

# Preventing **Natural Disasters** 07

## Using Advanced Technology

The Earth is Shaking!

Vulnerability Prediction and  
Disaster Readiness

Disaster Management Software



## How to Use This Program

Software is changing the world. The programs installed in computers and apps that make it more convenient to use smartphones are all software. Software is in every part of our lives, so it is difficult to find areas where we are not affected by software.

The state-of-the-art science and technology that we see in the news is also helped by software. In turn, progress in math, science and technology advances software further. As such, math, science and technology are closely related with and cannot be separated from software.

These module series were created through collaboration between experts in related fields and software education, and its suitability for classrooms has been verified. As students follow teachers' direction through each module, they will be able to better understand the world that has been changed by software.





## CONTENTS

|                       |                                                                  |    |
|-----------------------|------------------------------------------------------------------|----|
| Intro                 | Can Earthquakes be Forecasted?<br>Predicting Natural Disasters   | 02 |
| PART1                 | The Earth is shaking! Earthquakes                                | 08 |
| Activity1             | Frequent earthquake locations                                    | 12 |
| Activity2             | Measure a virtual earthquake with<br>a vibration measurement app | 13 |
| PART2                 | Vulnerability prediction and<br>disaster readiness               | 14 |
| Activity3             | Prevent a disaster<br>in your neighborhood!                      | 18 |
| PART3                 | Disaster management software                                     | 20 |
| Activity4             | Create an app to send out<br>a disaster warning message          | 25 |
| Career<br>Exploration | Climate change specialists                                       | 28 |
| Maker<br>Activity     | Surviving an earthquake                                          | 30 |





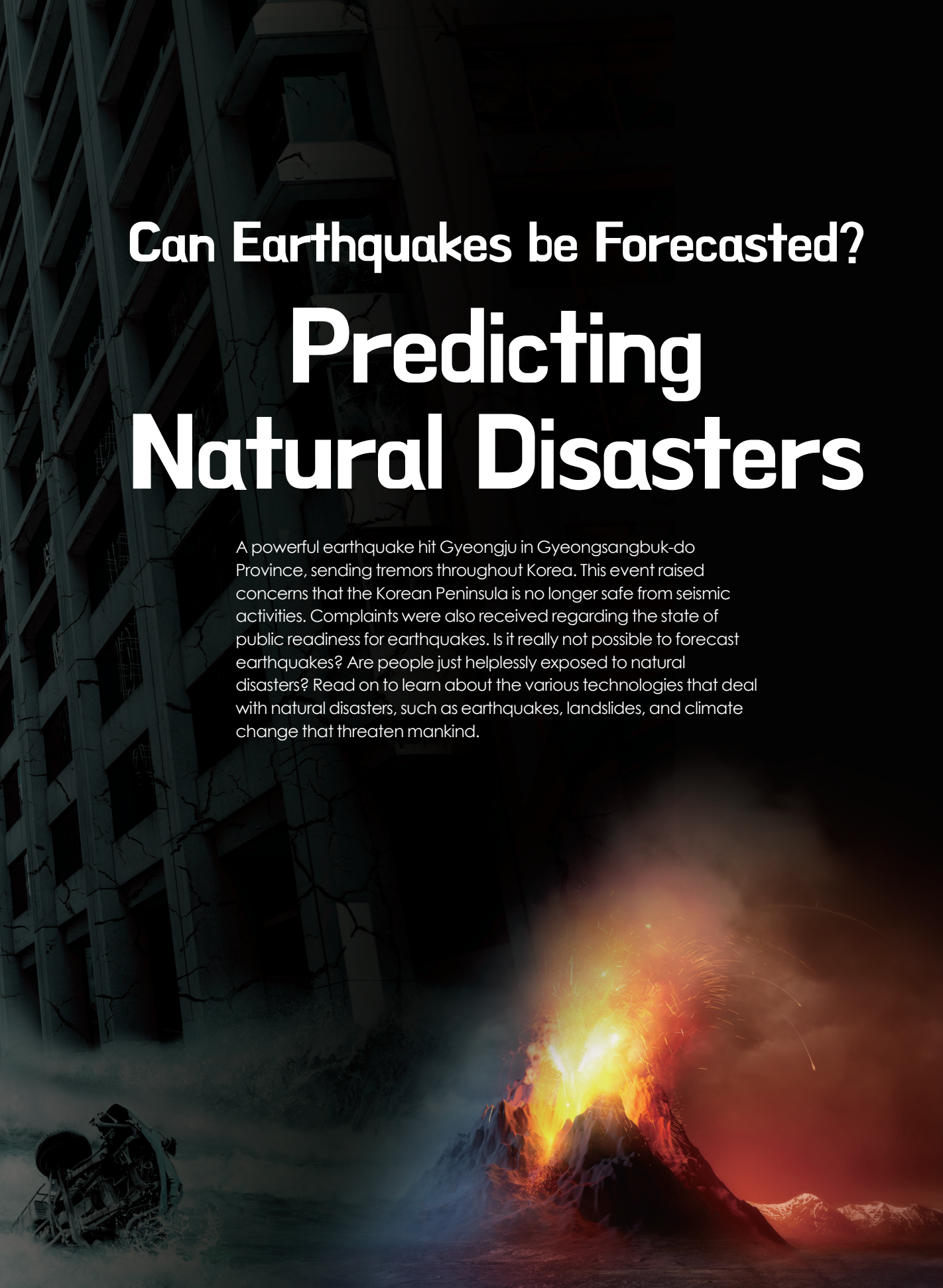




# Can Earthquakes be Forecasted?

# Predicting Natural Disasters

A powerful earthquake hit Gyeongju in Gyeongsangbuk-do Province, sending tremors throughout Korea. This event raised concerns that the Korean Peninsula is no longer safe from seismic activities. Complaints were also received regarding the state of public readiness for earthquakes. Is it really not possible to forecast earthquakes? Are people just helplessly exposed to natural disasters? Read on to learn about the various technologies that deal with natural disasters, such as earthquakes, landslides, and climate change that threaten mankind.



# ENHANCING EARTHQUAKE PREDICTION

On September 12, 2016, a powerful earthquake hit in Gyeongju that was the strongest ever since the nation began measuring tremors in 1978. Tremors spread throughout the country, including Seoul more than 300 kilometers away. Cultural assets like the Bulguksa Temple and Cheomseongdae Observatory were damaged. Seismic centers in Gyeongju and Ulsan were subject to about 500 aftershocks for about a year.

The year 2016 was marked by frequent, powerful earthquakes not only in Korea but also around the world. The earthquakes in Kyushu, Japan and Ecuador raised concerns that the circum-Pacific belt, or Ring of Fire, may have begun to be active. Following the September earthquake in Korea, Italy was also hit by the largest-ever earthquake in its history in October, shaking Rome's ancient ruins. More recently, a powerful 7.8 magnitude earthquake lifted New Zealand's shore.

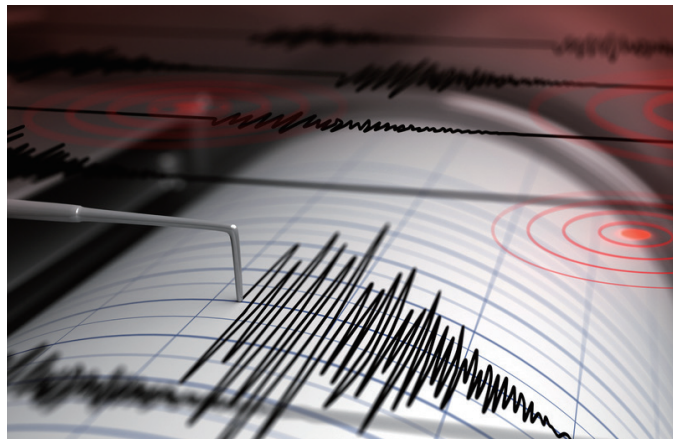
Unlike other natural disasters, earthquakes are characterized by extensive damages they cause. The shaking of the ground can result in second and third hazards, and there is little time to prepare because seismic waves have short arrival times. But the biggest reason why damages can be so extensive is that earthquakes are difficult to forecast.

Volcanic eruptions, a natural disaster that occur on the earth's crust, can be

forecasted thanks to a variety of precursors. The growth of a magma body near the surface is preceded by rising temperatures in the surrounding earth, gas emissions, and earth tremors.

However, earthquakes are rarely preceded by clear precursors. Some may predict seismic earthquakes through microearthquakes or changes in ground radon gas concentrations, but neither has been highly successful in forecasting earthquakes.

Thus, scientists are looking for new ways of doing so. They are trying to understand the cycle of earthquakes by analyzing past data or tracking the energy (stress) concentration in the ground to monitor regions with a high probability of earthquakes. New methods were actually employed in predicting the 8.6 magnitude earthquake in Northern Sumatra, Indonesia in 2005 as well as the 7.6 magnitude earthquake in Haiti in 2010. The earthquake in



The current forecast system cannot make accurate earthquake forecasts. This is why past earthquakes are analyzed to monitor regions with a high probability of subsequent earthquakes.





Haiti, however, left 220,000 casualties due to the country's poor economic resources to enhance readiness.

Using IT technology for warning and evacuation

Continuous efforts have recently been made to develop technologies for detecting earthquakes as quickly as possible and send warning to as many people as possible. The intent is to minimize damages, rather than prevent earthquakes.

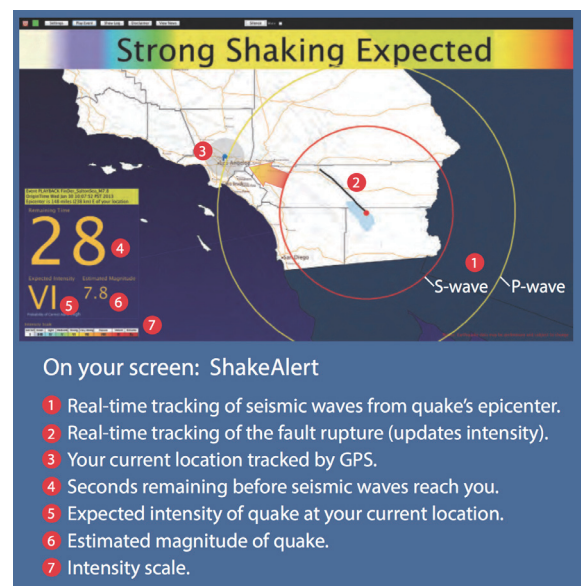
The United States Geological Survey (USGS) developed the ShakeAlert, an early warning system using the characteristics of seismic waves and smartphones. Seismic waves consist of P-waves and S-waves, with the latter arriving after the faster-moving P-waves but being more damaging in nature. This allows for calculation of the anticipated location and intensity of expected S-waves immediately after the arrival of P-waves. Though a matter of just a few seconds, it gives time to stop public transportation means and evacuate people, thus minimizing damages.

Based on a finding that smartphone GPS log a sudden lurch in one direction the moment P-waves arrive, USGS came up with the idea of using smartphones as P-waves detection sensors. In a test simulating the Great East Japan earthquake of 2011, ShakeAlert was able to give an early warning 23 seconds before seismic waves hit downtown Tokyo.

An earthquake usually leads to secondary damages due to a sudden concentration and congestion

of vehicles on the roads or people unable to find the right shelter location. This is why the Great East Japan earthquake resulted in greater casualties in the tsunami-hit region.

Subsequently, 11 interagencies in Japan gathered and came up with the Project 311 to find ways to efficiently prepare against earthquakes and other natural disasters. Residents' smartphone GPS records and tsunami data were analyzed to verify evacuation routes. Decision was made to organize shelters in hilly areas. The project also came up with measures to re-design roads in a way to prevent traffic congestions. As such, a thorough analysis of what already happened can significantly contribute to mitigating the damages of future earthquakes.



ShakeAlert's warning screen

© Erin R. Burkett, Douglas D. Given, and Lucile M. Jones

# SEEING THE FUTURE OF THE GLOBE THROUGH EQUATIONS!

Earthquakes are not the only natural disasters threatening mankind. Various disasters impact people's lives at this very moment, from flooding and landslides, to long-term climate change. Fortunately, a lot of research is being made and technologies developed to enhance readiness. Efforts are also made to scientifically predict the effects of climate change and the depletion of energy resources on all organisms of the Earth.

Using mathematics to prevent climate change?

Climate change is a disaster that would threaten the Earth in the long term. The warming of the entire



globe causes glaciers to melt, raising sea levels and threatening the lives of people living in coastal areas. of the whole island of Tuvalu on the Pacific could soon be submerged under water. Dwindling glaciers and rising seawater temperatures are also endangering various life species living in Polar Regions.

A mathematician set out to mitigate the catastrophe caused by climate change. Ken Golden of the University of Utah came up with a mathematical formula to predict sea ice meltdown. The minute structure of ice is investigated by X-ray and computer tomography (CT), and the formula expresses how this structure changes in relation to temperature and salinity of seawater. This



Arctic ice continues to dwindle due to global warming, forcing polar bears to swim for days without rest until they encounter a slab of sea ice large enough to sustain them.

study helped understand and predict how seawater moves in the ice. It will also help explain the effects of climate change on glaciers.

Depletion of energy resources is also a serious threat for the Earth. With the dwindling of major energy sources like petroleum and coal, methane and shale gas have emerged as substitutes. However, the extraction of these gases requires fractures to be created in rocks deep into the ground by pumping large quantities of chemical fluids at high pressure. This process can result in secondary damages like contamination of underground water.

Professor Anthony Peirce and his team at the University of British Columbia are working on a mathematical formula to predict the movement of fluids and chemicals pumped into the ground and how it





fractures rocks. This equation would show what could happen when people exploit the earth for natural gases. To minimize contamination, engineers involved in extracting gas can use the result of this study to estimate the appropriate amount of chemicals considering soil characteristics prior to drilling.

### Equation for landslides

These mathematical studies are also helpful in preventing disasters occurring in small areas. The landslide in Mount Umyeonsan, Seoul in 2011 resulted in 18 deaths and caused access to nearby institutions like the Seoul Arts Center and roads to be restricted for a while. An intense rain that fell over a short period of time had caused the weakened mountain ground to collapse. The number of casualties and damages could have been smaller had the landslide been predicted and an evacuation order issued. However, the only criteria to forecast a landslide in those days was the amount of rain fallen, so nobody could predict when, where and how the mountain would collapse.

To prevent similar future incidents, the Korea Institute of Geoscience and Mineral Resources analyzed Korea's mountain characteristics over two years. Using measuring equipment installed in areas most representative of a mountain's vegetation, the research team continuously monitored the rate at which rain permeates into the ground and the extent of soil movement. They also entered the results of 6,000 surveys of landslides that occurred since 1991 to develop a formula to

calculate the probability of a landslide by soil quality. The system they will put into place will notify the public of a possible landslide an hour before it happens to ensure that those living nearby can be safely evacuated.



Landslides could be predicted and damages minimized if a formula is developed to calculate the probability of a landslide using past landslide data.

## PART 1

**Recommended target**  
Elementary and Secondary Curriculum

**Relevant subjects**  
Practical course, elementary school

# The Earth is Shaking! Earthquakes

At 20:32 on September 12, 2016, a record 5.8 magnitude earthquake hit an area eight kilometers south-southwest of Gyeongju, Gyeongsangbuk-do Province in Korea. The quake was preceded by a 5.1-magnitude tremor detected 48 minutes prior. There was also another aftershock of 4.5 magnitude a week later on the 19th of September.

The earthquake jolted most of South Korea. An overwhelming number of calls were received by broadcasting companies and the Ministry of Public Safety and Security, and their websites went down due to excessive traffic. The earthquake revealed that the country is no longer a safe haven from earthquakes. Then, why and where do earthquakes happen, and how big are they?



Result of the automatic measurement analysis of the Meteorological Administration, showing the earthquake's magnitude (5.8), time (20:32:54 on September 12, 2016), and epicenter (eight kilometers south-southwest of Gyeongju, Gyeongsangbuk-do).

© Meteorological Administration

### + Focus versus epicenter

The focus is the point of which the seismic wave originates.

The epicenter is the point on the ground surface directly above the focus. The epicenter sustains the biggest damage as it is closest to the focus.

On the contrary, the farther from the focus, the weaker an earthquake.

### Two seismic waves – P-waves and S-waves

An earthquake is the shaking of the surface of the Earth, resulting from a sudden release of energy in the Earth's lithosphere. The strata undergo transformation when exposed to the Earth's internal energy and culminates in a break, suddenly releasing a large amount of energy.

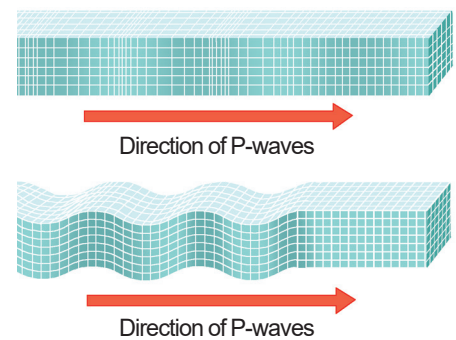
What people feel is this energy sent in the form of seismic waves.

Seismic waves consist of P-waves and S-waves. P-waves and S-



waves. P-waves (primary waves) are a type of elastic wave that shakes the ground back and forth. S-waves (secondary waves) shake the ground up and down. P-waves move at a speed of six to seven kilometers per second, S-waves at a speed of three to four kilometers per second. Thus, P-waves are faster than S-waves. Thus, P-waves are the first waves to arrive at a seismograph, and their detection are a precursor of more destructive S-waves, so an early warning must be quickly issued.

The Earth's interior can be studied using the qualities of P-waves and S-waves. P-waves can travel through solids, fluids, and gases, but S-waves only through solids. It is possible to assume that areas inside the Earth where P-waves, and not S-waves, travel through consist of liquids.

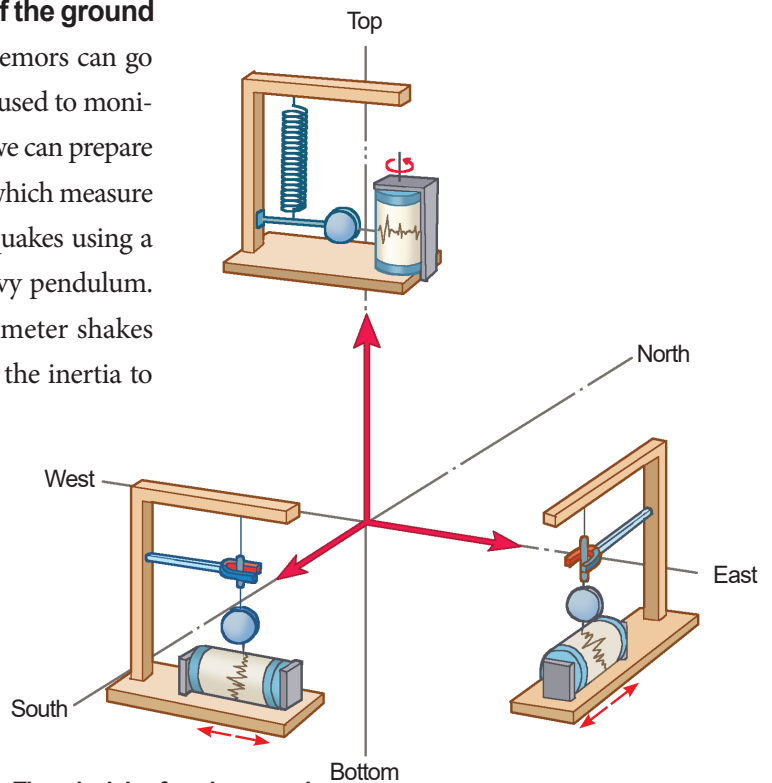


P-waves move back and forth while S-waves move up and down. This is why S-waves entail larger tremors and damages.

### Seismometers to measure motion of the ground

Big earthquakes can be felt, but small tremors can go unnoticed. This is why seismometers are used to monitor the movement of the ground, so that we can prepare against a big earthquake. Seismometers, which measure the motion of the ground, record earthquakes using a stationary object, which is usually a heavy pendulum. The bottom and column of the seismometer shakes with the ground, but the pendulum has the inertia to stay still.

Vertical motions are usually caused by P-waves. On the contrary, horizontal motions are caused by S-waves. This is why seismometers separately measure vertical and horizontal shakings. Usually comprising of one vertical pendulum and two horizontal ones, they detect motions in three directions.



#### The principle of a seismograph

How seismometers work: A seismograph consists of a heavy pendulum connected to a pen mounted in the air. A paper is placed below. When the ground vibrates, the pendulum remains still while the paper moves, thus creating a record of the earth's movement. A typical seismograph contains three pendulums: one to record vertical movement and two to record horizontal movement.

#### + tsunami

The most terrifying aspect of an earthquake disaster is tsunami. A tsunami is a Japanese term for a seismic sea wave. The term became universal following the 1896 Sanriku earthquake's seismic sea waves that killed 22,000 people. Tsunamis are caused by the displacement of water caused by volcanic eruptions or earthquakes below water. The wavelength of tsunami waves are far longer than normal sea waves, and thus can cause considerable damages to coastal areas.

### Magnitude and seismic intensity of earthquakes

An earthquake's severity is described by both magnitude and intensity. Magnitude characterizes the size of an earthquake by indirectly measuring the energy released. Sometimes, when an earthquake of a big magnitude occurs, the damage may be small if the focus of the earthquake is distant from population centers.

By contrast, intensity indicates the local effects and potential for damage produced by an earthquake. Thus, it shows the actual degree of damages. This is why earthquakes of the same magnitude may have different intensities depending on where they occur. In the case of the Gyeongju earthquake, the magnitude was 5.8, but the focus was so deep that the damages were small. The earthquake's intensity was between 4 and 5 in coastal areas, 3 and 4 in Ulsan, and 2 and 3 in the farther metropolitan area.

#### Impact of earthquake and damage scale

| Intensity | Effects on structures and nature                                                                                                                                                          |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1         | Not felt except by a very few under especially favorable conditions.                                                                                                                      |
| 2         | Felt only by a few persons at rest, especially on upper floors of buildings.                                                                                                              |
| 3         | Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake.                                                      |
| 4         | Felt indoors by many, outdoors by few during the day. Standing motor cars rocked noticeably.                                                                                              |
| 5         | Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned.                                                                                         |
| 6         | Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster.                                                                                              |
| 7         | All run outside home. Damage slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures.                                      |
| 8         | Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Heavy furniture overturned. People driving car feel shaking. |
| 9         | Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb.                                                                                 |
| 10        | Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rail bent.                                                                     |
| 11        | Few, if any (masonry), structures remain standing. Bridges destroyed. Wide cracks on the surface. Underground pipes become unfunctional. Rails bent greatly.                              |
| 12        | Lines of sight and level are distorted. Objects thrown into the air.                                                                                                                      |



## What to do in an earthquake?

Unlike Japan, Korea has never suffered major earthquake damages. This is why Korean people are not well aware of what to do in an earthquake. Because Korea is no longer a safe zone, it is best to become familiar with what to do in such a situation.

- ① During an earthquake, crawl underneath a desk or table for shelter.
- ② Turn off the gas and electricity to prevent fire. Open the door to secure an exit.
- ③ When shaking stops, take the stairs to move out of the building.
- ④ If you come out of a building, cover your head with a bag or hands.
- ⑤ Stay away from buildings or anything that could fall on you and quickly move to the open like a park or schoolyard.
- ⑥ Follow the guidelines on the TV or radio, or sent by disaster prevention institutions.

The National Disaster Safety Portal ([www.safekorea.go.kr/idsiSFK](http://www.safekorea.go.kr/idsiSFK)) offers information on how to react in various disaster situations.

## Frequent earthquake locations

According to plate tectonics, the Earth's crust surrounds a fluid, solid material called mantle. The crust is made up of thick, interconnecting pieces called tectonic plates that fit together like a puzzle. These plates move by the Earth's internal energy and crustal movements occur where two tectonic plates meet. When two tectonic plates collide, they can form high mountain ranges like the Himalayas; when two plates move away from one another, a sea trench can form deep in the sea.

Earthquakes and volcanic eruptions frequently occur where tectonic plates meet. These areas are called earthquake zones or volcanic zones. The most well-known earthquake zone is the circum-Pacific belt surrounding the Pacific Ocean. Let's learn more about earthquake zones through the following activity.



Roads damaged in the Chuetsu earthquake in Japan on October 23, 2004 © Tubbi

## Activity ①

# Frequent earthquake locations

Earthquake belts are ring-shaped zones corresponding to active plate tectonic zones. The most well-known of these belts are the circum-Pacific belt and the Alpine belt. Of the world's earthquakes, 80% are found in the circum-Pacific belt in the Pacific Ocean. Look for the circum-Pacific belt and earthquakes there, and show them on a map.

What to prepare PC

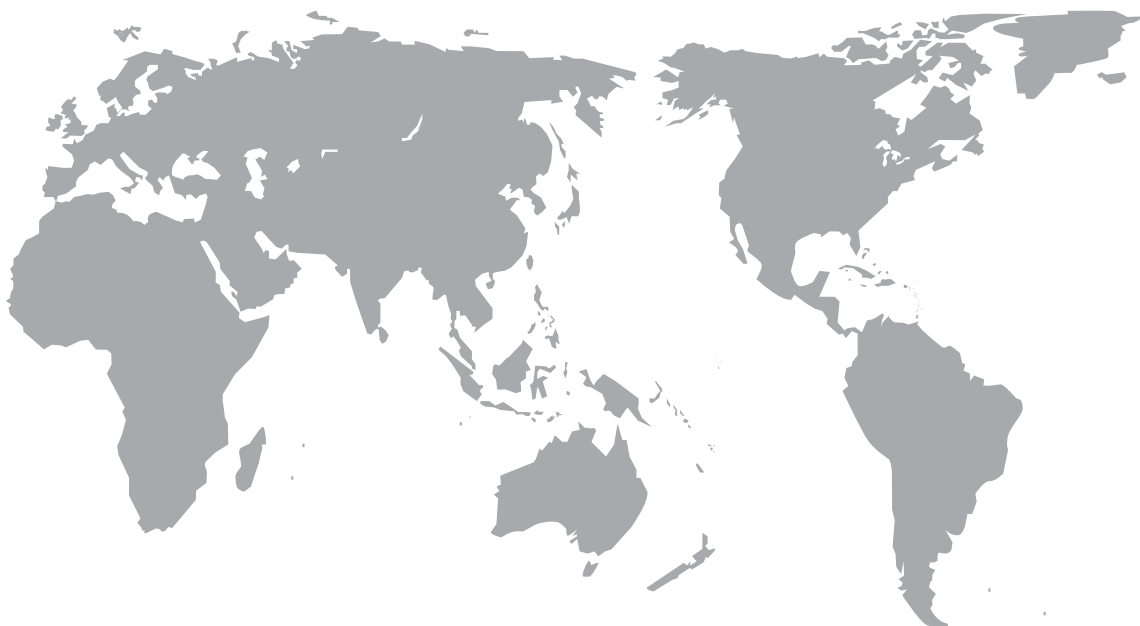
## Activity

### 1 Check recent earthquakes

- ① At the USGS Earthquake Information Center (<http://earthquake.usgs.gov/>), click 'Latest Earthquakes' for a map showing all earthquakes that occurred over the last day. Do you see the Pacific Ocean? The red lines represent plate boundaries, and you earthquakes happen along these boundaries. Can you see how the various continents are interconnected like a puzzle?

### 2 Find major earthquakes

- ① Connect to the Korea Meteorological Administration ([www.kma.go.kr](http://www.kma.go.kr)). Go to Weather > Earthquakes & Volcanoes > Earthquakes > List of earthquakes overseas.
- ② Search for the last five years and for earthquakes with a magnitude of 7.0 or higher.
- ③ Show the searched data on a world map.





## Activity 2

# Measure a virtual earthquake with a vibration measurement app

Seismic waves consist of P-waves and S-waves. P-waves (primary waves) are a type of elastic wave that shakes the ground back and forth. S-waves (secondary waves) shake the ground up and down. In this activity, you will measure the strength of a vibration using a smartphone app.

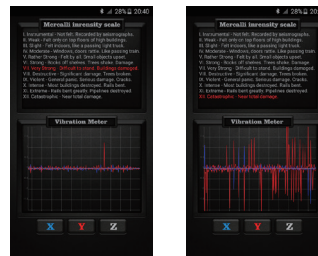
**What to prepare** A smartphone or a tablet PC

## Activity

- Connect to Google Play on a smartphone or a tablet PC. Search for the Vibration Meter app (available on Android only) and install it. This app helps measure the strength of a vibration. It shows how the strength changes by distance and creates a vibration graph.  
※ You can also install and use the 'Vibration Meter (English app).' The x-, y-, and z-axes are shown in different colors.



Seismometer: Vibration Meter



Vibration Meter

- Create some vibration and see how it is measured on the app.
- Create the same vibration in different spots and record the measurements.

| Distance               | 50cm | 100cm | 150cm |
|------------------------|------|-------|-------|
| Intensity of vibration |      |       |       |

- Discuss why you think you got these results.

## PART 2

**Recommended target**  
Elementary creative experience activities

**Relevant subjects**  
Practical course

# Vulnerability Prediction and Disaster Readiness

The movie *Interstellar* depicts a world decimated by severe climate change. In reality, the globe has experienced extreme weather events such as flooding, drought, heavy rain, and intense heat and cold. Scientists claim that the major cause of such climatic changes is global warming, which is caused by greenhouse emissions generated by the excessive use of fossil fuel. The most representative of greenhouse gases that cause greenhouse effect is carbon dioxide (CO<sub>2</sub>). The incoming solar radiation passes through greenhouse gases, but the latter absorbs the radiation released by the earth. Greenhouse emissions act like a greenhouse glass, raising the temperature of the surface of the earth (greenhouse effect). Increased heat on the earth leads to various climatic disasters.

### United States Tornado and cold wave in Eastern region

Wind chill temperature 45°C, 26 dead

### Nepal Earthquake of 7.8 magnitude

8,800 dead, 14,000 injured

### Mexico Tornado

13 dead, hundreds injured

### Egypt Heat waves

highest temperature  
47°C, 76 dead

### China Heavy rain

50 dead, 250,000  
migrants

### Guatemala Heavy rain and landslide

350 dead or missing

### Ghana Heavy rain

50 dead

### India Heat wave in Southern region;

highest temperature

48°C, 2,000 or so dead

### Australia Heavy rain; blackout in

210,000  
households

### Chile Flood and landslide

26 dead, 100 missing

### Malawi Flood

329 dead or missing

Key abnormal climate events in 2015

## Climatic changes in the world

According to the report of the United Nations International Strategy for Disaster Reduction (UNISDR) released on November 24, 2014, there were 6,457 recorded floods, storms, tsunamis, and other weather-related events over the last twenty years (1995-2015), causing approximately 606,000 deaths. In particular, there has been a surge in disasters caused by floods, storms, heatwaves and cold waves in the last ten years.

Global warming is a phenomenon where the average global temperature is rising, changing the globe's climatic system. Sea water swells due to thermal expansion and glaciers melt, causing the sea level to rise and submerging low-altitude coastal areas. Increased evaporation rates results in an increase in rainfall, causing floods. On the contrary, certain regions can suffer droughts. These changes can also exacerbate unusual weather events such as El Niño and La Niña on a global scale.

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)\*, warming of the climate system is unequivocal and the largest contribution is caused by rising concentrations of carbon dioxide, primarily from the burning of fossil fuel for industrial activities. Clearance of forest to convert land to other uses degrades the globe's ability to store carbon dioxide. If the current trend of greenhouse emissions is sustained, the globe's temperature will increase by an average of 3.7°C by 2100 and the sea level will rise by 63cm by 2100. Even if greenhouse gas emission is stopped immediately, their effects will persist for hundreds of years.

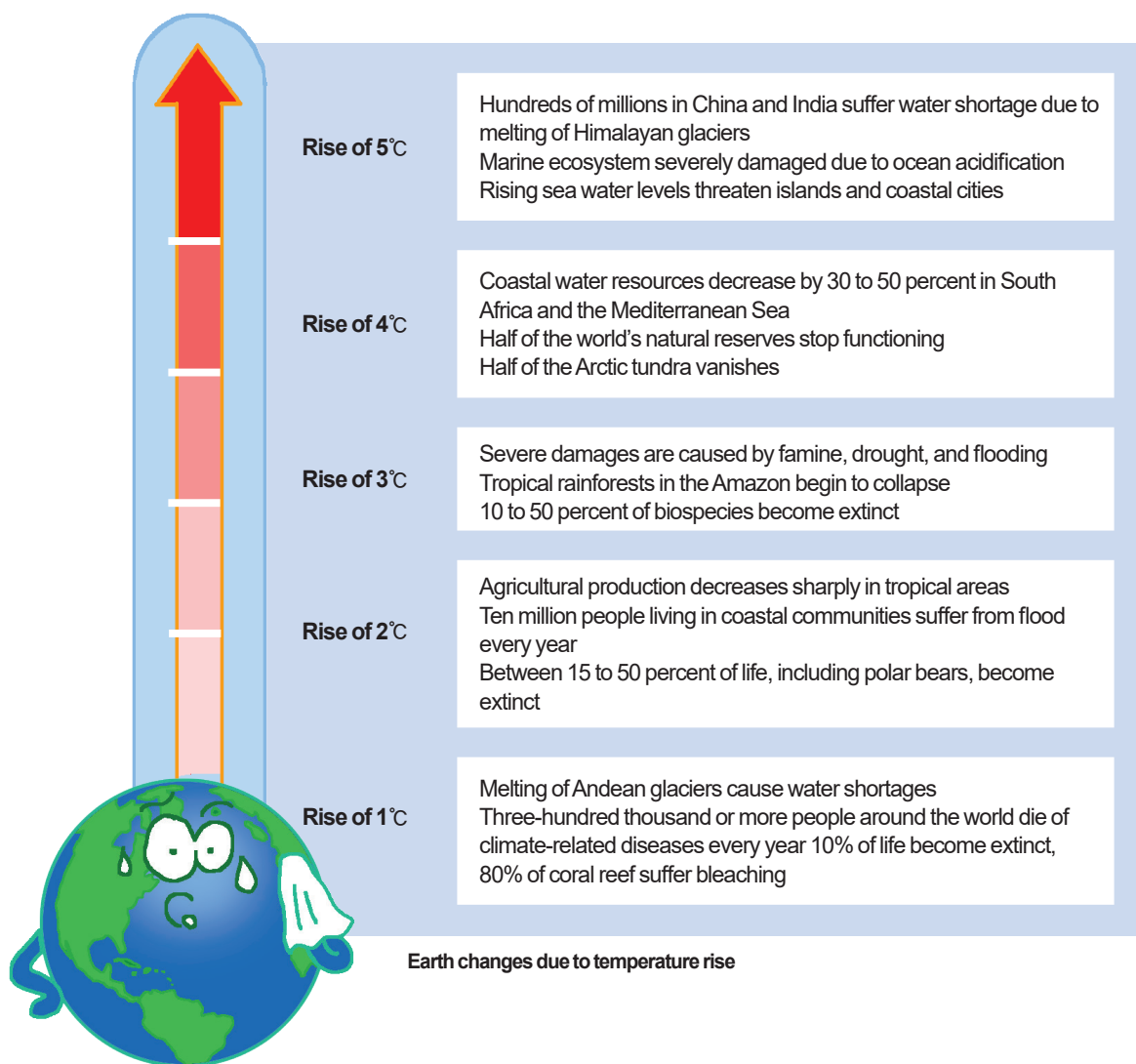
### \* Intergovernmental Panel on Climate Change (IPCC)

Established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in November 1988, IPCC is an intergovernmental body where thousands of meteorologists, oceanographers, glacier experts, and economists from member states.

Homepage  
(<http://www.ipcc.ch>)

What can be done to reduce greenhouse emissions? Think about the small things that you can do.





Korea is not exempted from these effects. Springs and summers will be longer, and autumns and winters shorter. Crops that had been grown forever may no longer grow, while greenhouse crops could be grown outside. Pine trees, which feature in Korea's national anthem, are a common tree species that account for 20% of Korea's forest area. They may be hard to find in the second half of the 21st century. According to the Meteorological Administration, the Korean Peninsula may turn into a subtropical region in the second half of the 21st century, with the temperature rising by 6°C and 5°C in North Korea and South Korea, respectively.

## Disasters, Risk factors, and Vulnerabilities

A disaster entails widespread human and material loss as a result of changes in natural phenomena or accidents. Factors that cause a disaster are called risk factors. The types of risk factors are varied, including natural risk factors such as earthquake, storm, volcanic eruption, flood, drought, and landslide, and man-made risk factors such as environmental pollution, traffic accident, and industrial accident. Disasters caused by the risk factor of climate change are called climatic disasters.

Not all risk factors result in a disaster. Despite having the same risk factor, some regions may undergo severe damages, while others will only suffer minor damages. What determines the degree of damages is the level of vulnerability. For example, a building with a poor design is more vulnerable than one with a good design. People who are older, sick, pregnant, or have a disability are more vulnerable to a disaster.

Natural risk factors cannot be prevented by human power, but man-made risk factors must be stopped to the extent possible. Even when a risk factor is at work, the degree of damages can be greatly reduced if actions are taken in advance to mitigate vulnerabilities. Let's take landslide as an example.

- ① Vulnerability: Houses are present near risk factors.
- ② Risk factors: Heavy rains or earthquakes cause landslides.
- ③ Disaster: Risk factors combine into a disaster and causes significant human and material loss.

Even if there were heavy rains or earthquakes, no significant damages would be entailed if there are no houses near risk factors. In order to minimize damages, risk factors must be considered in advance and vulnerabilities improved.

### + Environmental migrants

People who are forced to leave their home region due to a climatic disaster become migrants. The flow of Syrian refugees escaping the Syrian civil war has caused a serious problem for Europe. Though some claim that the cause of the civil war is political and religious, other studies indicate that the fundamental cause is the severe drought that hit the country from 2007 to 2010.

Half of Syria's land had been fertile, but the country suffered the worst drought ever in its history due to reduced rainfall resulting from global warming and decreasing humidity in the soil. Large numbers of farmers left their hometown and moved to urban areas, causing various social issues such as poverty and crime. Ultimately, public dissatisfaction developed into political unrest, which in turn led to a civil war.

Damages can be mitigated if risk factors are considered and vulnerabilities improved in advance. © Orlovic



## Activity ③

# Prevent a disaster in your neighborhood!

Meteorological data reveal that Korea is no longer safe from the consequences of global warming. Let's find out more about this to enhance our awareness. Learn about the topography in your neighborhood and think about, from the perspective of an urban engineer, how we should prepare against a potential climate disaster.

**What to prepare** PC

## Activity

### 1 Analyze climatic changes in Korea

Find the data on greenhouse emissions observed in Anmyeon-do Island from 1999 to 2016 and draw a graph showing the emission levels by year. Present your findings about the changes.

- ① Access the Climate Information Portal site. Go to Monitoring of Climate Change Status > Climate Change Monitoring Data > Greenhouse Emissions. (Go to [http://www.climate.go.kr/home/04\\_watch/02.html](http://www.climate.go.kr/home/04_watch/02.html)).

The screenshot shows the '기후정보포털' (Climate Information Portal) website. The main navigation bar includes links for '기후·기후변화정책', '기후변화현황·감시', '기후예측정보', '기후변화시나리오', and '홍보·일반매담'. The left sidebar lists various climate-related topics. The main content area is titled '변화하는 지구의 첨단정보 기후정보포털' and features a '기후변화감시 현황' (Climate Change Monitoring Status) section. This section includes buttons for '온실가스' (Greenhouse Gases), '탄소배출' (Carbon Emissions), '에너지' (Energy), and '기후변화' (Climate Change). Below these buttons, there is a '기후정보검색' (Climate Information Search) section with a search bar and filters for '지역' (Region), '연도' (Year), and '기간' (Period). The search results show a table of greenhouse gas emissions for Anmyeon-do Island from 1999 to 2016.

| 관측지점 | 기체종류 | 기체명                     | 관측기간              |
|------|------|-------------------------|-------------------|
| 안면도  | 온실가스 | 이산화탄소(CO <sub>2</sub> ) | 99년 01월 ~ 19년 12월 |
| 안면도  | 온실가스 | 메탄(CH <sub>4</sub> )    | 99년 01월 ~ 19년 12월 |
| 안면도  | 온실가스 | 이산화질소(N <sub>2</sub> O) | 99년 01월 ~ 19년 12월 |
| 안면도  | 온실가스 | 염화불화탄소(HFC-11)          | 99년 01월 ~ 19년 12월 |
| 안면도  | 온실가스 | 염화불화탄소(HFC-12)          | 99년 01월 ~ 19년 12월 |
| 안면도  | 온실가스 | 염화불화탄소(HFC-13)          | 07년 01월 ~ 19년 12월 |
| 안면도  | 온실가스 | 육불화탄소(SF <sub>6</sub> ) | 07년 01월 ~ 19년 12월 |

해당 자료는 2015년 지구대기감시보고서에 수록된 통계를 토대로 작성되었습니다.

- ② Download the data on carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) in Excel format and see how the numbers have changed.
- ③ These are greenhouse emissions that cause global warming. Discuss how you think the climate in Korea will change.



## 2 Design your neighborhood to reduce vulnerabilities

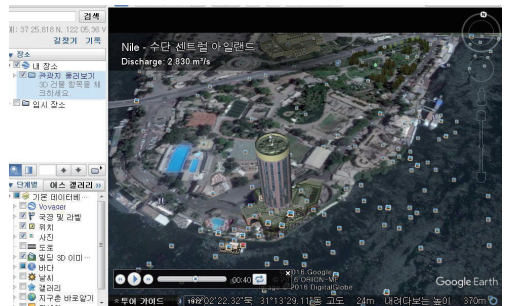
① Download and run Google Earth (www.google.co.kr/intl/ko/earth).



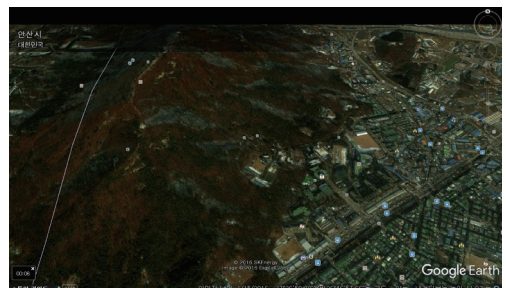
② First select 'Visit places with Street View.' Click + to view various tourist sites like the Eiffel Tower. Double click to move to that region.

- Drag the human icon on the top right and place it on the map for a street view. You can get street views with 360-degree photos.

- Click the building icon on the top right (and not the human icon) for a ground-level view. You can see places as if you were there in person.



③ Find your neighborhood on Google Earth. In the Search box on the left, type the name of your neighborhood. Explore the surroundings and buildings as described in ② above.



④ Analyze your neighborhood vulnerabilities considering the surrounding environment and building arrangements. What vulnerabilities is your neighborhood exposed to? How can you deal with such vulnerabilities?

| Neighborhood name            |                              |
|------------------------------|------------------------------|
| Neighborhood vulnerabilities | Dealing with vulnerabilities |
|                              |                              |

## PART 3

**Recommended target**  
Elementary creative experience activities

**Relevant subjects**  
Practical course

# Disaster Management Software

The Great East Japan earthquake that occurred in the Tohoku region on March 11, 2011 was of a 9.0 magnitude and caused extensive and heavy damages. The accompanying tsunami caused the worst nuclear accidents or radiation releases in the Fukushima Daiichi Nuclear Power Plant complex. Though Japan is relatively well prepared against earthquakes, its man-made safety system turned out to be helpless in the face of such a huge, unanticipated disaster.

Is it not possible to predict natural disasters like these great earthquakes? How can we quickly and efficiently respond to disasters?

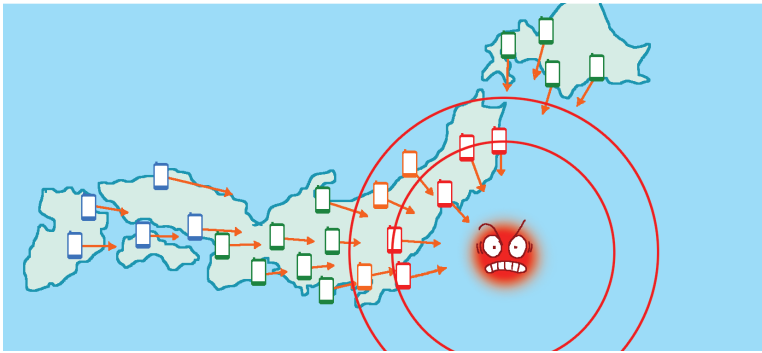
### Earthquakes and big data

Reports of earthquakes are heard every year. Earthquakes are the most dangerous of natural disasters. They come without warning and cause severe damages in cities where there are many buildings and facilities. There is nothing much that people can do when the ground is relentlessly shaken by an earthquake. Nevertheless, men have not given up efforts to overcome disasters.

The most efficient ways to prevent earthquake damages is predic-



Tsunami damages during the Great East Japan earthquake. Minamisanriku in Miyagi Prefecture © Christopher Johnson



Smartphone GPS log a sudden lurch in one direction the moment earthquake waves arrive. If it were observed on thousands of smartphones, the possibility of an earthquake would be high.

tion and early warning. New information can be found regarding risk factors and vulnerable areas by analyzing the big data of past earthquakes. Though perfect prediction is not possible, probabilities of an earthquake occurring in certain areas can be calculated. Using big data, damages can be minimized by sending early warnings.

The technology for analyzing GPS data can also be used for early warnings. This is possible because smartphones are now readily available. Smartphone GPS log a sudden lurch in one direction the moment earthquake waves arrive. If such movement were noticed on just a few smartphones, the possibility of an earthquake would be low. But if it were observed on thousands of smartphones, the possibility of an earthquake would be high. In this case, an earthquake warning could be sent to smartphone users.

### Disaster situation and SNS

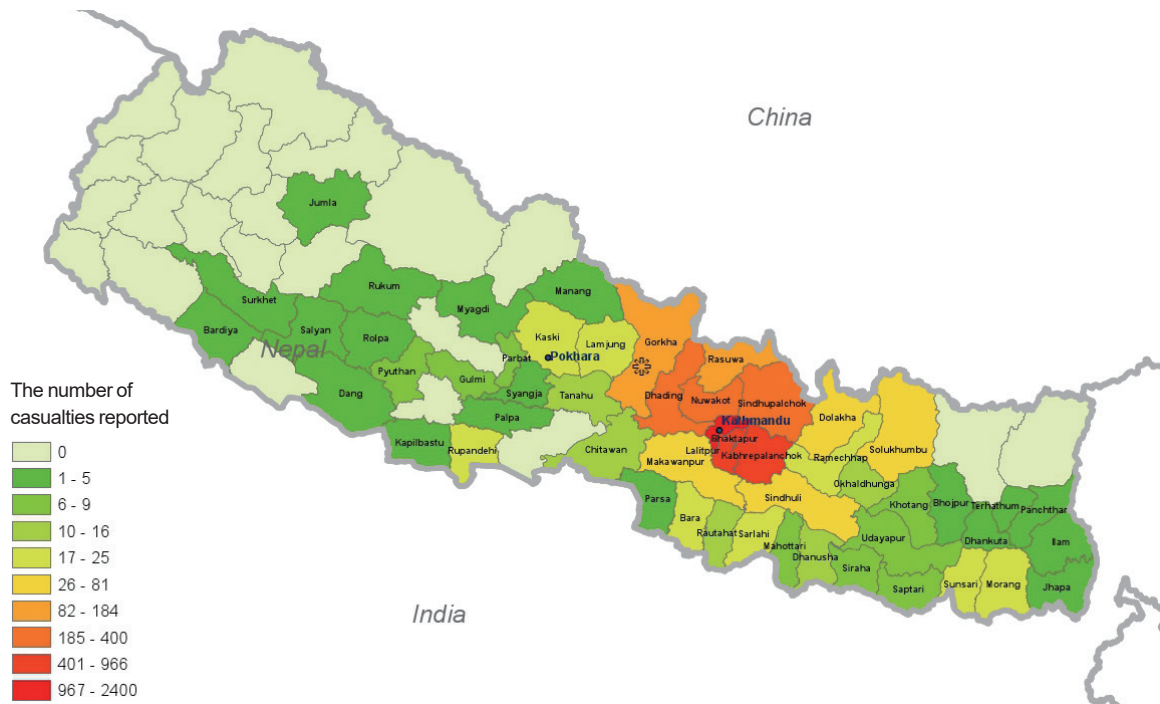
Facebook, twitter, and other SNS media data are useful in major disaster situations. For example, a tagged tweet or comment can be an important source of information when it is hard to know the degree of damages caused in affected areas.

Google's Person Finder and Facebook's Safety Check help locate people. Simply put, these services offer a quick database of people who are missing or dead. For example, once the safety of person A is confirmed, then others do not have to go through the process of verifying A's safety status. As such, these services enable quick disaster recovery.

#### + Animals' earthquake prediction

On July 18, 1969, unusual behavior was observed in animals at a zoo in Tianjin, China. Bears were howling, swans were reluctant to go near waters, and snakes withdrew into their caves. The zoo manager reported this observation to the earthquake forecast institution, and a 7.4 magnitude earthquake struck around noon that day. Animals have a more advanced sensory response to the environment than humans and this is why unusual animal behavior is observed prior to an earthquake. However, there are limitations to estimating an earthquake or other natural disasters by the behavior of animals alone.





Nepal earthquake map showing the number of reported casualties by area (dated April 27, 2015)

© Mapaction

Accurate guidance is critical in disaster situations. Mapaction, a charity group in the U.K., produced a spatial map to help Nepal during a major earthquake. The map allowed for an efficient allocation and delivery of relief personnel and supplies by the United Nations and other international relief organizations. The map shows in three dimensions the location of affected areas, damage size, population distribution in affected areas, undestroyed roads, number of rescue personnel, and location of relief stations.

In a disaster situation, activities can easily get confused due to the number of disaster-stricken areas and the variety of relief stations. Mapaction looks for the shortest route between a relief station and affected area using simulation. When various conditions must be considered for an extensive area, countless combinations can be possible, and this would not be possible without a program like Mapaction.

## World's Best Disaster Robot HUBO

South Korea's HUBO won the DARPA Robotics Challenge (DRC) in 2015. HUBO is a robot developed by Professor Oh Jun-ho and his team at the Korea Advanced Institute of Science and Technology (KAIST).

HUBO is a walking humanoid robot, head mounted on a life-size bipedal frame with long arms. It can roll on four wheels by bending and using wheels incorporated into its knees. HUBO's legs can stretch to walk; when going long distances, it can go by wheels.

Robots that take part in the DRC must perform various missions under disaster situations. They must drive a utility vehicle to a site, open a door and enter a building. Once inside, they must perform eight tasks, including closing a valve, using a tool to break through a concrete panel, traveling across rubble, climbing a ladder, and overcoming a contingency. Of the 23 teams that took part in the competition, only three teams completed all eight tasks. HUBO won the competition with a winning time of 44 minutes and 28 seconds. This was six minutes faster than the second place taken by the U.S. Running Man (Atlas). Scan the QR code to view HUBO executing its mission. DRC practice session filmed by Team KAIST (top) and a feed from the actual competition (below).

Unlike other robots that chose to walk, go on wheel, or move on caterpillar tracks, HUBO could adapt in all environments. When going on wheels, it could go both forward and backward, and also quickly turn around in place. HUBO can also swivel 180 degrees. A member of a U.S. University research team said that "no other structure is better suited to deal with a disaster rescue environment."



Robot DRC HUBO II passes through rubbles like a bulldozer.

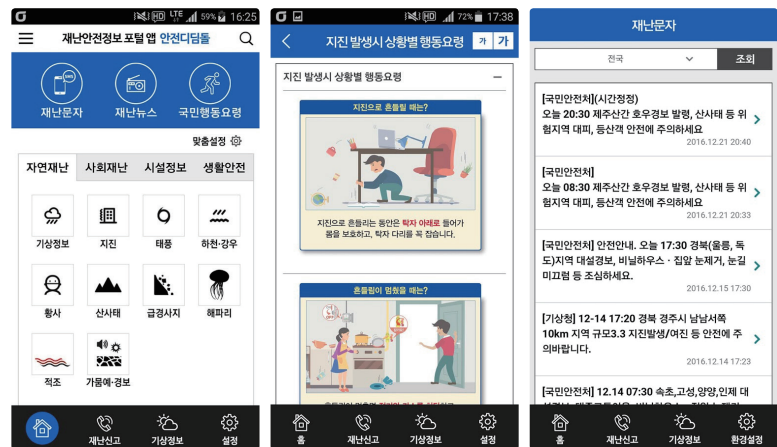


Scan the QR code to view HUBO executing its mission. DRC practice session filmed by Team KAIST (top) and a feed from the actual competition (below).

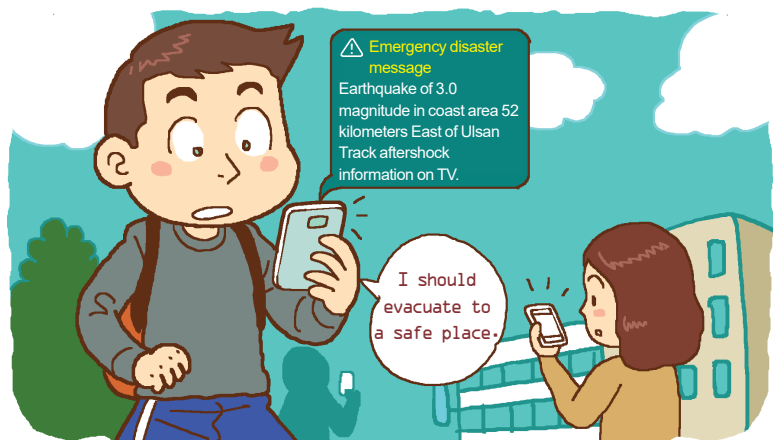
## Mobile Disaster Safety Information Portal App

In Korea, the Ministry of Public Safety and Security has oversight of disaster management and safety. The ministry provides information on what to do in the event of natural disasters. It also runs an app called Stepping Stone to Safety to provide disaster-related information. Users can find weather information, disaster updates, what-to-do in an emergency and disaster situation, and nearby shelter information. The app also sends disaster messages on SNS and receives disaster reports.

The emergency disaster SNS service offers updates on emergency situations, including heatwaves, heavy rains, heavy snow, and earthquakes. The service allows people to quickly respond to a natural disaster by offering regionally tailored information based on analysis of local data.



“Stepping Stone to Safety” app and  
real emergency disaster SNS service  
(Example)





## Activity ④

# Create an app to send out a disaster warning message

What kind of risk factors is your neighborhood exposed to? How can you send out a text message about these risks and what can be done to protect vulnerable people who are exposed to these risks?

**What to prepare** A computer or notebook with app inventor installed, Android smartphone, wireless Internet

## Activity

### 1 Create a disaster message

Based on the analysis made in Activity 3, let's think about a disaster situation that may occur in your neighborhood and how you can deal with such a situation. Think about what you would include in a disaster warning message that would be sent out to warn people. The key is to come up with a short message that contains all the necessary information. Create a message with no more than 40 Korean letters considering the maximum limits of an SMS text.

| Disaster situation & what to do? | Write a disaster warning message |
|----------------------------------|----------------------------------|
|                                  |                                  |

### 2 Create an app using the App Inventor

① Connect to the App Inventor and start a new project. Type the project name in English.

**Create new App Inventor project**  
  
Project name:

## ② Designer tab

Select Palette – User interface – Button and drag onto the Viewer pane.

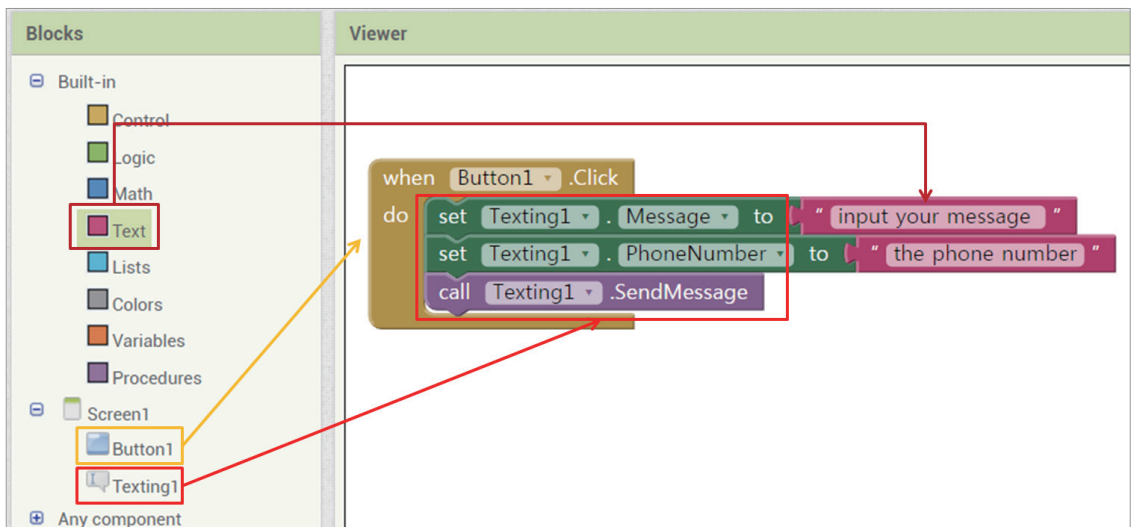
Select Palette – Social – Text message and drag onto the Viewer pane.



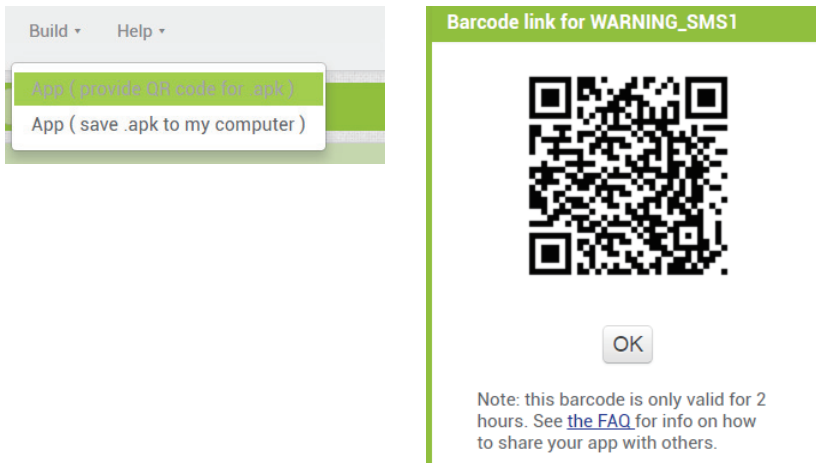
## ③ Block tab

Open the Blocks Editor and drag out the following blocks: Message Text block from the Text, block for setting Message and Phone Number from the button, and Send Message block from the Text Message.

**In the Message Text block, input your message and the phone number to which the message is sent out.**



- ④ Select Build – App (with QR code for apk) and create a QR Code.



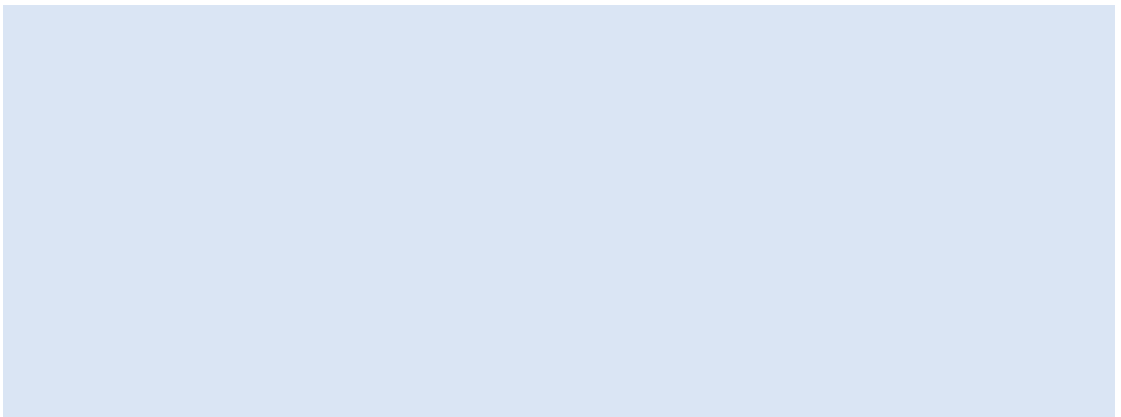
- ⑤ Run the app and see if the message goes out when the button is clicked.  
Fix errors, if any.

### 3 Change the program so that one of the following conditions is met

- ① Add a function for this message to be sent to a list of phone numbers.
- ② Add a function that allows incoming messages to be read out loud.

### 4 Activity wrap-up

Briefly discuss the lessons learned from this activity.





# Climate change specialists

Climate change has become a critical issue as the reckless use of fossil fuels and deforestation have increased the concentration of greenhouse emissions in the air. The world is working to address abnormal climatic conditions where temperatures and rainfalls have gone beyond normal levels. Climate change specialists anticipate climate changes and assess the impacts that these changes have on various sectors. They also come up with policies to mitigate climate change risks. Climate change is likely to be dealt with in a variety of sectors, including disaster prevention, ecology, public health, alternative energy, and conflict resolution. The areas of activities for climate change specialists are expected to widen further.

## What do they do?

- Analyzes contamination of the air, water, and soil, and studies ways to reduce environmental pollution
- Designs processes for the disposal of wastes, and develops more economic and environmentally friendly ways
- Observes the weather, movements of the earth's strata, and other related phenomena, makes short-term forecasts, and anticipates climate changes by analyzing long-term data
- Continuously measures and forecasts natural indications of large-scale natural disasters such as earthquakes, volcanic eruptions, and tsunamis

## Occupations related to artificial intelligence

|                                           |                                                                                                                                                                                                             |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Environmental research</b>             | Climate change specialist, noise vibration technician, air environment technician, environmental engineering examiner, environmental impact assessment specialist, water quality technician, energy auditor |
| <b>Water industry</b>                     | Dam engineer, water treatment facility engineer, water resources administrator, seawater desalination researcher                                                                                            |
| <b>Climate</b>                            | Climate change specialist, greenhouse gas verifier, research meteorologist, weatherman, aviation manager, weather consultant                                                                                |
| <b>Environment</b>                        | Air quality analyst, water quality analyst, geological analyst, waste administrator, energy analyst, noise analyst, environmental impact assessment specialist, environmental consultant                    |
| <b>Government and public institutions</b> | Public officials in weather- or environment-related positions, climate change specialist                                                                                                                    |





### Related majors

Department  
of earth and  
planetary  
sciences

department  
of earth system  
sciences

department of  
mathematics

department of  
statistics

A variety of methodologies are involved in understanding and forecasting phenomena that affect the globe, ranging from analysis of rocks through a microscope to observing topography changes from a satellite. While the academic foundation of earth science is necessary, the analysis of huge volumes of data also requires mathematical and statistical knowledge and skills. Also necessary is the ability to use IT technologies.



### Required aptitude

- Must have an interest in the earth and be sensitive to changes in the surrounding environment (weather, climate, pollution, etc.)
- Must have the endurance and persistence to track and understand earth science data, which repeat similar patterns of changes
- Must be active and have the enduring qualities to work under challenging circumstances as these jobs involve frequent on-site visits



### Expert interview

In the past, hydrologic study mainly involved estimation based on existing data. But climate change has caused a significant range of fluctuation in data, and it was found that forecasting is practically difficult. Our past approach and methodology are no longer valid for forecasting the future.

This limitation has triggered a change in the way research is conducted. Instead of using existing models, which assumed that perfect forecasting of phenomena was possible, we now use the feedback methodology where predictive values are constantly compared with actual measured values to calibrate errors. Perfect forecasting is not possible in one shot; but this method has the advantage of anticipating the future with increased accuracy through repetitions. It also involves complex and difficult statistical computation, but this challenge makes the effort all the more worthwhile because I enjoy the thrilling experience of seeing the future through rare data.

Kim Young-oh, Professor of Civil and Environmental Engineering, Seoul National University



# Surviving an earthquake



Written by  
Hee-jun Seol (Seokang High School)



## Product overview

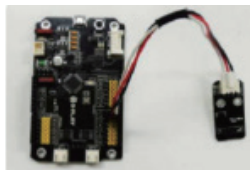
### ■ Product function

Install a seismometer at home to detect the intensity of vibration or possible gas leak during an earthquake and have related data sent to a smartphone

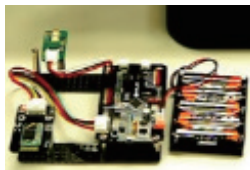
### ■ How it works

A tilt sensor determines the occurrence of an earthquake by measuring shaking for a set period of time and a gas sensor determines gas leakage. The related data is sent to a smartphone.

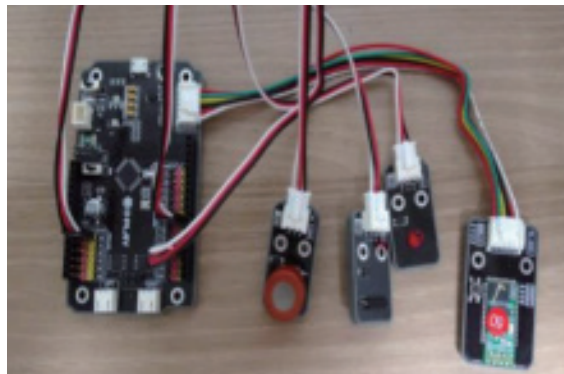
### ■ Product picture



Tilt sensor attached



Bluetooth attached



Completed

### ■ Product structure



Earthquake sensed  
using a tilt sensor



Gas leak detected  
immediately after an  
earthquake is sensed



Related data collected and  
sent via bluetooth



Related data sent to  
smartphone or warning  
device via bluetooth



## Production overview

- **Production time** : About 5 hours
- **Needed materials and tools**



▲ D Play board(Arduino function)



▲ Tilt sensor



▲ Gas leak sensor



▲ Bluetooth sensor



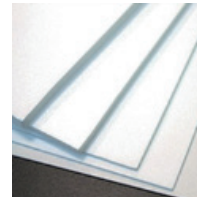
▲ Cable



▲ Breadboard



▲ 3D printer (optional)



▲ Foam board

- **Key production principles**

Function combining a tilt sensor and a gas leak sensor

Take measurement with the tilt sensor and compare it with those taken in other times. If the new measurement is different, take the gas leak sensor to measure the gas value and send the measurement to your smartphone via bluetooth.

- **What requires attention in production**

- ① Learn simple ways of using Arduino and S4A.
- ② Make a garage model to express only a simple structure.
- ③ Be careful of safety accidents while using the cutter.

- **Required knowledge and functions**

- ① How to link Arduino and S4A
- ② How to connect diverse sensors and the actuator with Arduino
- ③ How IoT is implemented

## SW Education Module Textbook

- ❶ Artificial Intelligence
- ❷ Driverless Vehicles
- ❸ IoT(Internet of Things)
- ❹ Virtual Reality
- ❺ CRISPR
- ❻ Space Launch Vehicles
- ❼ **Natural Disasters**
- ❽ Smart Medicine
- ❾ Game Engines
- ❿ Sports Statistics

SW Education Module Textbook ❷ Natural Disasters

### Preventing Natural Disasters Using Advanced Technology

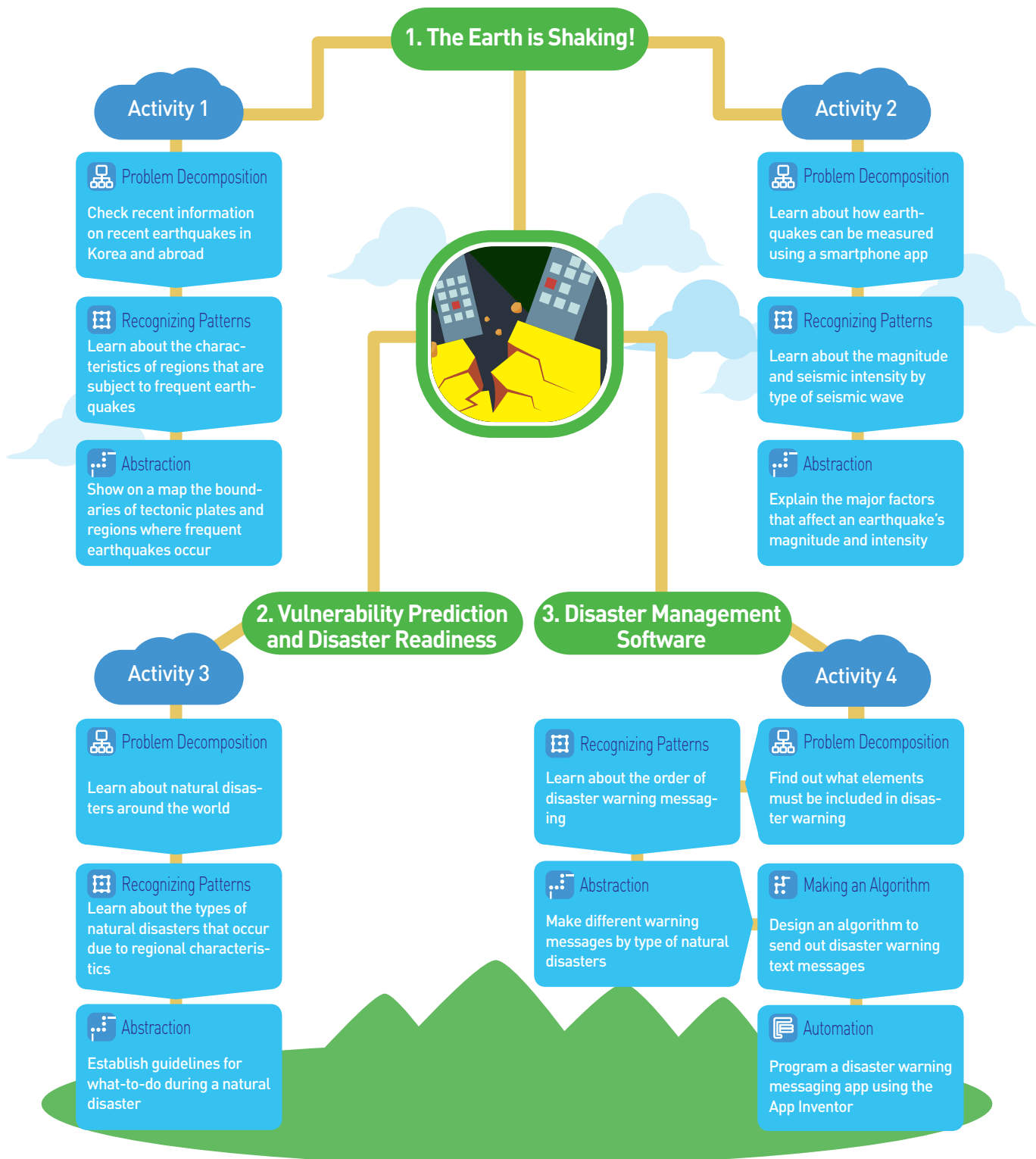
**Issued on** February 23, 2017  
**Issued by** Ministry of Science and ICT, Korea Foundation for the Advancement of Science and Creativity  
**Written by** Sang-mi Lee  
**Planned by** Ji-young Park, Jong-geol Son, Hye-ja Kim (MSIP)  
Yun-jeong Kim, Se-man Park, Ok-su Hong, Jae-min Han, Hye-ran Go (KOFAC)  
**Edited by** Ho-yeong Jo, Wu-cheon Cheon  
**Reviewed by** Il-yeong Jeong

**Published by** Doo-hui Kim  
**Publisher** Dongascience Inc.  
**Responsible editor** Kyeong-ae Chang

**Inquiries** Software Education Center, Korea Foundation for the Advancement of Science and Creativity  
**Email** swedu@kofac.re.kr  
**Phone** (02)559-3841~9  
**Address** (135-867) 602 Seolleung-ro, Gangnam-gu, Seoul (Samreung Building, Samseong-dong)  
**Homepage** www.kofac.re.kr



# Computational Thinking Map



# software

education module



Ministry of Science and ICT



**KOFAC**  
Korea Foundation for  
the Advancement of Science & Creativity  
한국과학창의재단