BE THE KEY PRINCIPLE WHEN INVENTING A NEW TOOTHBRUSH CUP?







01 Teaching point

Let the students reflect on the mission, either individually or in groups. Then, reexamine and discuss the conditions, materials, and standards of evaluation involved in the project.

Setting up the project mission

Help students understand the given mission and guide them to complete it according to the pre-determined conditions and standards of evaluation.

1) Check out the provided materials.
- Students can substitute the recommended materials for others, but at least one team will need to use thesuggestedmaterials in order for the activity to be as effective as possible.

2) Things to remember
- Makesure thestudents are using the tools safely.

3) Standards of performance evaluation.
- Help the students keep in mind the standards of evaluation as they work to complete the mission.

02 Teaching point

Help students realize that the key principle involved with making a cup stand on its handle is to change the location of the cup's center of gravity.

Exploring the project mission

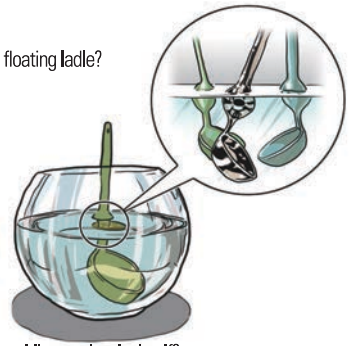
1) Take a look at common cup handles.
- Pay special attention to the location and function of the handles.

2) Students should figure out how to design the handle for conveniently draining water after use.

3) Let them find the center of gravity of a spoon, then discuss the merit of having it located in that particular place.

4) Use an exemplary picture of a rock for explaining the center of gravity.

5) Floating ladle
- Where is the center of gravity on the floating ladle?



6) Roly-poly rice paddle
- How can a roly-poly rice paddle stand up by itself?
- What are the pros and cons of this rice paddle?
- Where should we locate its center of gravity in order to improve it?

CONCEPT PERSPECTIVE 2
THINK ABOUT DESIGN!

VARIOUSLY-SHAPED HANDLES

Look through the variously-shaped cup handles below.

Perspectives

- Does a handle's location contribute to its use?
- Is the shape of the handle in harmony with the cup?

NEW IDEAS

Add new functions

New design and features

▶ Explain the idea you came up with!

PROJECT RESOLUTION AND EVALUATION C

1. IDEA SKETCH

Draw a blueprint based on your new idea, and give a simple explanation
(Think about how to use the provided materials).

Blueprint

Explanation

2. MAKE A MODEL!

Build a model using the provided materials.

Materials

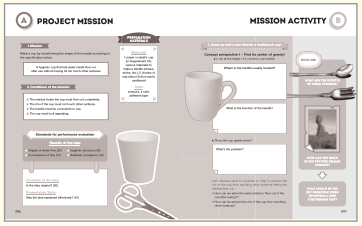
1 paper or plastic cup (or supplement 07), various materials to make a handle (straws, sticks, etc.), 5 chunks of clay (about 5x3 cm each), cardboard

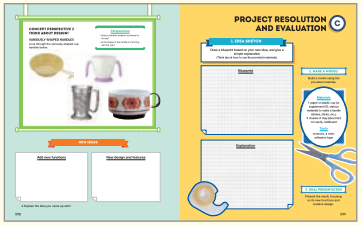
Tools

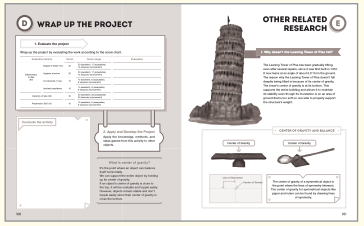
scissors, a ruler, adhesive tape

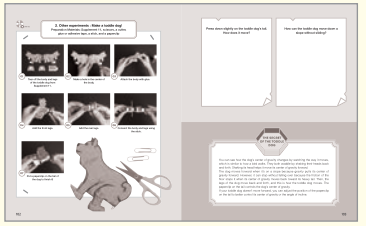
3. ORAL PRESENTATION

Present the result, focusing on its new functions and creative design.









03 Teaching point

Let students come up with ideas for a handle based on center of gravity, and in consideration of the handle's function and design.

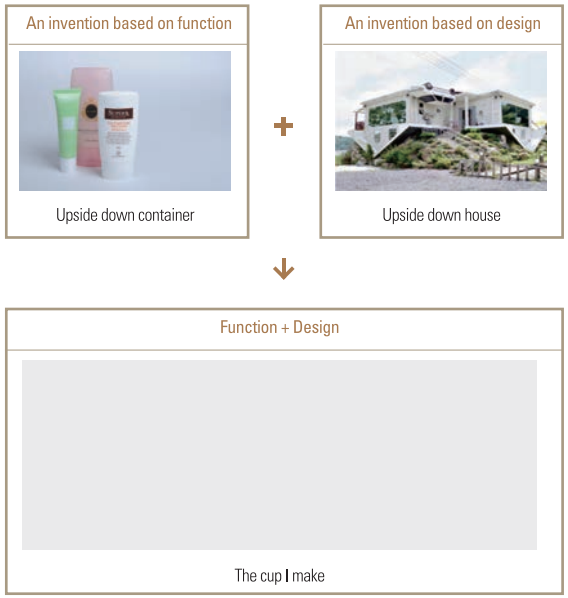
1) Examine the variously shaped handles
   - Help the students determine the location and function of common handles while simultaneously coming up with their own ideas. (Variables to consider: size, direction, open/enclosed condition, curve of the handle)

2) Notice how the added function works in accordance with the cup's design.

3) The students should come up with their own model through brainstorming combinations of its function and design.

4) Come up with ideas!
   - Think of as many ideas as possible.
   - Find the pros and cons for each idea.

※Reference: Integrate your ideas for functions and designs.



04 Teaching point

Let students use simple illustrations to display the ideas they came up with during the mission activity and present the models they made with the provided materials.

Complete the project

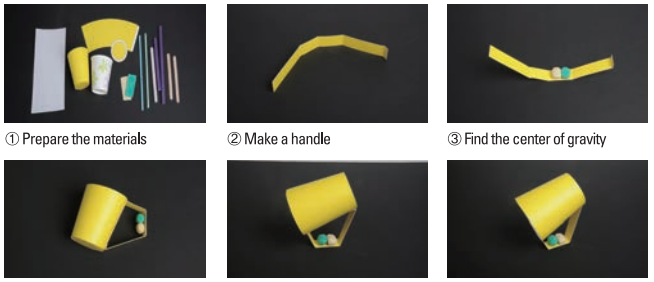
1) Students should present their ideas in detail, focusing on key points and effects.

2) Students should draw a blueprint for the final idea and explain it.
   - When the students draw a blueprint for a model based on their own idea, they should explain the overall shape and details for each part.

3) Students should make a model from the provided materials.
   - The provided materials can be changed depending on certain conditions. Also, the tools should not be used as materials.
   - Safety is the top priority while making the model.
   - As long as the final model resolves the problems, it is fine for it to vary from the original blueprint.

4) Listen to the other presentations and take note of all creative ideas.

Example of how to complete the mission



Example of completing the mission

※Present the final model. It is OK if the model remains unfinished, due to a lack of time.

D WRAP UP THE PROJECT

1. Evaluate the project

Wrap up the project by evaluating the work according to the score chart.

Evaluation factors		Score	Score range	Evaluation
Effectiveness of Idea (60)	Degree of Water Flow	20	20 (excellent), 17 (acceptable), 15 (requires improvement)	
	Hygienic structure	20	20 (excellent), 17 (acceptable), 15 (requires improvement)	
	Convenience of Use	10	10 (excellent), 8 (acceptable), 6 (requires improvement)	
	Aesthetic excellence	10	10 (excellent), 8 (acceptable), 6 (requires improvement)	
Creativity of Idea (30)		30	30 (excellent), 25 (acceptable), 20 (requires improvement)	
Presentation Skill (10)		10	10 (excellent), 8 (acceptable), 6 (requires improvement)	

Conclude the activity

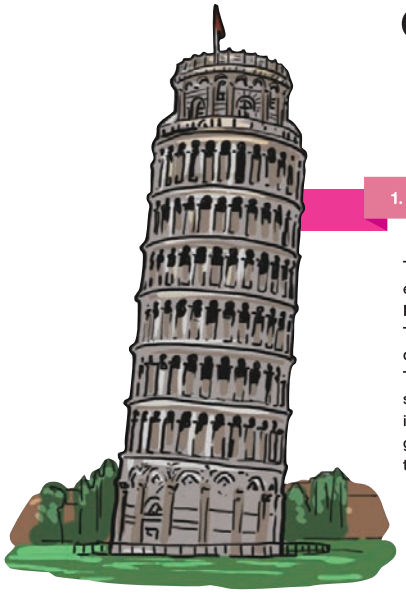
2. Apply and Develop the Project

Apply the knowledge, methods, and ideas gained from this activity to other objects.

What is center of gravity?

It's the point where an object can balance itself horizontally.
We can support the entire object by holding up its center of gravity.
If an object's center of gravity is close to the top, it will be unstable and topple easily. However, objects remain stable and don't topple easily when their center of gravity is close the bottom.

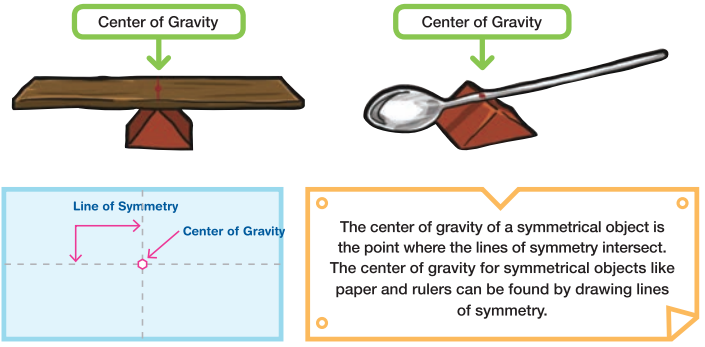
OTHER RELATED RESEARCH E



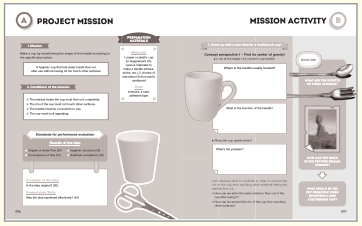
1. Why doesn't the Leaning Tower of Pisa fall?

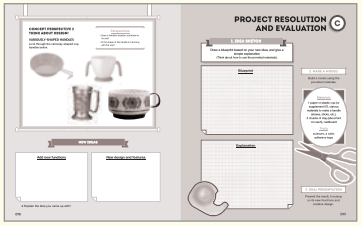
The Leaning Tower of Pisa has been gradually tilting, even after several repairs, since it was first built in 1372. It now leans at an angle of about 5.5° from the ground. The reason why the Leaning Tower of Pisa doesn't fall despite being tilted is because of its center of gravity. The tower's center of gravity is at its bottom. This supports the entire building and allows it to maintain its stability even though its foundation is on an area of ground that is too soft on one side to properly support the structure's weight.

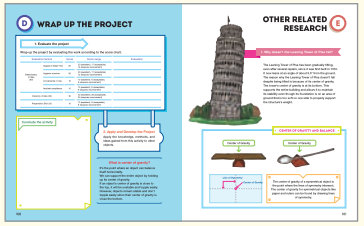
CENTER OF GRAVITY AND BALANCE

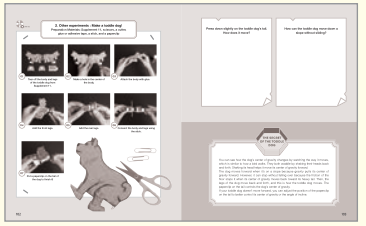


The center of gravity of a symmetrical object is the point where the lines of symmetry intersect. The center of gravity for symmetrical objects like paper and rulers can be found by drawing lines of symmetry.









05 Teaching point

Let the students evaluate the model and wrap up the activity.

Evaluation

1) Evaluate the students' cup stands and handles. Focus on whether the students were able to complete the mission and meet all the conditions, as well as how effectively they utilized or substituted the provided materials.

2) After the evaluation, discuss the innovative aspects of the students' ideas and find areas for improvement.

3) Display and show appreciation for everyone's work.

Wrap up the project

1) Conclude the process of completing the mission based on the evaluation tables of the models. Below could be an example of such developmental process.
   - Center of gravity of my cup → Center of gravity of a cup → The shape of a handle of the cup → Effect → Areas that need improvements → Future goals, etc.

Make use of the final product

1) Apply the knowledge and invention principles used in the mission to other objects.

2) Apply learned principles to other objects
   ① Choose an object to apply the principles to (e.g., a bag).
   ② Come up with ideas for the selected object.
   ③ Present the ideas via pictures and writing.
   ④ Give an oral presentation focusing on the idea's advantages.

3) It's helpful for students to use drawings and writing to present the main parts of their inventions, as well as the aspects that were improved.

06 Teaching point

Help students understand that the Leaning Tower of Pisa remains upright because its center of gravity is within its center of support—the condition that defines stability. Students can also track changes in movement by making and experimenting with a simple toy that uses the movement of the center of gravity.

Related research

1) Additional related materials should be provided for students to read, although you should stress that the Leaning Tower of Pisa remains upright due to the fact that its center of gravity is positioned in such a way as to allow for stability.

2) What is center of gravity?

It's the point on which an object can balance itself horizontally. We can support the entire object via itscenterof gravity.
If the center of gravity for an object is near the top, it will be unstable and easily fall over. However, if its center of gravity is at the bottom, the object will remain stable and not topple easily.

3) Examples of using center of gravity

- **A roly poly never remains toppled**: Its center of gravity is at the bottom, so it immediately returns to its original position after being tipped over. It would never be able to right itself if its center of gravity were near the top, because this would weaken its stability.

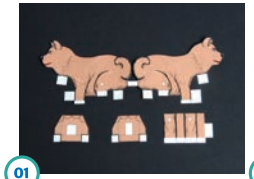
- **A balancing clown**: This toy spins on one foot, and its center of gravity is located at the bottom of the foot. When it tilts to the right, its center of gravity moves to the left, and vice-versa. In other words, there is a force that causes the clown to balance itself whenever it inclines to one side.

4) Other experiments
- Follow the instructions and assemble a toy using the easy-rip paper found in the supplement section, in addition to the provided materials.
- Understand the relationship between the re-positioning of center of gravity and the movement of a toddle dog.

DVD 03

2. Other experiments : Make a toddle dog!

Preparation Materials: Supplement 11, scissors, a cutter, glue or adhesive tape, a stick, and a paperclip



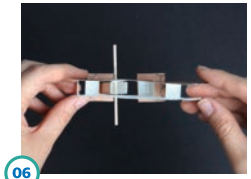
01 Tear off the body and legs of the toddle dog from Supplement 11.

02 Make a hole in the center of the body.

03 Attach the body with glue.

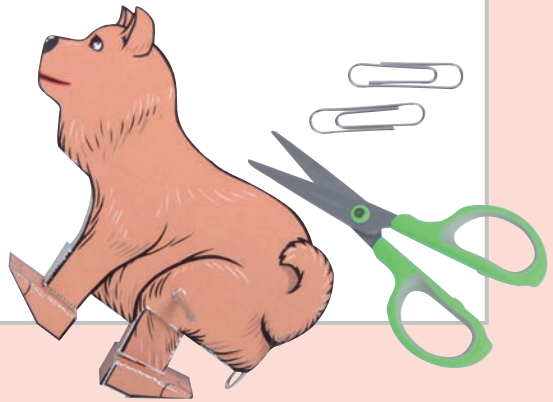
04 Add the front legs.

05 Add the rear legs.



06 Connect the body and legs using the stick.

07 Put a paperclip on the tail of the dog to finish it!



Press down slightly on the toddle dog's tail. How does it move?

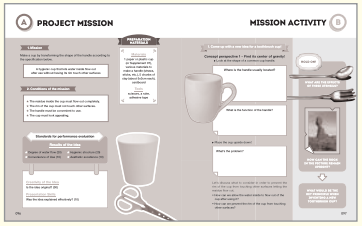
How can the toddle dog move down a slope without sliding?

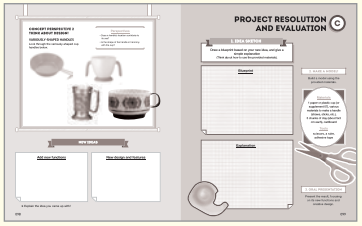
THE SECRET OF THE TODDLE DOG

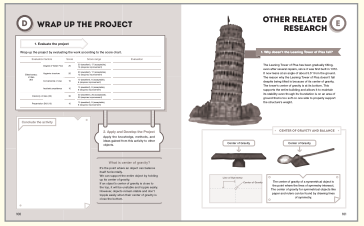
You can see how the dog's center of gravity changes by watching the way it moves, which is similar to how a bird walks. They both waddle by shaking their heads back and forth. Shaking its head helps it move its center of gravity forward.

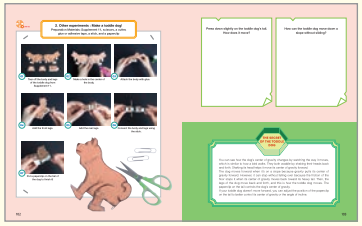
The dog moves forward when it's on a slope because gravity pulls its center of gravity forward. However, it can stop without falling over because the friction of the floor stops it when its center of gravity moves back toward its heavy tail. Then, the legs of the dog move back and forth, and this is how the toddle dog moves. The paperclip on the tail controls the dog's center of gravity.

If your toddle dog doesn't move forward, you can adjust the position of the paperclip on the tail to better control its center of gravity or the angle of incline.









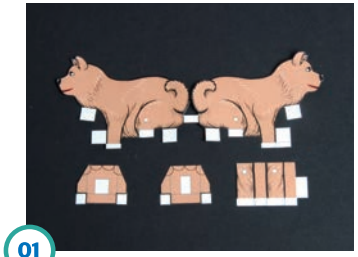
07 Teaching point

Students can track changes in movement by making and experimenting with a simple toy that uses center of gravity.

Other related research

Other experiments

- Follow the instructions and assemble a toy with the easy-rip paper found in the supplement section, in addition to the providedmaterials.
- Understand the relationship between an object's center of gravity and the movement of a toddle dog.



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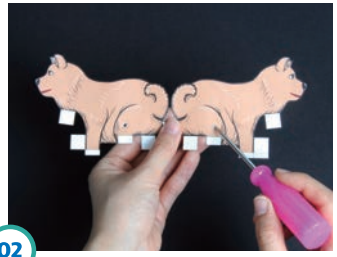
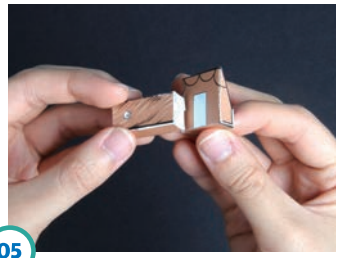


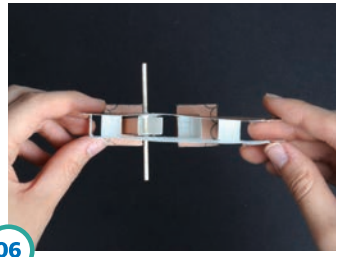
02 Make a hole in the center of the body.

03 Attach the body with glue.

04 Add the front legs.



05 Add the rear legs.



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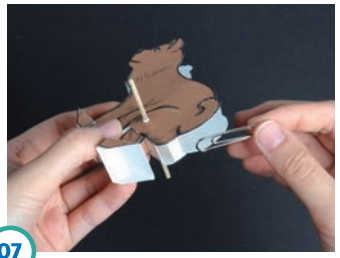


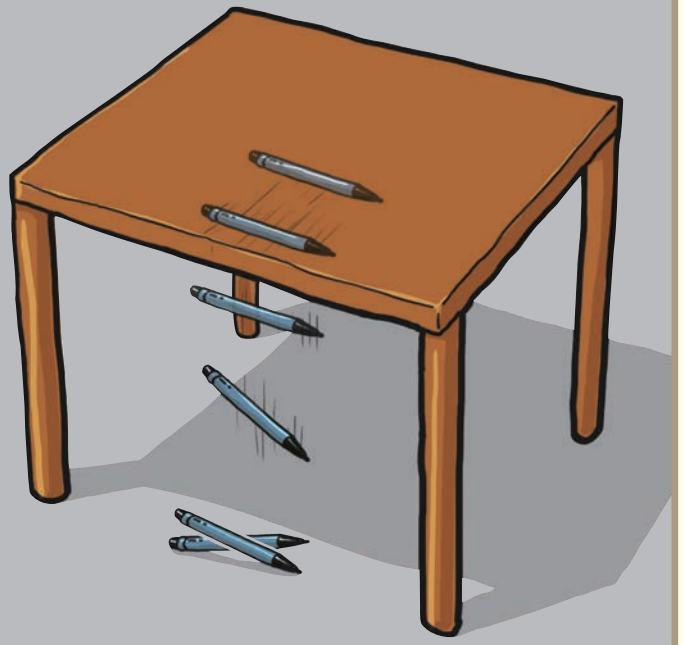
07 Put a paperclip on the tail of the dog to finish it!

CREATIVE PROBLEM-SOLVING PROJECT

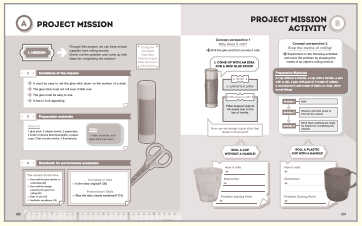
TOPIC 2

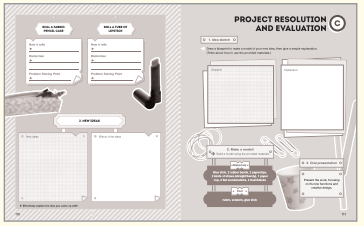
GRAB THE ROLLING OBJECT!

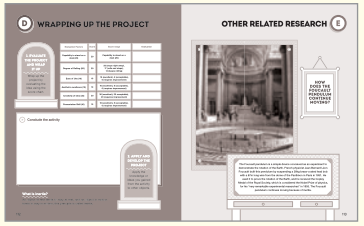
Many school supplies, such as pencils and glue sticks, are round. They often roll around and even fall from desks. When they fall, the noise can be distracting. How can we prevent round objects from rolling?

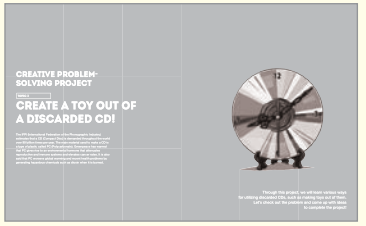


Through this project, we can keep school supplies from rolling around.
Check out the problem and come up with ideas for completing the mission!









Grab the rolling object!

Teacher's Guide

Have students come up with ideas for equipment or methods that cause friction to prevent school supplies from rolling.

Main principles of invention

Pros and cons — Borrowing ideas — Changing the material — Changing the shape

Class management

Introduce	Develop	Conclude
• Discuss common inconveniences that arise from school supplies rolling around. • Inform students of the learning goal.	• Introduce themission. • Provide the preparation materials and evaluation standards. • Inform the students of the learning activity. • Explore the mission. • Complete the mission. • Oral presentation. • Evaluation of the effects.	• Wrap up. • Other related research.

Introduction

- Have students share anecdotes about inconveniences that have arisen due to school supplies rolling around. Use the provided materials to devise a tool for preventing objects from rolling.
  (e.g., What was it that rolled around? Why did it cause you inconvenience?)
  - Ask the students to listen to each other's presentations carefully and make sure that the stories and details they come up with differ from that which have already been presented.
- Assist students in coming up with possible scenariosto actout and discuss. They should also ask questions(e.g., Why did it happen?) and come up with answers by thinking through the questions carefully.

Inform them of the learning goal

Use the provided materials to devise a tool that prevents objects from rolling around.

Inform them of the learning activity

Clearly explain the entire procedure for the day's class, then help the students to understand the activity and prepare for it.

A PROJECT MISSION

1. MISSION

Through this project, we can keep school supplies from rolling around.
Check out the problem and come up with ideas for completing the mission!

Using the provided materials, fashion a glue stick that won't roll around.

2 Conditions of the mission

- It must be easy to set the glue stick down on the surface of a desk.
- The glue stick must not roll even it falls over.
- The glue must be easy to use.
- It has to look appealing.

3 Preparation materials

Material

1 glue stick, 2 rubber bands, 2 paperclips, 2 kinds of straws (bendy/straight), 2 paper cups, 2 flat wooden sticks, 4 thumbtacks

Tools

1 ruler, scissors, and glue stick per team

4 Standards for performance evaluation

The results of the idea

- ★ How well the glue stands on a flat table (20)
- ★ How well the design prevents the glue from rolling (20)
- ★ Ease of use (10)
- ★ Aesthetic excellence (10)

Creativity of Idea

- ★ Is the idea original? (30)

Presentation Skills

- ★ Was the idea clearly explained? (10)

PROJECT MISSION ACTIVITY B

Concept perspective 1
Why does it roll?

→ Roll the glue and find out why it rolls.

1. COME UP WITH AN IDEA FOR A NEW GLUE STICK!

Shape
a cylindrical pillar

Why does it roll?
Pillar-shaped objects roll easily due to the law of inertia.

How can we design a glue stick that doesn't roll around?

Concept perspective 2
Stop the inertia of rolling!

→ Experiment on the following activities and solve the problem by stopping the inertia of an object's rolling motion!

Preparation Materials
A cup without a handle, a cup with a handle, a pen with a clip, a pen with part of it made of rubber, a round pencil case made of fabric or vinyl, other round things

Activity 1	Roll!
Activity 2	Observe and take notes to find out the causes
Activity 3	Write down anything hat might be helpful for completing the mission

ROLL A CUP WITHOUT A HANDLE!

How it rolls →

Distinction →

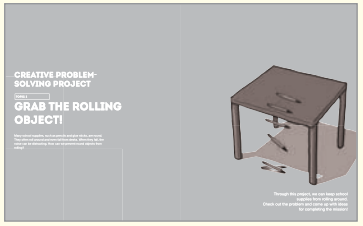
Problem Solving Point →

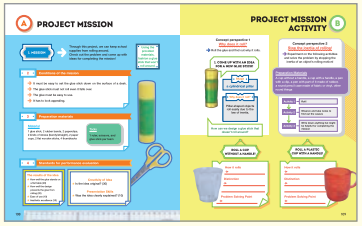
ROLL A PLASTIC CUP WITH A HANDLE!

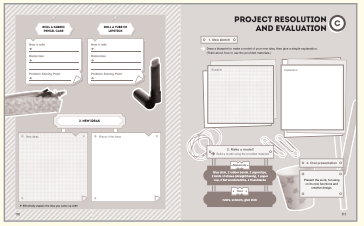
How it rolls →

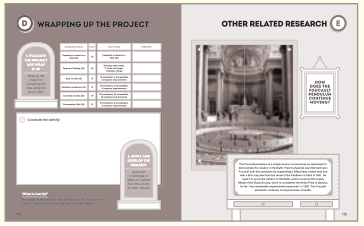
Distinction →

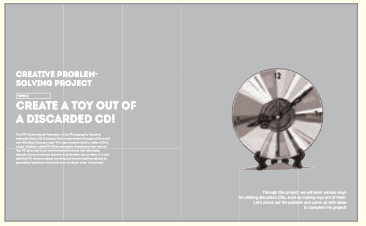
Problem Solving Point →











01 Teaching point

Let the students reflect on the mission, either individually or in groups. Then, reexamine and discuss the conditions, materials, and standards of evaluation involved in the project.

Setting up the project mission

1) Help students understand the given mission and guide them to complete it according to the predetermined conditions and evaluation standards.

2) Check out the provided materials.
- Students can substitute the recommended materials for others, but at least one team will need to use the suggested materials in order for the activity to be as effective as possible.

3) Things to remember
- The tools are not to be used as materials. Don't forget that safety is the top priority.

4) Performance evaluation standards.
- Have the students check out the evaluation standards in order to determine goals toward completing the mission.

02 Teaching point

Help students realize that the key principle for reducing the inertia of a rolling glue stick is to increase friction or to install auxiliary equipment.

Exploring the project mission (summarized from Wikipedia)

1) Understand the concepts of braking and friction
- Braking
  ① Stops a machine or car that is in motion
  ② Makes an object stop moving
- **Braking power**: The force that stops or controls motion
- **Friction**: The force that resists relative motion between two objects in contact with each other
- **Frictional force**: The force exerted by a surface as an object moves across it or tries to move across it
- **Coefficient of friction**: A dimensionless scalar value which describes the ratio of the force of friction between two bodies and the force pressing them together. It depends on the amount of friction, the ratio in comparison to the normal force, the quality of materials in friction, and the lubricity of the contact surface.

2) Study the concept of braking through various examples
- A large bus sliding down a hill due to a faulty brake system
  ① Why can't the driver reduce the bus' speed on the way down?
  ② How can we reduce the speed (brake) on the way down?
- **Cause**: It's because of the degradation (fade) of brake systems. Brake systems deteriorate because friction is temporarily reduced as the contact surface of brake parts (brake linings and brake drums) become hardened by heat during sudden or consecutive braking. It decreases the coefficient of friction.
- **Solution**: Use auxiliary brakes to avoid the degradation (fade) of brake systems. Auxiliary brakes assist the main brake system, reduce the overload of the main brake system, and maintain their function when they're used concurrently with the main brake systems.
- **Conclusion**: We can raise the coefficient of friction or use an auxiliary device to stop an object from rolling.

ROLL A FABRIC PENCIL CASE

How it rolls

Distinction

Problem Solving Point

ROLL A TUBE OF LIPSTICK

How it rolls

Distinction

Problem Solving Point

2. NEW IDEAS

New ideas

Effects of the ideas

▶ Effectively explain the idea you came up with!

PROJECT RESOLUTION AND EVALUATION C

1. Idea sketch

Draw a blueprint to make a model of your new idea, then give a simple explanation. (Think about how to use the provided materials.)

Blueprint

Explanation

2. Make a model!

Build a model using the provided materials.

Materials

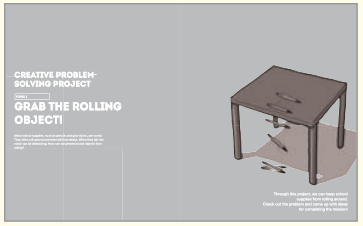
Glue stick, 2 rubber bands, 2 paperclips, 2 kinds of straws (straight/bendy), 1 paper cup, 2 flat woodensticks, 4 thumbtacks

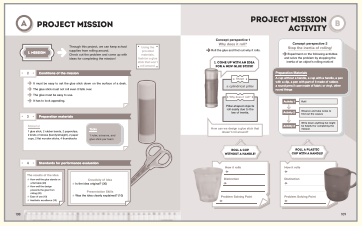
Tool

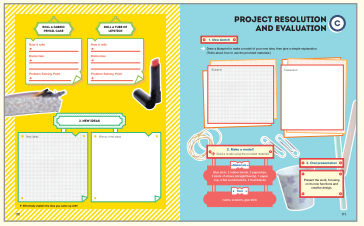
rulers, scissors, glue stick

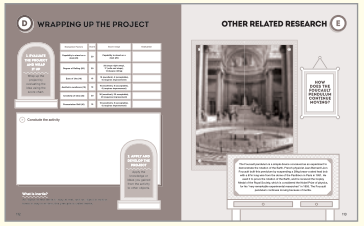
3. Oral presentation

Present the work, focusing on its new functions and creative design.









03 Teaching point

Let students roll any round objects to look for the key point for completing the mission. They can then apply it to the problem of a rolling glue stick by thinking while solving the problem.

1) Complete the mission
   - Roll a paper cup, a plastic cup with a handle, a pencil case made of fabric, a tube of lipstick, etc., to solve the problem.

2) Conduct the activity as shown below. Then determine the principle of invention and apply it to solve the problem.
   - **Activity 1**: Roll the object.
   - **Activity 2**: Observe the result and take notes.
   - **Activity 3**: Note any ideas that might be helpful.

3) Come up with ideas for completing the mission, then determine their pros and cons
   - Think of as many ideas as possible.
   - Determine the pros and cons for each.

4) Choose the best idea

04 Teaching point

Let the students display their ideas with simple illustrations, and present the models made with the provided materials.

Complete the project

1) Students should be encouraged to imagine their models being made into actual inventions. The purpose of this activity is to make a glue stick that stands still without rolling.

2) Students should understand that creating a device that is two or three times more effective than its original design is very difficult and something of which they should be proud.

3) Students should be aware that simple yet creative and effective ideas are often best.

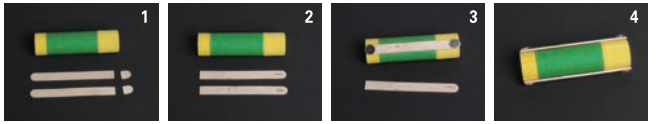
4) Sketch the ideas
   - Have students draw an idea map and explain it in writing.

5) Make a model
   - Each team makes a model using the provided materials.

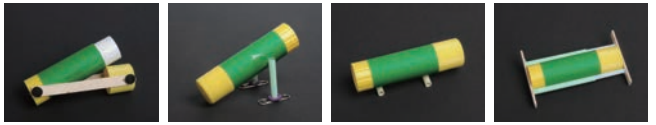
6) Prepare a presentation
   - The students can present their mind map or instructions for building their invention.

7) Present the work
   - All the members of each team should help present the ideas and choose a representative to conduct the final presentation.
   - Let students present in detail their idea and it potential results.

Example of how to complete the mission



Example of completing the mission



D WRAPPING UP THE PROJECT

1. EVALUATE THE PROJECT AND WRAP IT UP

Wrap up the project by evaluating the idea using the score chart.

Evaluation Factors	Score	Score range	Evaluation
Capability to stand on a desk (20)	20	Capability to stand on a desk (20)	
Degree of Rolling (20)	20	20 (stops right away), 17 (rolls and stops), 14 (keeps rolling)	
Ease of Use (10)	10	10 (excellent), 8 (acceptable), 6 (requires improvement)	
Aesthetic excellence (10)	10	10 (excellent), 8 (acceptable), 6 (requires improvement)	
Creativity of Idea (30)	30	30 (excellent), 25 acceptable), 20 (requires improvement)	
Presentation Skill (10)	10	10 (excellent), 8 (acceptable), 6 (requires improvement)	

Conclude the activity

2. APPLY AND DEVELOP THE PROJECT

Apply the knowledge or ideas you gained from the activity to other objects.

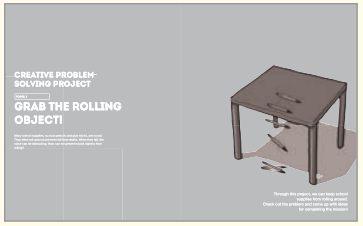
What is inertia?

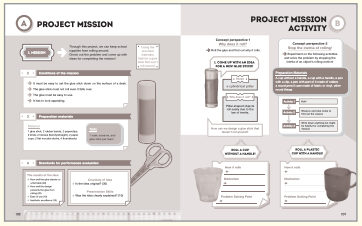
An object at rest tends to stay at rest, and an object in motion tends to stay in motion; this principle is called inertia.

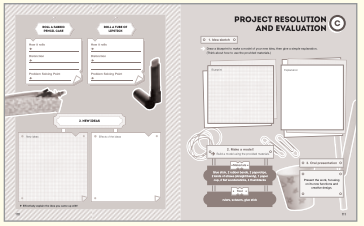
OTHER RELATED RESEARCH E

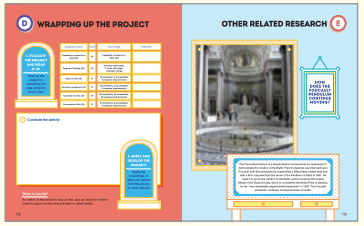
HOW DOES THE FOUCAULT PENDULUM CONTINUE MOVING?

The Foucault pendulum is a simple device conceived as an experiment to demonstrate the rotation of the Earth. French physicist Jean Bernard Léon Foucault built this pendulum by suspending a 28kg brass-coated lead bob with a 67m long wire from the dome of the Panthéon in Paris in 1851. He used it to prove the rotation of the Earth, and he received the Copley Medal of the Royal Society, which is considered the Nobel Prize of physics, for his "very remarkable experimental researches" in 1855. The Foucault pendulum continues moving because of inertia.









05 Teaching point

Help the students evaluate the model using the predetermined evaluation standards, then encourage them to conclude the mission activity on their own.

Evaluation

1) Have the students roll their toys and evaluate themselves and each other. Evaluate each student's work according to whether it meets the conditions for completing the mission, as well as how effectively the student utilized or substituted the provided materials.

2) After the evaluation, discuss the innovative aspects of the students' ideas and find areas for improvement.

3) Display and show appreciation for everyone's work.

Wrap up the project

Review the scientific principles applicable to the mission. Students may need to be guided in modifying or adding onto their work.

Make use of the final product

1) Share ideas that can be applied to other objects or activities.

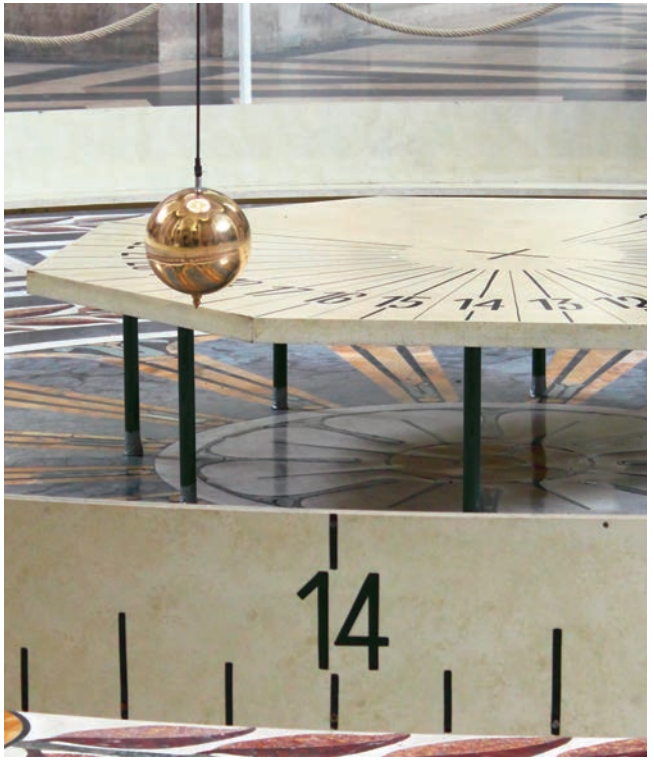
2) Broaden their horizons
   - Various school supplies have different characteristics. Students could look for creative ways to improve various objects. They should also understand the significance of using models that are consistent with real-life objects, the importance of putting the models to use, and the necessity of coming up with innovative solutions.

06 Teaching point

Help students understand that the swing plane of the Foucault's pendulum steadily rotates clockwise in Paris, because of Earth's rotation. Also, they should see how motion changes according to inertia by playing with the toy they made.

Related research

Research may include related articles that help students broaden their understanding of the scientific concept. However, it would be best not to go too deep into related research.

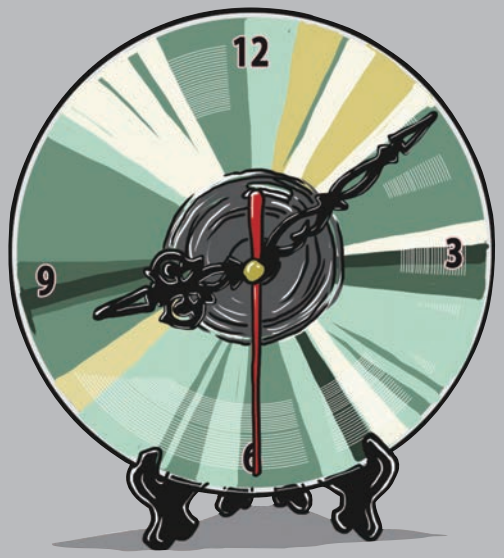


CREATIVE PROBLEM-SOLVING PROJECT

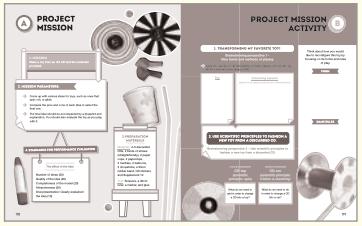
TOPIC 3

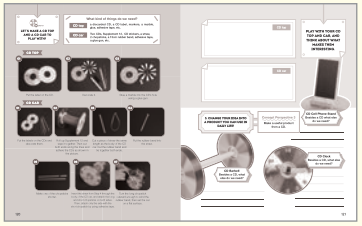
CREATE A TOY OUT OF A DISCARDED CD!

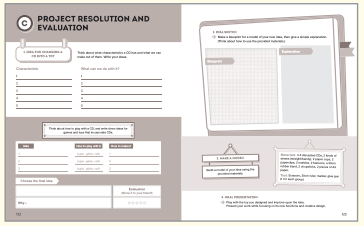
The IFPI (International Federation of the Phonographic Industry) estimates that a CD (Compact Disc) is demanded throughout the world over 90 billion times per year. The main material used to make a CD is a type of plastic called PC (Polycarbonate). Greenpeace has warned that PC gives rise to an environmental hormone that attenuates reproductive and immune systems and elevates cancer rates. It is also said that PC worsens global warming and recent health problems by generating hazardous chemicals such as dioxin when it is burned.

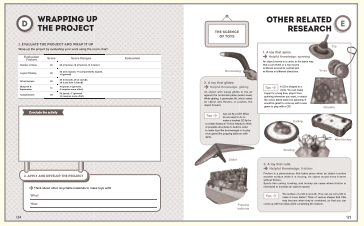


Through this project, we will learn various ways for utilizing discarded CDs, such as making toys out of them. Let's check out the problem and come up with ideas to complete the project!









Make a toy out of a discarded CD

Teacher's guide

We can make an interesting toy from a discarded CD.

Method of invention

PMI method — Pros and cons — Listing possibilities — Addition

Class management

Introduce	Develop	Conclude
• Introduction. • Give the background information for the mission. • Inform students of the learning goal.	• Explain the mission. • Provide the materials and evaluation standards. • Explain the activity. • Explore the related principles of invention through actual inventions. • Conceptualize various ideas and select the best one. • Make a model. • Conduct oral presentations and evaluations.	• Wrap up the mission activity. • Related research.

Introduction

- Have students share personal anecdotes about their favorite toys or the most interesting toys they've played with. They should include details such as how these toys work and how to play with them. It would be best to offer detailed examples (e.g., ○○ toy worked like this and I played with it in this way.)
- Ask the students to listen to each other's presentations carefully and try to come up with stories and details that differ from what has already been presented.

Inform them of the learning goal

We can use scientific principles to make an interesting toy from a discarded CD.

Inform them of the learning activity

Clearly explain the entire procedure for the day's class, then help the students to understand the activity and prepare for it.

A PROJECT MISSION

1. MISSION

Make a toy from an old CD and the materials provided.

2. MISSION PARAMETERS:

- Come up with various ideas for toys, such as ones that spin, roll, or glide.
- Compare the pros and cons of each idea to select the final one.
- The final idea should be accompanied by a blueprint and explanation. You should also evaluate the toy as you play with it.

4. STANDARDS FOR PERFORMANCE EVALUATION

The effect of the idea

Number of ideas (20)
Quality of the idea (20)
Completeness of the model (20)
Attractiveness (30)
Oral presentation: Clearly explained the idea (10)

3.PREPARATION MATERIALS

Materials: 4-5 discarded CDs, 2 kinds of straws (straight/bendy), 2 paper cups, 2 paperclips, 2 marbles, 2 balloons, 2 chopsticks, a 50cm rubber band, CD stickers and Supplement 12

Tool: Scissors, a 30cm ruler, a marker, and glue

PROJECT MISSION ACTIVITY B

1. TRANSFORMING MY FAVORITE TOY!

Brainstorming perspective 1 – New forms and methods of playing

Let's choose the most interesting or memorable toy from among all the ones we have played with!

Toy	Interesting aspects (related to its playing methods and characteristics)

2. USE SCIENTIFIC PRINCIPLES TO FASHION A NEW TOY FROM A DISCARDED CD.

Brainstorming perspective 2 – Use scientific principles to fashion a new toy from a discarded CD.

CD top (scientific principle: spin)

What do we need to add in order to change a CD into a top?

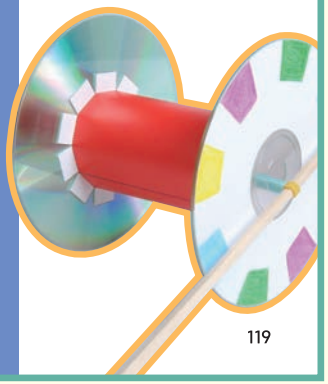
CD car (scientific principle: friction & elasticity)

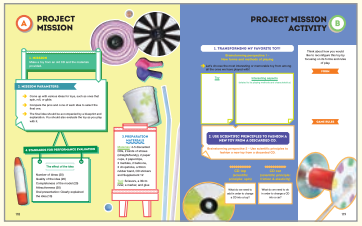
What do we need to do in order to change a CD into a car?

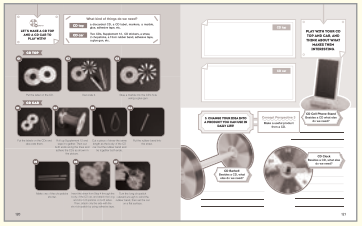
Think about how you would like to reconfigure this toy by focusing on its forms and rules of play.

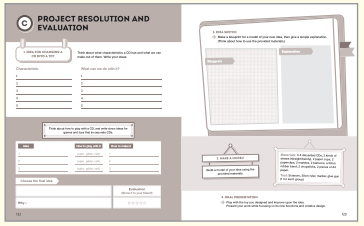
FORM

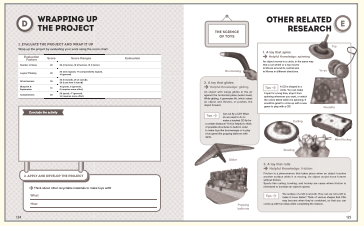
GAME RULES











01 Teaching point

Let the students reflect on the mission, either individually or in groups. Then, reexamine and discuss the conditions, materials, and standards of evaluation involved in the project.

Setting up the project mission

1) Help students understand the given mission and guide them to complete it according to the predetermined conditions and evaluation standards.

2) Check out the provided materials.
   - Students can substitute the recommended materials for others, but at least one team will need to use the suggested materials in order for the activity to be as effective as possible.

3) Things to remember
   - The tools are not to be used as materials. Don't forget that safety is the top priority.

4) Performance evaluation standards.
   - Have the students check out the evaluation standards in order to determine goals toward completing the mission.

02 Teaching point

Let students observe the core principle of transforming an old toy into a new one. Have them use scientific principles to make a new toy from a discarded CD.

Exploring the project mission

1) Examples help students come up with new ideas for making a toy from discarded CDs. However, it would be best not to go too deep.

2) Encourage the students to come up with ideas while playing with existing toys and figuring out how they work and what makes them fun to play with.

3) Examples of learning supplies that can be made from discarded CDs
   - Flags, number boards, ball carriers, etc.

4) Typical modes of play: sensory, exercise, imitation, acceptance, construction, gaming, etc.

DVD 04

LET'S MAKE A CD TOP AND A CD CAR TO PLAY WITH!

What kind of things do we need?

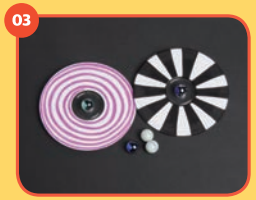
CD top a discarded CD, a CD label, markers, a marble, glue, adhesive tape, etc.

CD car Two CDs, Supplement 12, CD stickers, a straw, 2 chopsticks, a 15cm rubber band, adhesive tape, a glue gun, etc.

CD TOP

01 Put the label on the CD.

02 Decorate it.

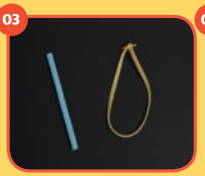


03 Glue a marble into the CD's hole using a glue gun.

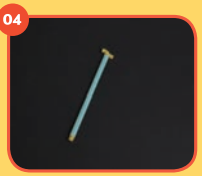
CD CAR

01 Put the labels on the CDs and decorate them.

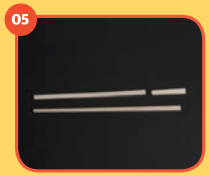
02 Roll up Supplement 12 and tape it together. Then cut both ends along the lines and adhere the CDs as shown in the picture.



03 Cut a piece of straw the same length as the body of the CD car. Cut the rubber band and tie together both ends.

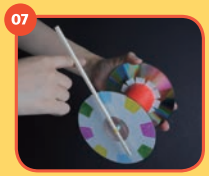


04 Put the rubber band into the straw.



05 Make one of the chopsticks shorter.

06 Insert the straw from Step 4 through the body of the CD car, and attach the long and short chopsticks on both sides. Then, attach only the side with the short chopstick by using adhesive tape.



07 Turn the long chopstick outward enough to wind the rubber band, then set the car on a flat surface.

CD top

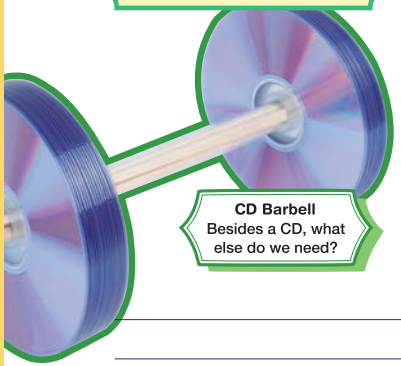
CD car

PLAY WITH YOUR CD TOP AND CAR, AND THINK ABOUT WHAT MAKES THEM INTERESTING.

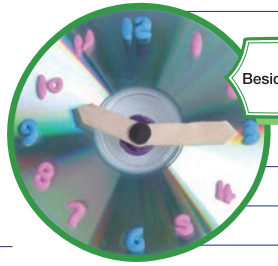
CD Cell Phone Stand
Besides a CD what else do we need?

3. CHANGE YOUR IDEA INTO A PRODUCT YOU CAN USE IN DAILY LIFE!

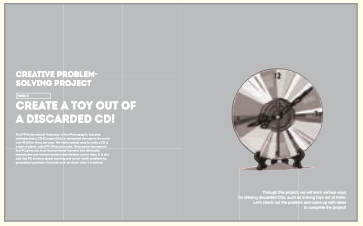
Concept Perspective 3
Make a useful product from a CD.

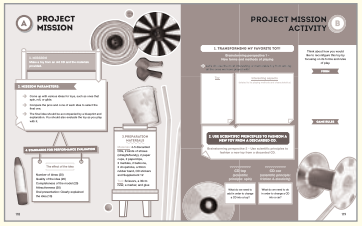


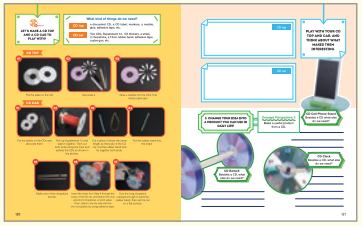
CD Barbell
Besides a CD, what else do we need?

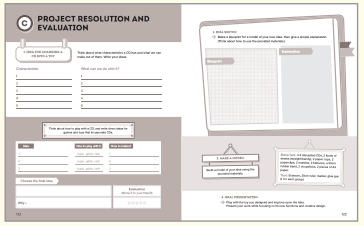


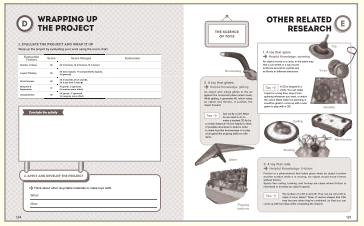
CD Clock
Besides a CD, what else do we need?











03 Teaching point

Let students come up with new methods of play using a toy made from a discarded CD.

1) If time is limited, students can use the CD to make a top or a car.

2) You can substitute the provided materials for others.

3) Something to remember
   - Make sure the students wear gloves when using a glue gun.

4) Paste a marble on the bottom of a CDto make a top.

5) When students make a CD car, they need to connect two CDs with a straw to keep their central axes the same. They should use a glue gun to connect the CD and chopsticks, and the rubber band should be wound around the chopsticks.

04 Teaching point

Help students come up with ideas for a new product while looking into existing products made from CDs.

1) Encourage students to think about how they can add various uses and functions by combining multiple CDs, then help them come up with ideas for useful products in everyday life.

2) Students may choose to use recycledmaterials in place of the provided materials.

3) When running out of time, students can choose to make one of the three objects, or they can use the reference photographs to come up with something new.

C PROJECT RESOLUTION AND EVALUATION

1. IDEA FOR CHANGING A CD INTO A TOY

Think about what characteristics a CD has and what we can make out of them. Write your ideas.

Characteristic	What can we do with it?
1	1
2	2
3	3
4	4
5	5

Think about how to play with a CD, and write down ideas for games and toys that incorporate CDs.

Idea	How to play with it	How to make it
1	(spin, glide, roll)	1
2	(spin, glide, roll)	2
3	(spin, glide, roll)	3

Choose the final idea

	Evaluation (Show it to your friend!)
Why ▸	☆☆☆☆☆

2. IDEA SKETCH

Make a blueprint for a model of your new idea, then give a simple explanation. (Think about how to use the provided materials.)

Blueprint

Explanation

3. MAKE A MODEL!

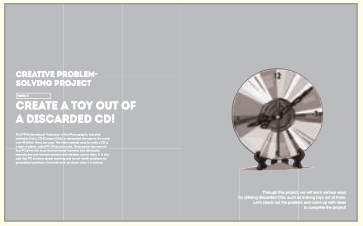
Build a model of your idea using the provided materials.

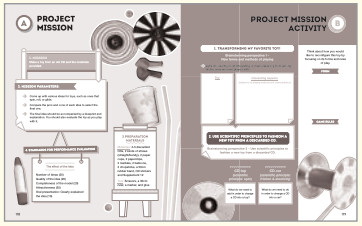
Materials: 4-5 discarded CDs, 2 kinds of straws (straight/bendy), 2 paper cups, 2 paperclips, 2 marbles, 2 balloons, a 50cm rubber band, 2 chopsticks, 2 pieces of A4 paper.

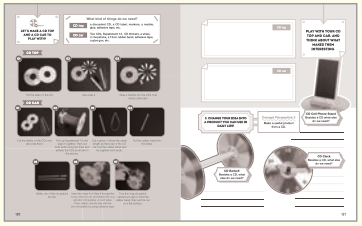
Tool: Scissors, 30cm ruler, marker, glue gun (1 for each group)

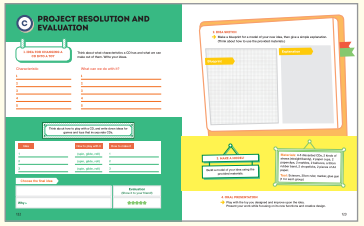
4. ORAL PRESENTATION

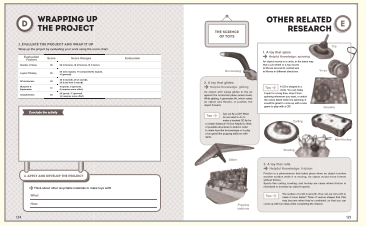
Play with the toy you designed and improve upon the idea.
Present your work while focusing on its new functions and creative design.











05 Teaching point

Help students consider the various characteristics of a CD and the ways they can use them to complete the mission. Then have them come up with ideas based on how they might play with the toy.

1) It would be best to let students imagine their model being made into an actual toy, since the purpose of this activity is to come up with ideas and ways to play with a toy made froma discarded CD.

2) It's easy to look at the different characteristics of a CD if the students think about and discuss the various common attributes of a normal CD.

3) After studying the attributes of a CD, they can consider whether to play with it by rolling it, spinning it, or gliding it.

4) Students should be reminded that coming up with ideas for how to play with a new toy is fun as well as educational.

5) Let the students know that simple yet creative and effective ideas often lead to inventions.

06 Teaching point

Let students present their ideas via a simple illustration and/or model.

Complete the mission

1) Help the students draw a blueprint of their idea and explain it to the class.
   - The blueprint should enable them to explain the overall shape and the details of each part.

2) Make a model from the provided materials.
   - The provided materials may be changed depending on certain conditions. Tools should not be used as materials.
   - Safety is the top priority while making models. A model may turn out differently from the blueprint if students encounter problems when making it. The final model should resolve such problems.

3) Present the result
   - Let the students explain in their own words the core factors and effects of their ideas.

Example of how to complete the mission

CD archery

① Put a discarded CD and a paper cup together, then add legsto construct a target.

② Makea bow and arrow out of a rubber band and a balloon, taking advantage of their elasticity.

Example of completing the mission

CD roller coaster

CD curling

CD top

CD roulette

CD pinball

D WRAPPING UP THE PROJECT

1. EVALUATE THE PROJECT AND WRAP IT UP

Wrap up the project by evaluating your work using the score chart.

Evaluation Factors	Score	Score Ranges	Evaluation
Number of Ideas	20	20 (3 factors), 18 (2 factors), 16 (1 factor)	
Logical Thinking	20	20 (very logical), 17 (comparatively logical), 14 (general)	
Attractiveness	30	30 (5 stars★), 25 (4 stars★), 20 (Less than 3 stars★)	
Blueprint & Explanation	10	10 (great), 8 (general), 6 (requires more effort)	
Completeness	20	20 (great), 17 (general), 14(requires more effort)	

Conclude the activity

2. APPLY AND DEVELOP THE PROJECT

Think about other recyclable materials to make toys with!

What

How

E OTHER RELATED RESEARCH

THE SCIENCE OF TOYS

Boomerang

1. A toy that spins

Helpful Knowledge: spinning

An object moves in a circle, in the same way that a car wheel or a top moves
★ Moves around its central axis
★ Moves in different directions

Top

Yo-yo

Tips → A CD is shaped in a circle. You can make it spin for a long time, stop it from spinning whenever you want, or watch the colors blend while it is spinning. It would be great to come up with a new game to play with a CD!

Roulette

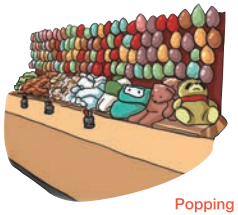
2. A toy that glides

Helpful Knowledge: gliding

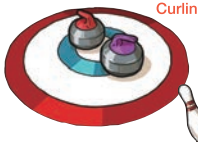
An object with wings glides in the air against the horizontal plane (water level). While gliding, it generates lift, which raises an object and thrusts, or pushes, the object forward.

Tips → Can we fly a CD? What do we need to do to make a trashed CD fly for a certain distance? It'd be helpful to think of possible structures to build in order to make toys like boomerangs or to play a fun game like popping balloons with darts.

Glider



Popping balloons



Curling

Mini Hockey

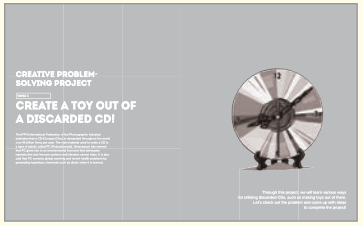
Bowling

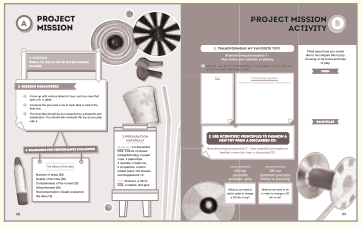
3. A toy that rolls

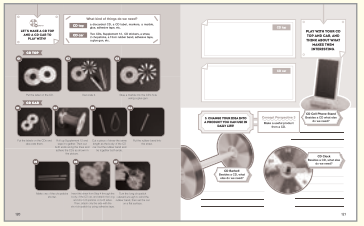
Helpful Knowledge: friction

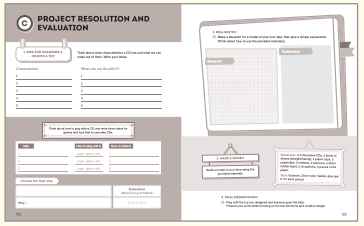
Friction is a phenomenon that takes place when an object touches another surface while it is moving. An object would move forever without friction.
Sports like curling, bowling, and hockey are cases where friction is minimized to increase an object's speed.

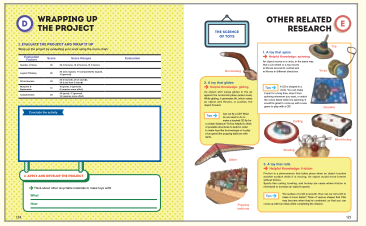
Tips → The surface of a CD is smooth. How can we roll a CD to make it move faster? Think of various shapes that CDs may become when they're combined, so that you can come up with fun ideas while completing the mission.











07 Teaching point

Let students evaluate their models according to the performance evaluation standards, and come to their own conclusions as to the mission's success.

Project evaluation

1) Let students play and evaluate the finished models. They should encourage each other while focusing on whether the activity was accomplished in accordance with the mission parameters, i.e. how the provided materials were used, and whether they were applied effectively.

2) After the self-evaluation, lead them in discussing talk about what was and wasn't effective in each other's models.

3) Have students display their work.

4) Review the basic principles by using the students' models as illustrations.

5) Introduce further activities to help them improve and develop their models.

Make use of the final product

1) Help students apply their knowledge of the basic principles of their invention to other objects.

2) Applying principles to other objects
   ① Choose an object (ex. A plastic bottle)
   ② Come up with ideas for types of games (ex. Sensing things, acting something out, making up things, etc.)
   ③ Think about how to play with the object (ex. glide it, throw it, etc.)

08 Teaching point

Help students understand that many different scientific principles, such as spinning, gliding, and friction, are applied in different ways to operate their toys.

1) Help the students come up with other recycling methods for making a toy.

2) Students will learn more effectively if they explore actual patented inventions or winning pieces from student invention competitions, but they should not look into it too deeply.

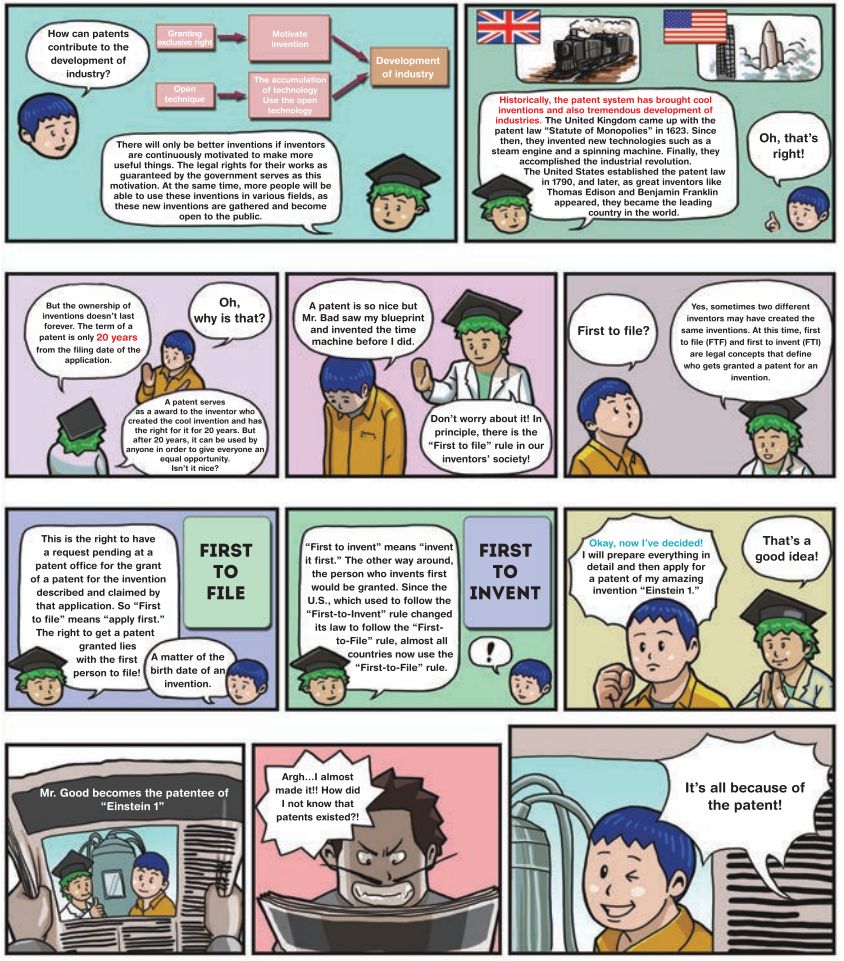
3) A spinning toy
- You can let students make up games and plays using a CD, such as watching the colors blend while the CD spins, spinning a CD for as long as possible, stopping its spin as quickly as possible, and so on.

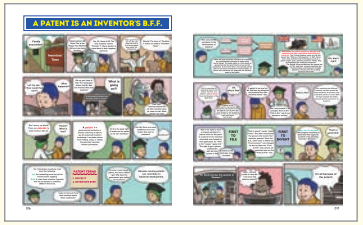
4) A gliding toy
- Asking questions like "Can we make a CD fly?", "How can we make a wrecked CD glide for a certain distance?", "What can we do to change a CD into a toy, like a plane, boomerang, or dart for popping balloons?" would help the students complete the mission successfully.

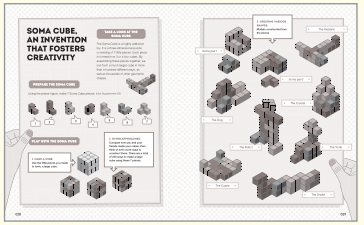
5) A rolling toy
- The surface of a CD is smooth. How can we make a CD roll for a long distance? Putting some CDs together or applying the sports principles sports would help students come up with ideas for completing the mission.

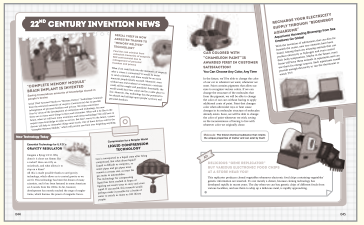
※ Let the students use recyclable materials other than CDs in order to demonstrate how to save energy by recycling. They should think of ways to improve their ideas and go through the related activities while applying them.

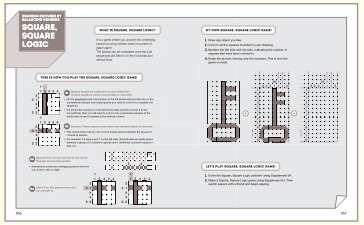
A PATENT IS AN INVENTOR'S B.F.F.

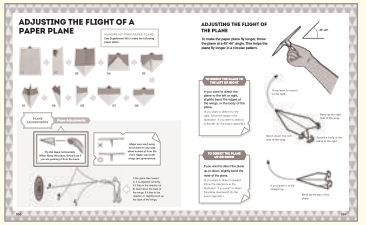








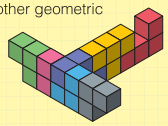




SOMA CUBE, AN INVENTION THAT FOSTERS CREATIVITY

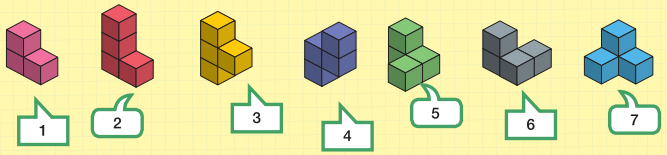
TAKE A LOOK AT THE SOMA CUBE

The Soma Cube is a highly addictive toy. It is a three-dimensional puzzle consisting of 7 little pieces. Each piece is formed from 3 or 4 tiny cubes. By assembling these pieces together, we can form a much larger cube in more than a hundred different ways, as well as thousands of other geometric shapes.



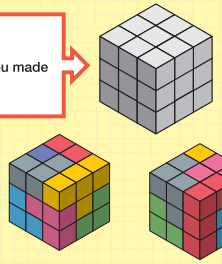
PREPARE THE SOMA CUBE

Using the planar figure, make 7 Soma Cube pieces. (Use Supplement 02)

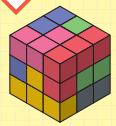


PLAY WITH THE SOMA CUBE

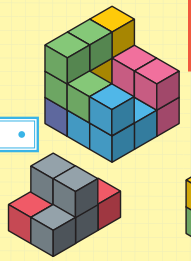
1. MAKE A CUBE:
Use the little pieces you made to form, a large cube.



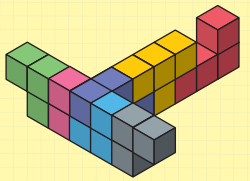
2. OTHER APPROACHES:
Compare how you and your friends made your cubes, then think of even more ways to construct them. There are a total of 240 ways to make a large cube using these 7 pieces.

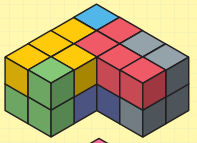


3. CREATING VARIOUS SHAPES:
Models constructed from the pieces

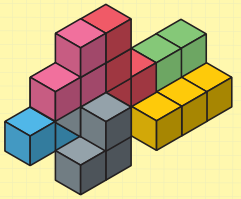


The Airplane

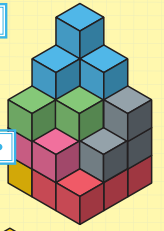




Soma pair2

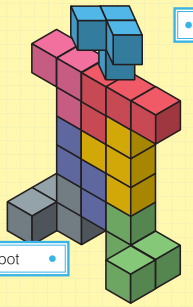


The Crystal

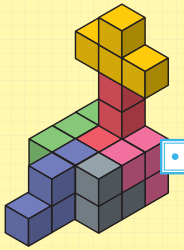


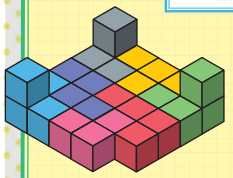
The Dog

The Robot

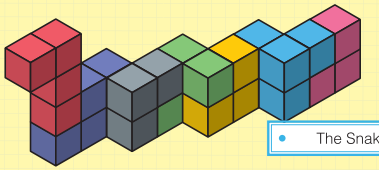


The Tomb

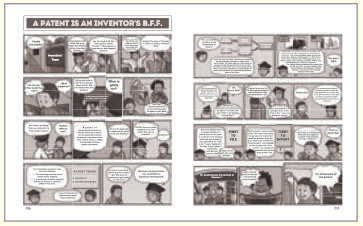


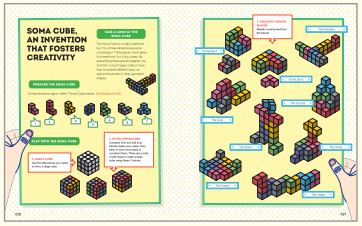


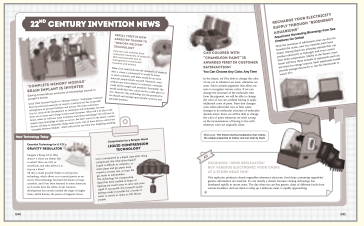
The Castle

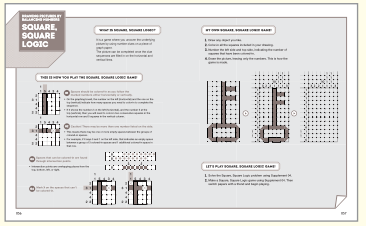


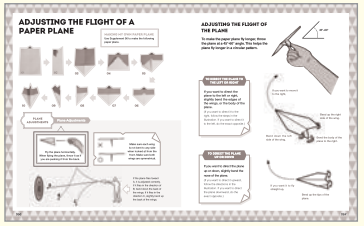
The Snake











22ND CENTURY INVENTION NEWS

"COMPLETE MEMORY MODULE" BRAIN IMPLANT IS INVENTED

Saving tremendous amounts of knowledge stored in people's brains

Serial Thief Arrested Thanks to "Memory Deliver" Technology Criminals from the extracted memories of suspects Controversial due to possible infringement of personal freedom and privacy. We enjoy convenient lives by virtue of the development of civilization and technology, but now there are so many more things to learn and remember. What will it be like in the future, when we will have more inventions and newer technology? We will have to acquire more knowledge in order to survive. But don't worry! In the future, various devices will help us remember things more easily. One of those devices will be the "Complete Memory Module," which will prevent you from ever forgetting anything.

SERIAL THIEF IS NOW ARRESTED THANKS TO "MEMORY DELIVER" TECHNOLOGY'

Find the real criminal from extracted memories of suspects Still controversial due to infringement of personal freedom and privacy

What if we could look into the memories of suspects after a crime is committed? It would be easier to catch criminals, and there would be no more innocent people falsely accused. Moreover, even without any real evidence or witnesses, criminals could still be caught and punished. Eventually, the world would have less crime and be a safer place to live. However, this technology has the potential to be abused and infringe upon people's privacy and personal freedom.

New Technology Today

Essential Technology for U.F.O.'s GRAVITY REGULATOR

Imagine a flying U.F.O. Why doesn't it shoot out flames like a rocket? How can it fly so noiselessly, and what allows it to stop on a dime?
All this is made possible thanks to anti-gravity technology, which allows us to control gravity as we see fit. This technology has been the dream of many scientists, and it has been featured in many American sci-fi novels from the 1900s. So far, however, development has merely reached the stage of maglev trains, which harness the power of magnetic forces.

Compression for a Simpler World LIQUID COMPRESSION TECHNOLOGY

Gas is transported in a liquid state after being compressed. But what about liquid? Liquid is difficult to compress, so water pipes and gas pipes must remain a certain size, as must the gas tanks in automobiles. The technology for compressing liquid has been studied in hopes of figuring out easier ways to carry and store liquid. If successful, this research would perhaps make it possible for a bottle of water to satisfy as many as 100 thirsty people.

CAR COLORED WITH "CHAMELEON PAINT" IS AWARDED FIRST IN CUSTOMER SATISFACTION!

You Can Choose Any Color, Any Time

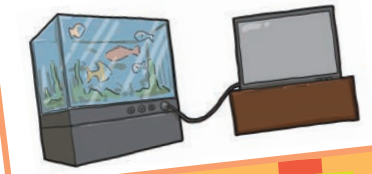
In the future, we'll be able to change the color of our car to whatever we want, whenever we want. Paint contains pigments that allow our eyes to recognize various colors. If we can change the structure of the molecules that form the pigment, we will be able to change the color of our cars without having to apply additional coats of paint. Paint that changes color when ultraviolet rays or heat cause changes in its molecular structure of molecules already exists. Soon, we will be able to change the color of paint whenever we wish, saving us the inconvenience of having to live with whatever color we originally chose.

Molecule: The tiniest chemical substance that retains the unique properties of matter and can exist by itself.

RECHARGE YOUR ELECTRICITY SUPPLY THROUGH "BIOENERGY AQUARIUMS"

Aquariums Harvesting Bioenergy from Sea Creatures Go Global

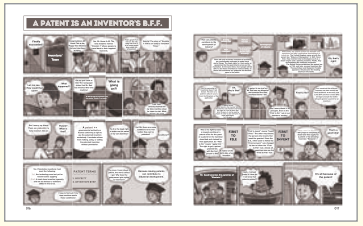
With the invention of submarines that can dive far beneath the ocean, new sea creatures have been found. Among them are amazing animals that can produce electricity or hydrogen and even control their body temperature. Maybe in the future, every home will have these animals in aquariums and can use them for energy sources. Such aquariums would provide enough electricity to run the thermostat or watch TV!!

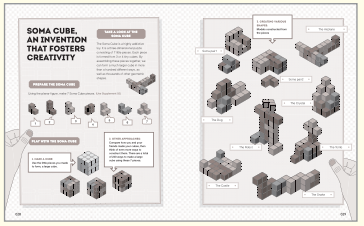


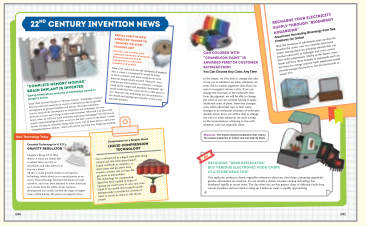
AD

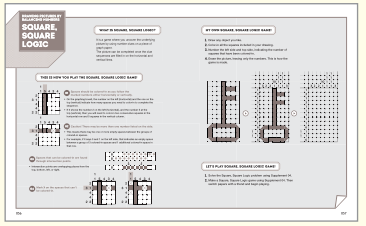
DELICIOUS "GENE REPLICATOR" BUY VARIOUS ELECTRONIC FOOD CHIPS AT A STORE NEAR YOU!

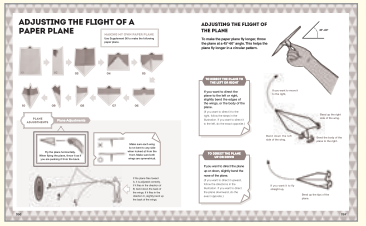
This replicator produces cloned vegetables whenever electronic food chips containing vegetables' genetic information are inserted. It's not merely a dream, because cloning technology has developed rapidly in recent years. The day when we can buy genetic chips of different foods from various localities, and use them to whip up a delicious meal, is rapidly approaching.











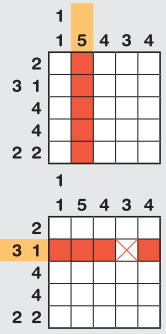
DRAWING PICTURES BY BALANCING NUMBERS

SQUARE, SQUARE LOGIC

WHAT IS SQUARE, SQUARE LOGIC?

It is a game where you uncover the underlying picture by using number clues on a piece of graph paper.
The picture can be completed once the clue sequences are filled in on the horizontal and vertical lines.

THIS IS HOW YOU PLAY THE SQUARE, SQUARE LOGIC GAME!



01 Spaces should be colored-in as you follow the marked numbers either horizontally or vertically.

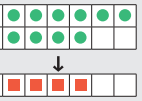
- On the graphing board, the number on the left (horizontal) and the one on the top (vertical) indicate how many spaces you need to color-in to complete the sequence.
- If it shows the number 2 on the left (horizontal), and the number 5 at the top (vertical), then you will need to color-in two consecutive squares in the horizontal row and 5 squares in the vertical column.

02 Caution! There may be more than one number listed on the side.

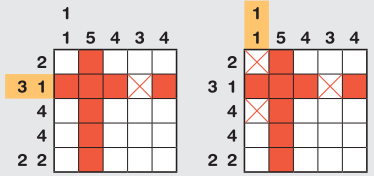
- This means there may be one or more empty spaces between the groups of colored-in spaces.
- For example, if it says 3 and 1 on the left side, that indicates an empty space between a group of 3 colored-in spaces and 1 additional colored-in space in that row.

03 Spaces that can be colored-in are found through intersection points.

- Intersection points are overlapping places from the top, bottom, left, or right.

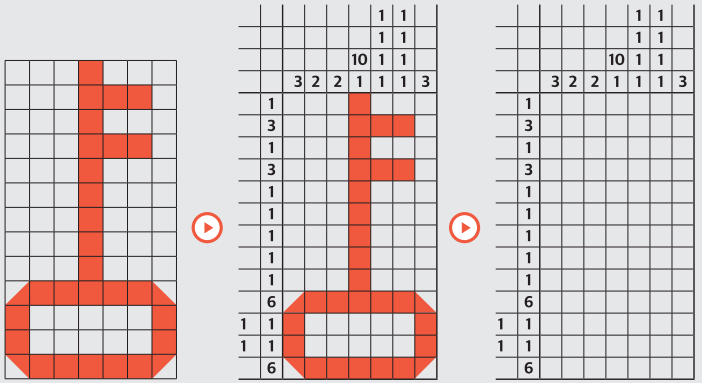


04 Mark X on the spaces that can't be colored-in.



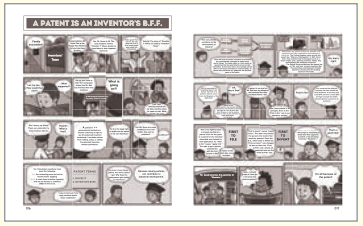
MY OWN SQUARE, SQUARE LOGIC GAME!

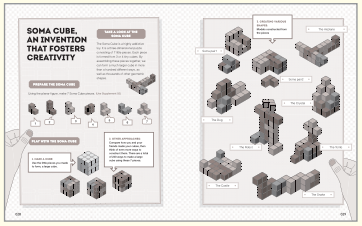
1. Draw any object you like.
2. Color-in all the squares included in your drawing.
3. Number the left side and top side, indicating the number of squares that have been colored-in.
4. Erase the picture, leaving only the numbers. This is how the game is made.

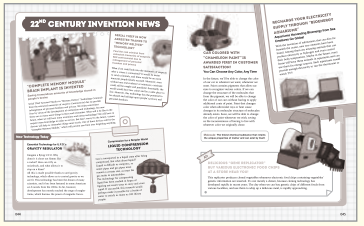


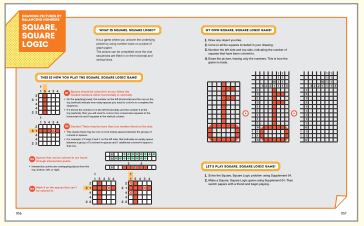
LET'S PLAY SQUARE, SQUARE LOGIC GAME!

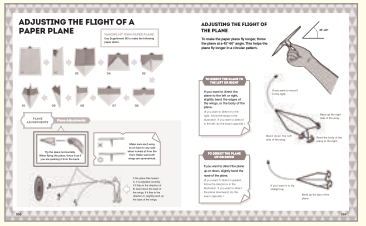
1. Solve the Square, Square Logic problem using Supplement 04.
2. Make a Square, Square Logic game using Supplement 04. Then switch papers with a friend and begin playing.







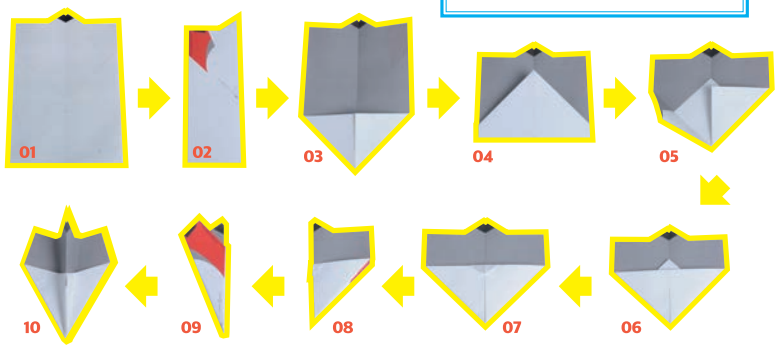




ADJUSTING THE FLIGHT OF A PAPER PLANE

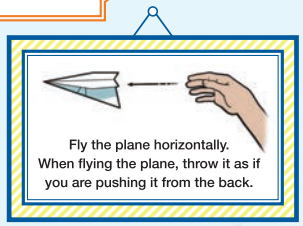
MAKING MY OWN PAPER PLANE

Use Supplement 06 to make the following paper plane.

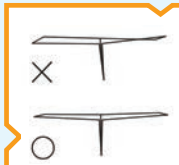


PLANE ADJUSTMENTS

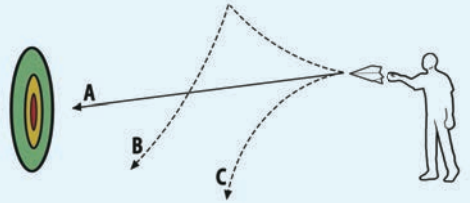
Plane Adjustments



Fly the plane horizontally. When flying the plane, throw it as if you are pushing it from the back.



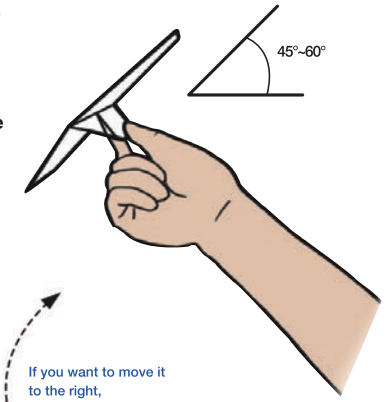
Make sure each wing is not bent to any side when looked at from the front. Make sure both wings are symmetrical.



If the plane flies toward A, it is adjusted correctly. If it flies in the direction of B, bend down the back of the wings. If it flies in the direction C, slightly bend up the back of the wings.

ADJUSTING THE FLIGHT OF THE PLANE

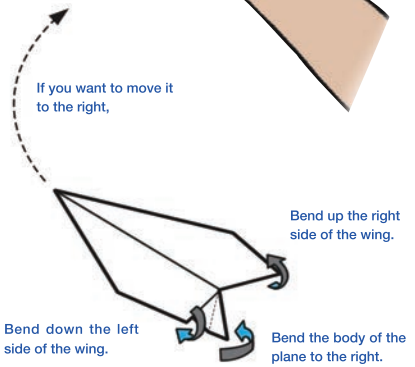
To make the paper plane fly longer, throw the plane at a 45°-60° angle. This helps the plane fly longer in a circular pattern.



TO DIRECT THE PLANE TO THE LEFT OR RIGHT

If you want to direct the plane to the left or right, slightly bend the edges of the wings, or the body of the plane.

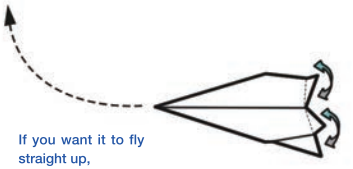
(If you want to direct it to the right, follow the steps in the illustration. If you want to direct it to the left, do the exact opposite.)

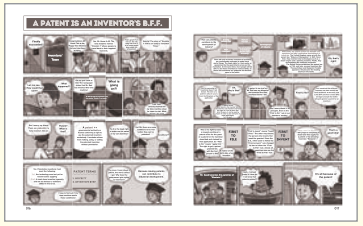


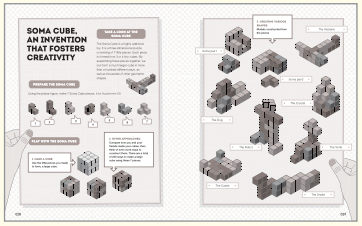
TO DIRECT THE PLANE UP OR DOWN

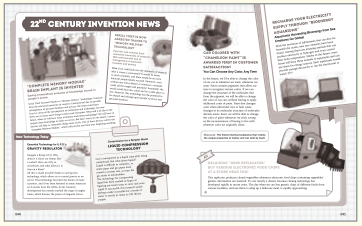
If you want to direct the plane up or down, slightly bend the nose of the plane.

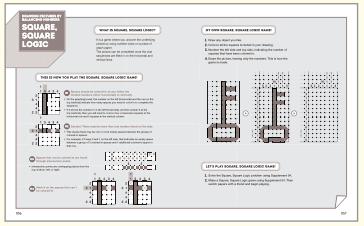
(If you want to direct it upward, follow the directions in the illustration. If you want to direct the plane downward, do the exact opposite.)

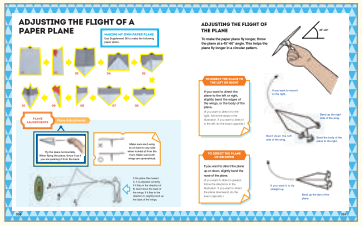








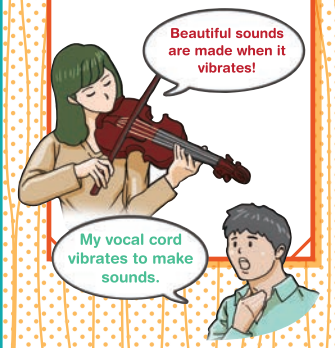




WHAT IS SOUND?

Sounds are made from vibration.

The principle of sound is based on vibration. The beautiful sounds of a violin or guitar come from the vibration of the strings. The human voice works the same way. Our voices are made through the vibration of our vocal cords. When you say "Ah~" and touch your neck, you can feel the vocal cords vibrate. The appearance of an object trembling is called "vibration."

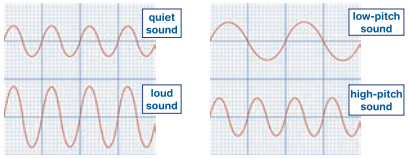


Sound needs air

Just as we need air to live, we also need air to deliver sounds to our ears. How does this work? The vibration of an object is transmitted to the air, which then vibrates in the same fashion as the object. Those vibrations are carried through the air until they reach our eardrums. Any kind of matter that transmits sound is called a "medium."

High and low pitches, and sound volume

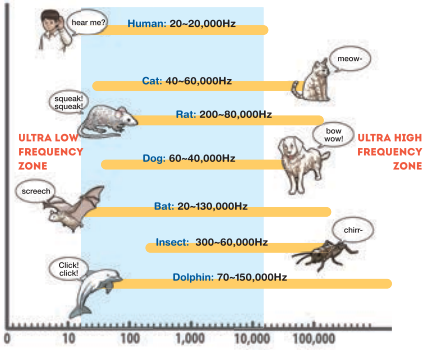
"In public, you have to speak quietly." "A woman's voice is higher than a man's voice." "What does it mean for sounds to be quiet or high?" First, the pitch of the sound being high or low is decided by the number of vibrations, or how frequently a voice trembles. If there are many vibrations, it is a high-pitched sound, and if there are fewer vibrations, it is a low-pitched sound. The loudness of sound is related to the width (amplitude) of the vibration. As the amplitude gets larger, loud sounds are made, and as the amplitude gets smaller, quiet sounds are made.



(a) the pitch of sound is the same (b) the strength of sound is the same

Sounds that humans can't hear

Why can't we hear ultrasonic waves made by dolphins and bats? This is because the sounds we can hear range from 16 (16Hz) vibrations per second to 20,000 (20,000Hz=20kHz) vibrations per second.
If the number of vibrations is lower than 16Hz or larger than 20,000Hz, the sounds can't be heard by human ears. The range of sounds we can hear, or the range ofvibrations from 16Hz~20kHz, is called the audio frequency, and the sounds we can't hear that are greater than 20kHz are called ultrasonic waves.



Inventions that use the Ultrasonic Wave

01 Ultrasound Medical Equipment

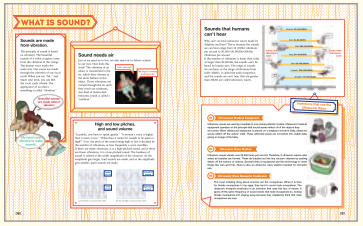
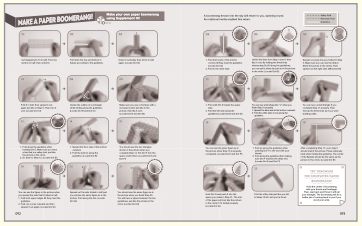
Ultrasonic waves are used by hospitals to look inside patients' bodies. Ultrasound medical equipment operates on the principle that sound waves reflect off of the objects they encounter. When ultrasound equipment is placed on a pregnant woman's belly, ultrasonic waves reflect off the unborn child. These reflected waves are converted into visible data, giving an image of the baby.

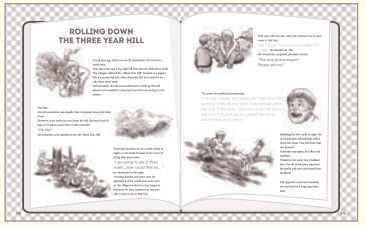
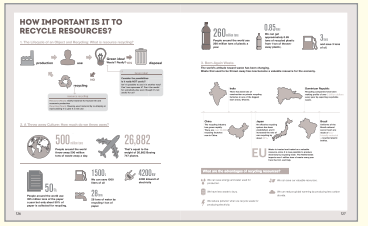
02 Ultrasonic Wave Washer

Ultrasonic waves vibrate over 20,000 times per second. Therefore, if ultrasonic waves enter water, air bubbles are formed. These air bubbles act like tiny vacuum cleaners by peeling debris off the surface of objects. Several kinds of equipment use this technology to clean things like cars and fruit. There is also an ultrasonic wave washer invented for domestic use.

03 Ultrasonic Wave Mosquito Eradicator

The most irritating thing about summer are the mosquitoes. When it is time for female mosquitoes to lay eggs, they tend to avoid male mosquitoes. The ultrasonic mosquito eradicator is an invention that uses this fact of nature. It gives off the same frequency of sound waves that male mosquitoes do, fooling female mosquitoes into staying away because they mistakenly think that male mosquitoes are near.

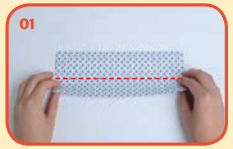



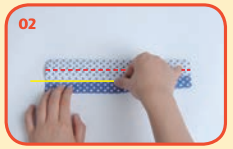
MAKE A PAPER BOOMERANG!

Make your own paper boomerang using Supplement 10!

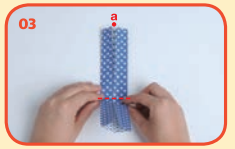
DVD 02



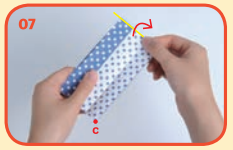
Cut Supplement 10 in half. Fold one section in half, then unfold it.



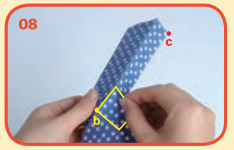
Fold both the top and bottom in halves according to the guideline.



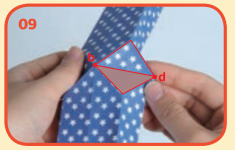
Orient it vertically, then fold it in half again. (Locate Dot A!)



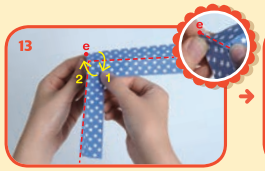
Fold it in half, then spread it out again just like in Step 6. Then turn it over. (Locate Dot C!)



Create the outline of a rectangle while folding along the guideline. (Locate Dot B and Dot C!)

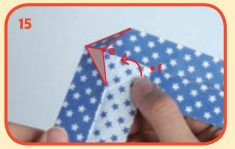


Make sure you see a rhombus with a recessed center just like in the picture, then flip it over. (Locate Dot B and Dot D!)

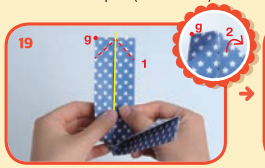


1. Fold along the guideline while holding Dot E. Make sure you have a line that is a valley fold, just like the picture in the circle.
2. Go back to Step 12. (Locate Dot E!)

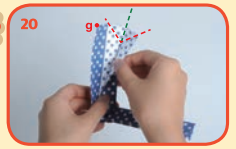
1. Spread the floor side of the bottom outward.
2. Fold the bottom along the guideline. (Locate Dot E!)



You should see the two triangles shown in the picture when you complete Step 14. Put Dot F into the space under them. (Locate Dot E and Dot F!)



You can see the figure in the picture when you spread the side that's folded in half.
1. Fold both upper edges till they meet the guideline.
2. Fold one corner outward and then spread it out again. (Locate Dot G!)

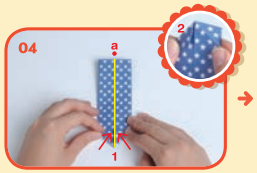


Spread out the side folded in half and you will see the same figure as in the picture. Fold along the line. (Locate Dot G!)

You should see the same figure as in the picture when you finish Step 20. You will have a space between the two guidelines, just like the picture in the circle. (Locate Dot G!)

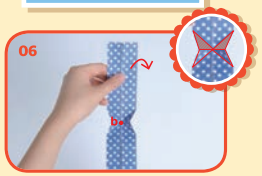
A boomerang thrown into the sky will return to you, spinning round.
Its rotational inertia enabled this return.

Valley Fold
Mountain Fold
Guideline

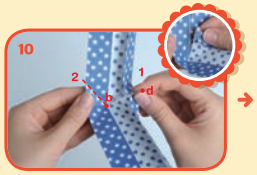


1. Fold both ends of the bottom corners till they meet the guideline. (Locate Dot A!)
2. Fold to the other side.

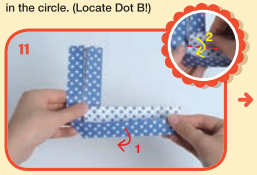
Unfold the lines from Step 3 and 4, then flip it over. By folding the three lines intersecting Dot B along the guidelines, you can get a sharp tip just as in the picture in the circle. (Locate Dot B!)



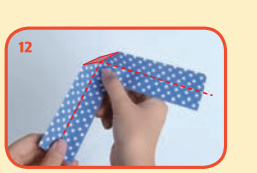
Spread out every line you folded in Step 5. Make sure you can see the ribbon (Note the picture in the circle). Then spread out the right side. (Mind Dot B!)



1. Fold until Dot D meets the upper side.
2. Fold the left side along the guideline (Locate Dot B and Dot D!)

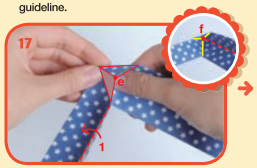


You can see a flat shape like "L" when you finish Step 10 properly.
1. Spread the blue side at the bottom outward.
2. Fold the white side on top along the guideline.

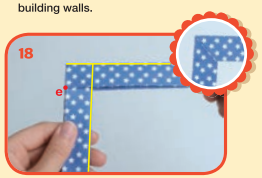


You can see a small triangle if you complete Step 11 properly. Then fold up the three lines as if you were building walls.

You can see the same figure as in the picture when Step 15 is properly completed. (Locate Dot E and Dot F!)



1. Fold up along the guideline while pushing Dot F to the end with your thumb.
2. Fold along the guideline after making sure Dot F reaches the deep end. (Locate Dot E and Dot F!)



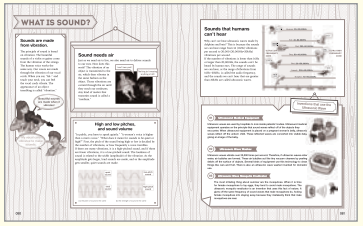
After completing Step 17, your object should match the picture. Press extremely hard when folding the guideline. The center of the flipside should be the same as the picture in the circle. (Locate Dot E!)

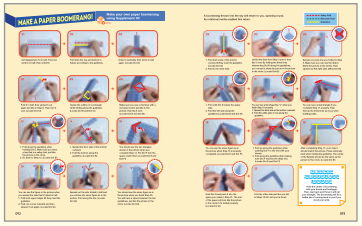
Hold Dot G and push it into the space you made in Step 21. The end of the paper will look like the picture in the circle if it's folded properly. (Locate Dot G!)

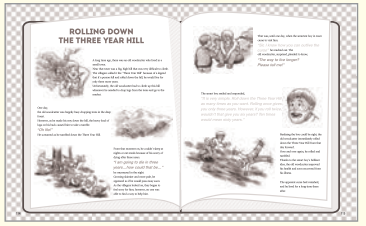
Fold the other side just like you did in Steps 19-22, and you're done!

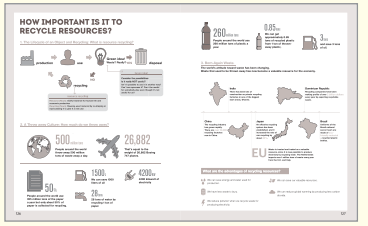
TRY THROWING THE COMPLETED PAPER BOOMERANG!

Hold the center of boomerang with your thumb and forefinger. Then, rear back and throw it with all your strength. The boomerang will do a better job of coming back to you if you recoil your wrist.









THE BEST INVENTION IN THE WORLD

Pikadu is a little boy living in a small town in Africa. He used to walk for long periods of time holding a small container under the blazing sun.
The only river he can get water from nearby is a few kilometers away from his home. Going back and forth was a daily mission, and with a full container, it was simply too much of a physical strain on this poor little boy.
The precious water would spill out of the container as he waddled and struggled with the weight of it all.
One day, something amazing changed his life. He was introduced to Q-drum, a container designed a funny shape. Like a donut, it was round and had a hole in its center, and it moved in the same way that you would roll a wheel, towing it via an attached rope.
Thanks to this invention, now Pikadu does not have to carry a heavy container filled with water in his hands or put it on his head. He won't lose any drops of the precious water and he can run like the wind, while the Q-drum follows behind. The container is not a burden anymore – it is lightweight.
The inventor of the Q-drum was Piet Hendrikse from the Republic of South Africa.
His sympathy for the women and children carrying heavy containers throughout theday just to get water to drink inspired him to work hard to offer them a better life for them.
Thus, the Q-Drum was invented.

INVENTION FOR A BETTER LIFE

MONEY MAKER PUMP

This pump was invented for poor farmers in Africa.
It functions when a person steps down on it. This simple, easy movement draws up the water flowing deep underground.
People in Africa who lacked the necessary water for farming can now easily get it using this pump.
The poor farmers in Africa can now make a living thanks to this pump.

INVENTING EQUAL OPPORTUNITIES

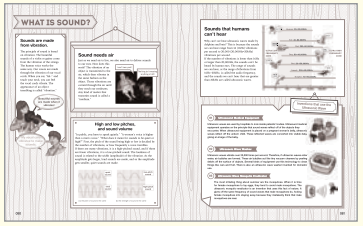
A 100 DOLLAR LAPTOP XO

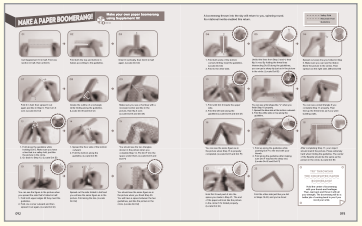
This laptop was invented for the education of students in needy countries.
It costs only 100 dollars, so even students without lots of money can afford it.
It has a pedal that the user can turn to charge the laptop.
Thanks to this laptop, many students in the world have been given an equal opportunity to learn and study.

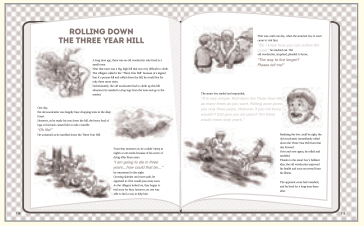
INVENTING TO SAVE THE ENVIRONMENT

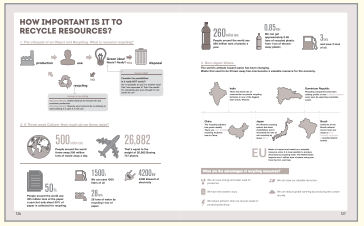
G-SAVER HEATING AID

G-saver was invented for Mongolians who suffered from exhaust gas given off by fossil fuels.
This heating aid conserves heat and can keep a room warm for a long time using just a small amount of coal. The less fossil fuel we burn, the less exhaust gas there will be.
We will not only be able to live in a better and healthier environment but we can also reduce atmospheric pollution by using this heating aid.









ROLLING DOWN THE THREE YEAR HILL

A long time ago, there was an old woodcutter who lived in a small town.
Near that town was a big, high hill that was very difficult to climb.
The villagers called it the "Three Year Hill" because of a legend that if a person fell and rolled down the hill, he would live for only three more years.
Unfortunately, the old woodcutter had to climb up this hill whenever he needed to chop logs from the trees and go to the market.

One day,
the old woodcutter was happily busy chopping trees in the deep forest.
However, as he made his way down the hill, the heavy load of logs on his back caused him to take a tumble.

"Oh No!"

He screamed as he tumbled down the Three Year Hill.

From that moment on, he couldn't sleep at nights or eat meals because of his worry of dying after three years.

"I am going to die in three years...how could that be..."

he murmured in the night.
Growing skinnier and more pale, he appeared as if he would pass away soon.
As the villagers looked on, they began to feel sorry for him; however, no one was able to find a way to help him.

That was, until one day, when the smartest boy in town came to visit him.

"Sir, I know how you can outlive the curse" he reached out. The old woodcutter, surprised, pleaded to know,

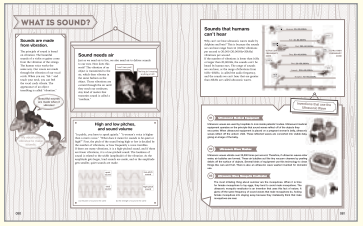
"The way to live longer? Please tell me!"

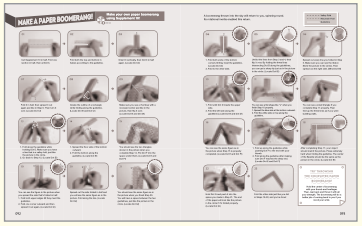
The smart boy smiled and responded,

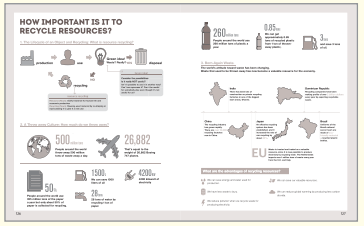
"It is very simple. Roll down the Three Year Hill as many times as you want. Rolling once gives you only three years. However, if you roll twice, wouldn't that give you six years? Ten times would mean sixty years."

Realizing the boy could be right, the old woodcutter immediately rolled down the Three Year Hill from that day forward.
Over and over again, he rolled and tumbled.
Thanks to the smart boy's brilliant idea, the old woodcutter improved his health and soon recovered from his illness.

The apparent curse had vanished, and he lived for a long time there after.

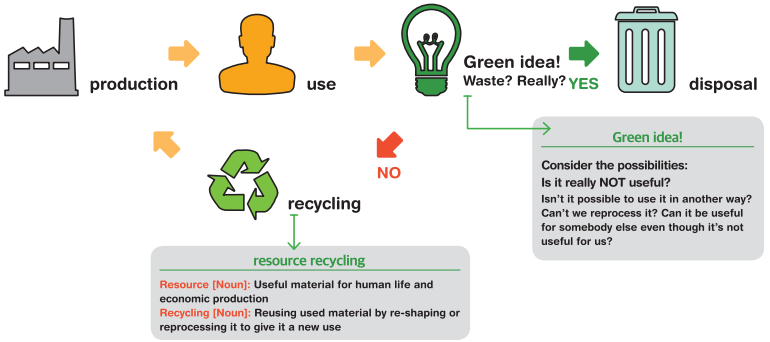






HOW IMPORTANT IS IT TO RECYCLE RESOURCES?

1. The Lifecycle of an Object and Recycling: What is resource recycling?



2. A Throw away Culture: How much do we throw away?

500 million tons

People around the world throw away 500 million tons of waste away a day.

26,882

That's equal to the weight of 26,882 Boeing 747 planes.

50%

People around the world use 355 million tons of the paper a year but only about 50% of paper is collected for recycling.

1500L

We can save 1500 liters of oil

4200KW

4200 kilowatt of electricity

28 tons

28 tons of water by recycling 1 ton of paper.

260 million tons

People around the world use 260 million tons of plastic a year.

0.85 tons

We can get approximately 0.85 tons of recycled plastic from 1 ton of thrown-away plastic,

3 tons

and save 3 tons of oil.

3. Born-Again Waste.

The world's attitude toward waste has been changing.
Waste that used to be thrown away has now become a valuable resource for the economy.

India
There has been lots of construction on private recycling factories in one of the biggest slum areas, Dharavi.

Dominican Republic
Recycling companies have been making profits of over 2 billion dollars every year by exporting recyclable waste.

China
The recycling industry has grown rapidly. There are over 10,000 recycling factories now in China.

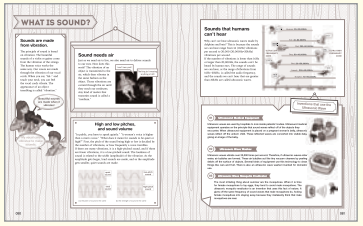
Japan
An effective recycling system has been established, and it increased the rate of can recycling by about 83%.

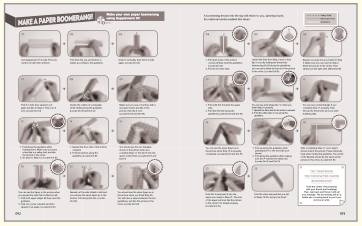
Brazil
Uniforms of the Brazil national soccer team are made of eco-friendly material —recycled plastic bottles.

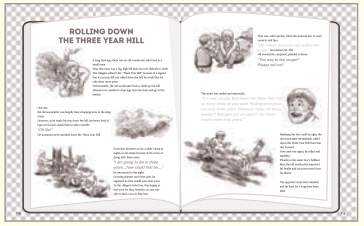
EU
Waste is treated and traded as a valuable resource, since it is now possible to produce electricity by recycling trash. The Netherlands imports over 1 million tons of waste every year from the U.K. and Italy.

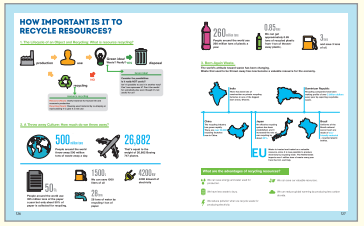
What are the advantages of recycling resources?

- We can save energy and water used for production.
- We have less waste to bury.
- We reduce pollution when we recycle waste for producing electricity.
- We can save our valuable resources.
- We can reduce global warming by producing less carbon dioxide.









Who and Why?

The Korean Intellectual Property Office (KIPO), using the Korea Funds-in-Trust supported by the World Intellectual Property Organization (WIPO), has developed course materials to enhance methods of inventive thinking and to promote a basic understanding of intellectual property among today's global youth, including those in developing countries.

The Methods

These course materials were developed through establishing and supporting the operation of invention classes at regular schools, and with the help of the Korea Invention Promotion Association (KIPA) and their experience in developing and promoting many invention education programs.

How Are They Used?

- Experimental research activities connected to regular curriculums (including science)
- Extracurricular after-school activities for promoting creativity

To Request These Materials

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