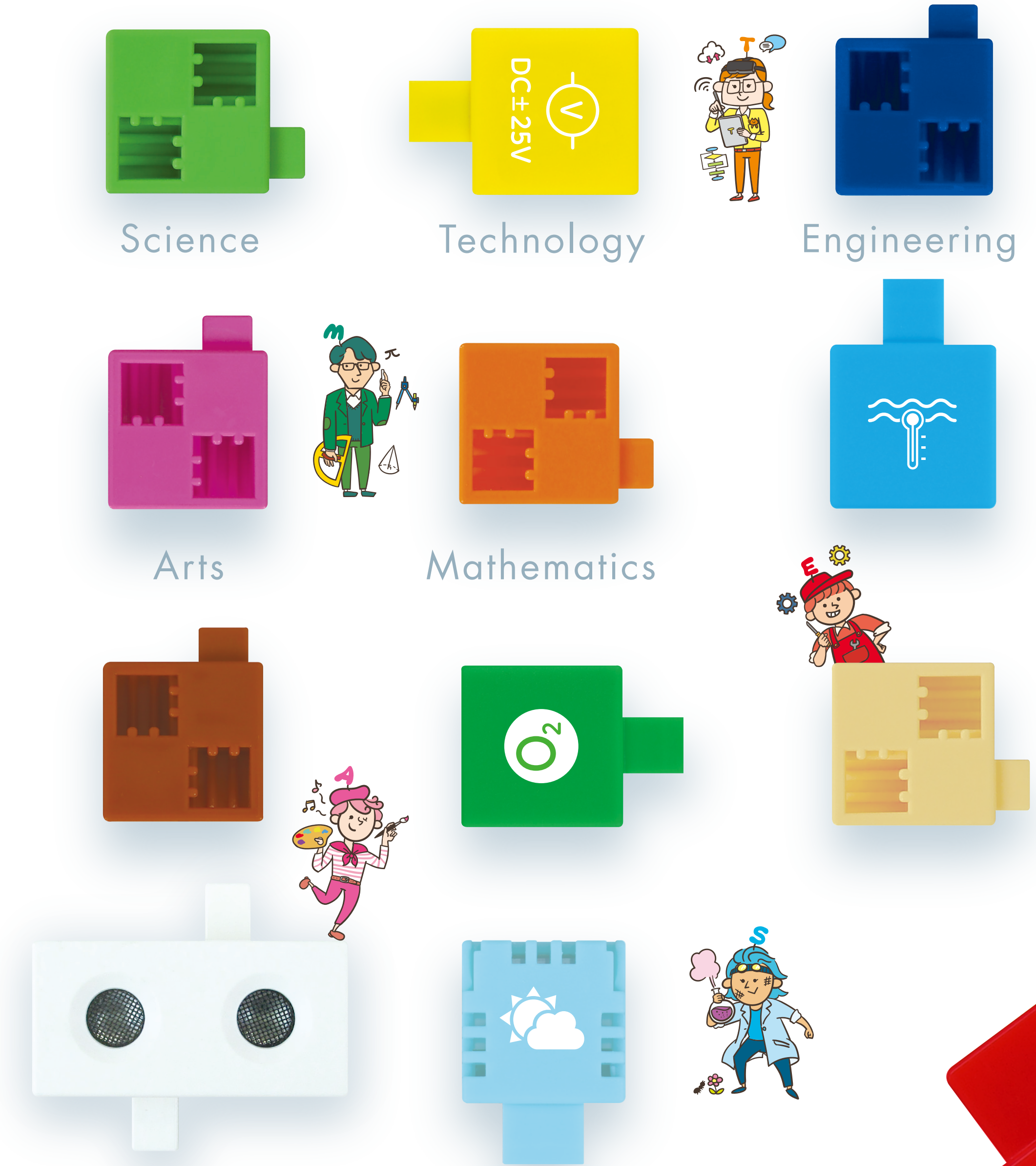
A curriculum casebook jointly researched by
Miyagi University of Education and ArTeC®

First Steps in STEAM Learning

With guidance and supervision by
Professor Akinobu Ando
Miyagi University of Education



Project-based learning with robotics for elementary and junior high school classrooms

Foreword

These days, the movement to promote STEAM education is attracting attention across the globe. In a complex and fast-changing world, STEAM education is a key ingredient in us living better lives and keeping society moving forward. There's also a need for us here in Japan to prepare our elementary and junior high schoolers for the interdisciplinary free study and inquiry-based science and mathematics periods that will become a part of high schools in 2022. We can add to this a demand for STEAM-focused classes which match each child's developmental level and are key in cultivating information literacy which, according to the country's Ministry of Education, Culture, Sports, Science, and Technology, forms the foundation for further learning. These classes are expected to encourage students to engage with their learning by offering challenges and creative activities geared towards their own interests.

It could be said the issue at hand is that, rather than being unable to add more time to an already-packed schedule, we simply don't offer children the opportunity to conduct their own research outside of designated periods. This is without even mentioning the results of evaluating this research and the burden doing so places on the teachers who are expected to guide them.

To drastically reduce these barriers, our research focused on implementing STEAM-centric lessons which can be easily worked into existing subjects and schedules. The themes in these lessons revolve around societal issues relevant to existing curricula, guiding students in creative projects and research as they combine and use devices with the latest programming materials and sensors. A special emphasis was placed on encouraging students to dive deeper into their studies by connecting the content at hand to other courses.

One could say that, compared to a curriculum that goes full STEAM ahead, ours is just a bit of the stuff. I believe that the experiences accumulated through multiple STEAM Bits modules will lead to more robust STEAM learning during comprehensive studies and elsewhere.

The research in this casebook was built on the cooperation of the Miyagi University of Education-affiliated elementary and junior high schools and Sendai City schools in planning and testing each lesson, and Artec in developing the materials including programs and blocks used with each device. It serves as a report on the work we've done in implementing these lessons over three years, and in it you'll find complete lesson plans as well as the programs developed for them. I sincerely hope it will catch the attention of instructors and prove itself to be of some use.

Akinobu Ando
Professor, Miyagi University of Education
Department of Technology Education
President, Institute for Information Literacy
and Competency Development

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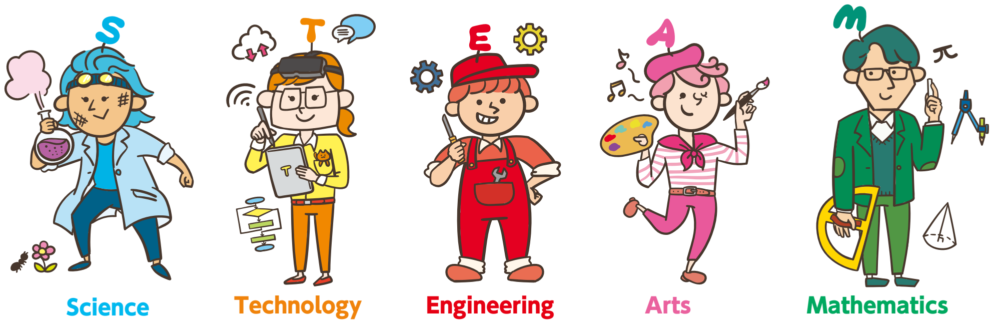
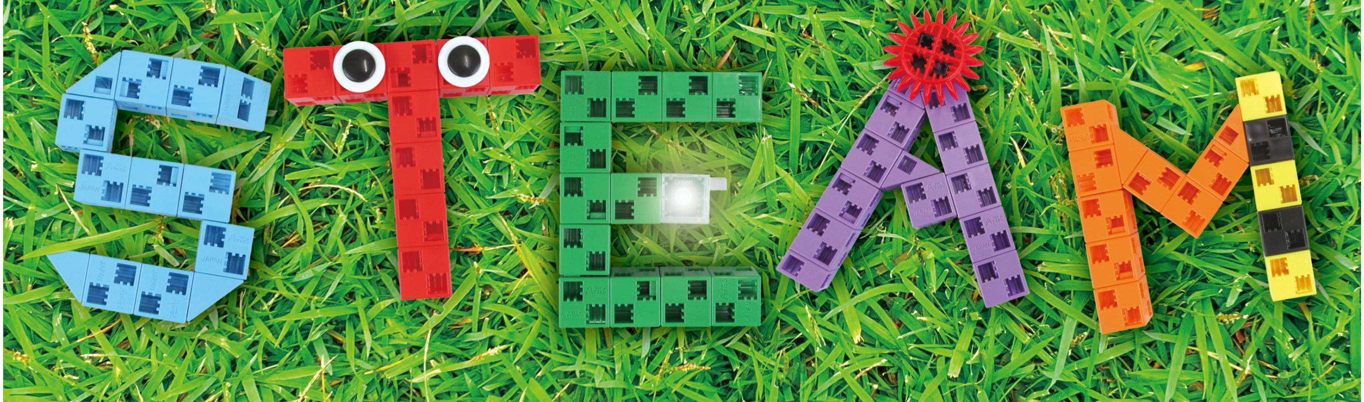


Chapter 0

What is STEAM?

STEAM is an acronym which stands for for **S**cience, **T**echnology, **E**ngineering, the **A**rts, and **M**athematics. What it means is cross-curricular exploratory learning with a heavy emphasis on collaboration in everything from problem finding to problem solving[★1]. STEM is a similar framework, though it doesn't include the arts. In this chapter, we'll take a closer look at the differences between STEM and STEAM learning.



★1 From handout 6-1 of the Central Council for Education's Summary of Deliberations in the Curriculum Subcommittee's 19th Joint Conference on the New Paradigm in Elementary and Secondary Education During the 129th Meeting of the Subcommittee on Elementary and Secondary Education (2021).

A Tale of STEM and STEAM

STEM stands for Science, Technology, Engineering, and Mathematics. This concept was born in the United States of America to describe a collection of elements in science and technology. It's also one of the most important parts of any plant! STEM began to attract attention as a means of cultivating the human talent in science and technology needed to stay in manufacturing on the international stage. The United States' STEM Education Act of 2015 allocated a great deal of the country's budget for use in human resource development, including teachers.

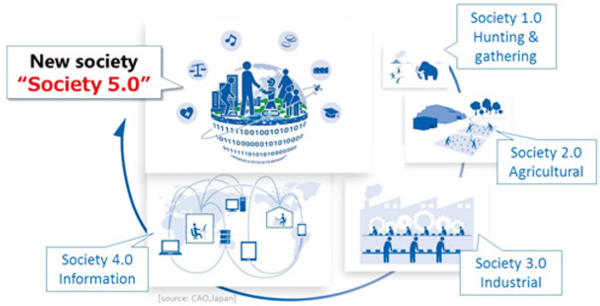
The continued adoption of the Internet and increased access to electronic devices in the 21st century added a critical need for accessible, human-centered design as well as fluid expression of information to our existing body of manufacturing knowledge and technology. With this trend as a backdrop, additional support has gathered around promoting STEAM education, which includes the elements of design and expression covered by the Arts.

Additionally, the skills and knowledge acquired in the humanities and social sciences will also be required due to their complex relationship with solving our myriad social challenges. This has led some to think of the A as standing not just for Art, but Liberal Arts.

This is what has led many countries to view STEAM learning, with strong STEM in the form of the hard sciences, as the essential education for citizens facing life in a new era. Japan's educational system has also taken this stance.

In 2018, the report Human Resource Development for Society 5.0★[2] by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) named the cultivation of talent with both humanity's unique strengths and the ability to reason, judge, and express themselves in the face of unforeseen challenges as essential in supporting and leading a new society in which we share our lives with advanced AI and robots. Individually optimized learning, acquiring the academic fundamentals and information literacy, and bridging the gap between science and the humanities were determined to be a key part of this.

In 2016, Japan's Cabinet Office set its sights on the Super-Smart Society, or Society 5.0 as the successor to the hunting and gathering, agricultural, industrial, and information eras.



From the Cabinet Office Society 5.0 website:
https://www8.cao.go.jp/cstp/english/society5_0/

The STEAMification of learning describes a reiterative process of creation and learning.

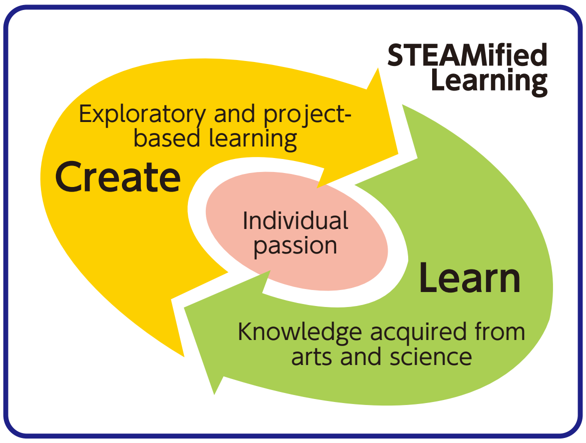


Figure from the Ministry of Economy, Trade, and Industry's Vision for Future Education (2nd Proposal) in June, 2019

It also clearly described a need to break away from the separate tracks for humanities and science seen in high school higher learning, instead integrating the two with frameworks such as STEAM and design thinking.

At the same time, the Ministry of Economy, Trade and Industry's (METI) Vision for a Future Classroom declared a need for this integrated learning from a young age, using the trial-and-error process of STEAMified learning to tackle the issues faced by our society.

The curriculum guidelines put into effect in 2020 named information literacy as the foundation for all learning, and programming education is a crucial element in STEM and STEAM learning.

High school curriculum guidelines additionally define STEAM education as interdisciplinary learning across subjects used to identify and solve real-world issues★[3].

2021 saw the Central Council for Education set out to broadly define the scope of the Arts in STEAM learning.

"Focusing on the aspects of STEAM learning which cultivate the character and talents required for citizens to prosper in modern society, with its complex relationship to every STEAM field, it is of critical need to define and promote the A in STEAM as not just covering the arts and literature, but the broader scope of liberal arts education including health and lifestyle, economics, law, government, and ethics."

From a Central Council for Education report (January 26, 2021)

★ 2 "Human Resource Development for Society 5.0: Changes to Society, Changes to Learning", MEXT (2018)

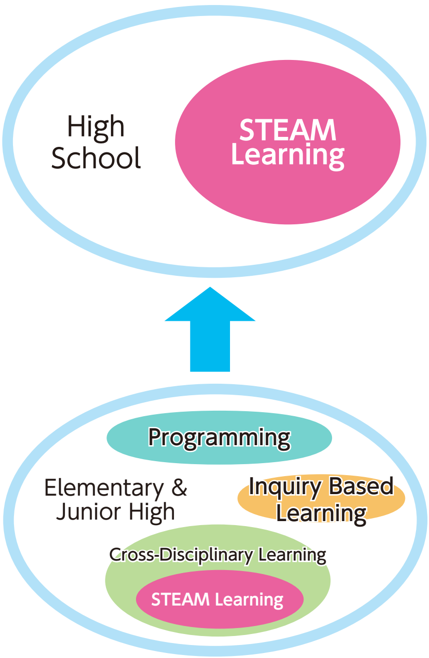
★ 3 "Learning Innovations in Response to Advances in Technology, High School Reform for a New Era (11th Proposal)", Executive Committee for Educational Reform (2019)

Chapter 0

Inquiry-Based Studies in High School

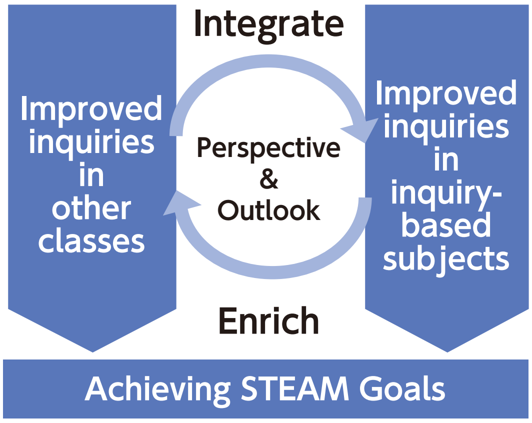
In order to promote STEAM learning, Japan's high schools will add cross-disciplinary as well as math and science-focused inquiry-based subjects to their schedules.

These cross-disciplinary inquiries involve challenges beyond the framework of traditional subjects, while the challenges of science and math-focused inquiries fit within the scope of those subjects★4.



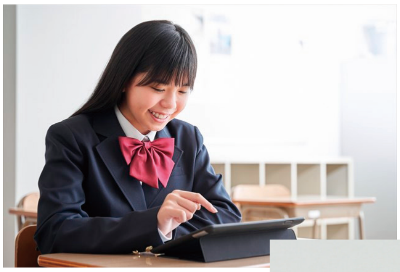
Created based on a Central Council for Education report (January 26, 2021)

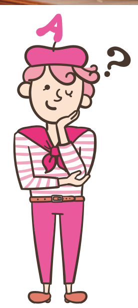
This is to say, cultivating abilities like information literacy which form the foundation for learning in all subjects starting in elementary and junior high is the first step in forming the base for these new subjects in high school and university.

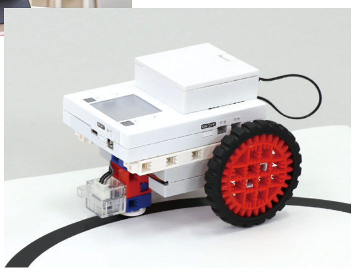


Created from "Promotion of Cross-Disciplinary Learning Including STEAM", MEXT (2021)

While STEAM education is designated as an opportunity for high school students to engage in CD studies, it is also paramount for children to set a foundation for this by engaging in hands-on activities and experiencing science for themselves or through cross-disciplinary and inquiry-based studies, programming education, and more. A report from the Central Council for Education states that, "Depending on students' learning situation, working STEAM education into cross-disciplinary learning is certainly feasible even at the elementary and junior high school level."







★ 4 "Promotion of Cross-Disciplinary Learning Including STEAM", MEXT (2021)

STEAM at the Lower Levels

Improving ICT with GIGA School

Starting in 2020, Japan's GIGA (Global and Innovation Gateway for All) School concept seeks to promote and help the spread of STEAM-like learning in elementary and junior high school by providing every student with their own computer as well as a high-capacity network. This is expected to help solve issues such as the disparity in computer access between regions as well as Japan's relatively low usage of ICT in learning compared to other countries.

MEXT's Path to GIGA School proposes three stages for implementing personal computers, starting with using search engines to help improve the learning experience in every subject and then tying what students learn into the real world as they take the challenges facing society head on. It also clearly details that computers can play a role in STEAM education.

The Path to GIGA School, MEXT (2020)

ICT for anyone in any subject at any time

Use search engines and software for individual and group learning

A computer for every student: Deeper, more enriched classes

Engage in document creation, communicate in both one's native and foreign languages, visualize diverse numerical data, and record videos of scientific experiments

A computer for every student: Solve real problems by tying learning into the real world

Use the process of inquiry across a range of situations

From the Path to GIGA School, MEXT (2020)

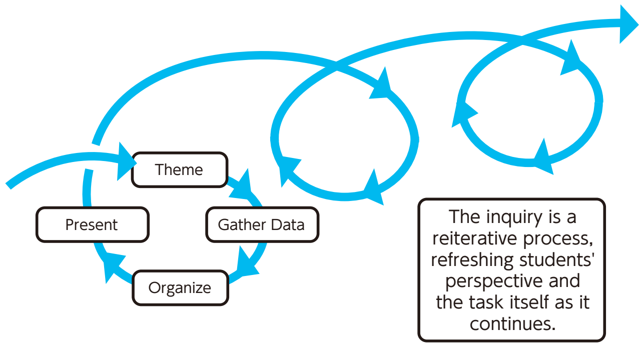
STEAM Library: Bringing School and Society Closer

The goal of STEAM learning is to get students to use what they've learned in each subject to identify and solve the issues in real society, however there can be serious limits on the information students pick up in school. This is where the Ministry of Economy, Trade and Industry's STEAM Library comes in. STEAM Library is a collaboration between industry and academia, an online library filled with learning materials, model lesson plans, and evaluation criteria built around corporate activities and social initiatives like the UN's Sustainable Development Goals.

The METI STEAM Library homepage
https://www.steam-library.go.jp/

The STEAM Difference

Traditional classes have students work through the chapters of a textbook in sequential order. STEAM learning, however, involves having students work to solve a given social issue through inquiry and investigation. While this cyclical four-step process of inquiry may resemble the learning process students are already familiar with, this process may change dramatically with the introduction of personal devices in elementary school, starting with the ability to use information and communications technology, or ICT.



Created based on "2018 Notice on High School Curriculum Guidelines: Period for Inquiry-Based Cross-Disciplinary Study", MEXT (2017)

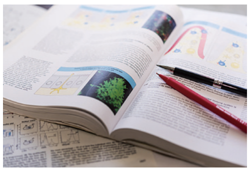
① The Theme

Set and explore challenges through hands-on and other activities.

[Applying ICT] Set themes related to real-world issues and challenges related to career paths, classes, and cross-disciplinary learning

② Gather Data

Find and gather necessary information.



[Applying ICT] Research literature, search online, and perform interviews, surveys, experiments, and fieldwork

③ Organize

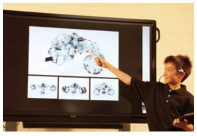
Organize, analyze, and think about the data you've collected.

[Applying ICT] Analyze data using statistical analysis, text mining, and other analysis tools

④ Present

Organize your discoveries and thoughts to determine conclusions before presenting them.

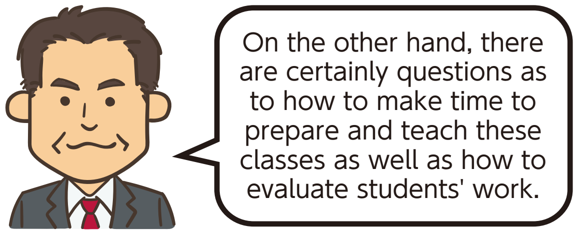
[Applying ICT] Convey information by writing papers, doing presentations, presenting posters, and making proposals



⑤ Set a New Theme

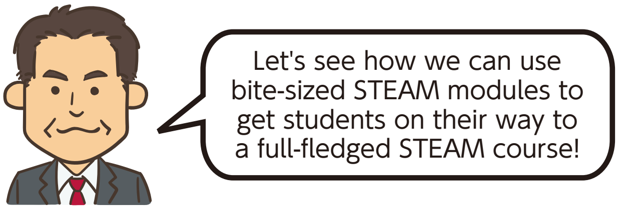
Created based on the Path to GIGA School, MEXT (2020)

Just like this, STEAM learning motivates students to learn by allowing them to set goals and tasks according to their own individual interests. It also carries the benefit of getting kids to make their own mistakes and discovery as they build, present, and express themselves.



Professor Ando

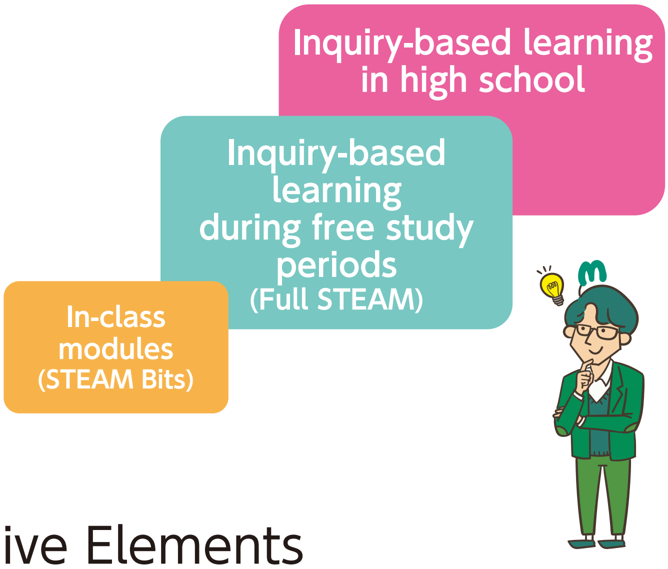
Start with a Bit of STEAM



Professor Ando

Our research aimed to create STEAM modules which can fit comfortably inside of and align with existing subjects before students move on to separate, full STEAM courses.

While the former might be considered going full STEAM ahead, ours is just a bit of the stuff. That being said, we'd like to start by narrowing down five elements of these smaller modules.



First Steps in STEAM: The Five Elements

1 Set the Theme

Let's start with an existing subject. We'll pick an issue which is both relevant to the unit being studied and to the real world, then aim to solve it. This is a worry-free way to engage in cross-disciplinary learning.

- ■ While it may be more realistic to start in an existing STEM subject here, relevant social issues are applicable to all subjects.

2 Apply ICT

Actively use ICT with devices as you start by gathering data and making observations, then finish by organizing, finding conclusions, and presenting the results. This helps both to cultivate and give students an opportunity to cultivate and showcase an information literacy which is the foundation for all learning.

- ■ This casebook uses computers and educational programming materials as measuring instruments in scientific experiments.

3 Mix Disciplines

Encourage students to use the qualities and skills they've acquired in classes already to solve problems. It's a great sign of success if you can get them to relate what they're doing to things they've already studied and what they're learning in other subjects.

- ■ Science: Take an interest in nature, make observations, and experiment.
- ■ Technology: Increase knowledge and skill in mechanisms and making, including programming.
- ■ Mathematics: Convert data into numbers and graphs in order to think logically.

4 Get Creative

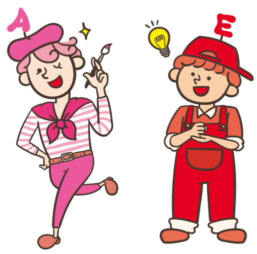
Urge students to get creative by making, moving, searching, and gathering in order to solve the task. The most important part of making anything is thought and experimentation. Have your class organize their thoughts and present them to their classmates.

- ■ Engineering and the Arts: Solve problems, convey information, plan, and design.

5 Reiterate

Once the challenge is solved, inspire your students to take an interest in new topics and what they learn in other classes. This will let them use their free study periods effectively.

- ■ It also helps get them ready for inquiry based learning in high school!

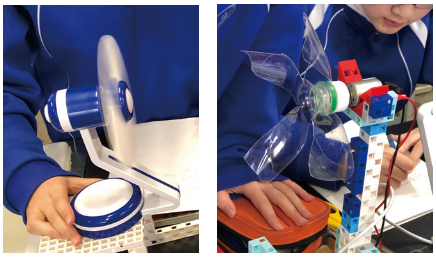


Digital Measurements with STEAM

During the course of our research, one of the methods we used to fit STEAM learning into an existing class schedule was to use ICT devices in technology and science classes to take digital measurements.

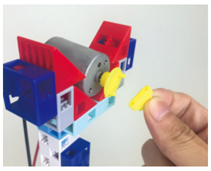
This involved taking the measurements from tools used in traditional experiments and observation like thermometers and putting them into charts and graphs. Digital measurement aims to incorporate devices like personal computers as well as programming tools into the scientific process, allowing us to visualize natural phenomena like energy, water currents, and seismic intensity using graphs and other methods. These devices and programming tools already being available at schools means that you can perform any number of experiments simply by mixing and matching sensors or making adjustments to your measurement methods. Our research worked to verify the efficacy of digital measurement in STEAM learning by tying it into real-world topics and using it in various ways to gather, compare, and analyze data as well as organize and present results during the course of an inquiry.

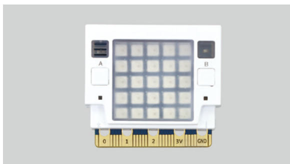
Make the Device + Apply ICT = Digital Measurement

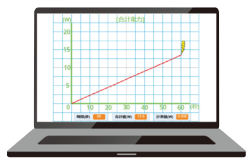


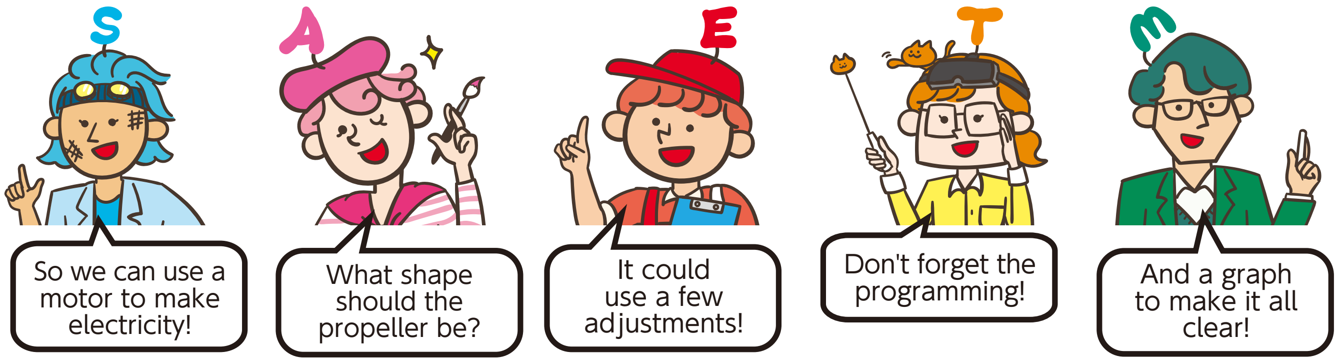
Experiment, Observe, and Solve!

Sensors | Programming Tools (microcontroller) | ICT Device (PC or tablet)





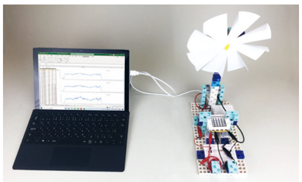
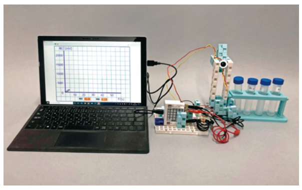
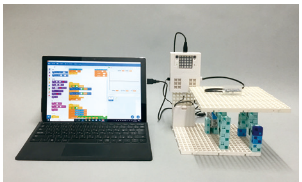
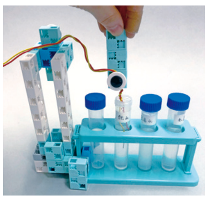
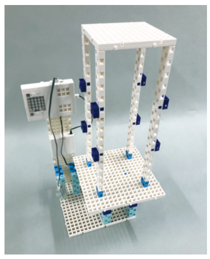




With digital measurement, figuring out how to measure something is a creative activity in and of itself. It also includes a wide variety of STEAM elements. It should also be noted that the setup and process of taking digital measurements can take up quite a bit of class time in elementary and junior high schools, meaning that the best option is to offer a package of hardware with some pre-assembled components along with sample programs and other materials. One of the goals of our research was to develop these materials for schools.

On the next page you'll find a table summarizing three modules that we have done yearly since 2019.

What is STEAM?

STEAM Element	Chapter 1: The Power of the Wind (page 13)	Chapter 2: The Secret of Clean Water (page 25)	Chapter 3: Shake Resistant Skyscrapers (page 37)
① Set the Theme	◎ [Junior High] Learn about electrical current and energy, measurement and control, and wind power as you think about how to use propellers to make an efficient energy source (science). 	◎ [Elementary] Investigate how water supports life (general studies). ◎ [Junior High] Do a deep dive into the concept of aqueous solutions (science). 	◎ [Elementary] Learn about the earth and natural disasters as you design an earthquake-resistant skyscraper (science). ◎ [Junior High] Learn about the nature of volcanoes and earthquakes (science) as well as humans and nature (social studies). 
② Apply ICT	PC or Tablet ArtecRobo 2.0 DC Motor (used as a generator) 	PC or Tablet ArtecRobo 2.0 Conductive Wire (electrode) 	PC or Tablet ArtecRobo 2.0 Servomotor, Accelerometer 
③ Mix Disciplines	[S] Electromagnetic induction [T] Programming, digital measurement [E] Making and tuning propellers, creating scientific instruments [A] Creating propellers, the energy crisis [M] Read graphs, gather and analyze data	[S] Conductivity and the properties of aqueous solutions [T] Programming [E] Creating scientific instruments [A] Environmental issues [M] Read graphs, gather and analyze data	[S] Earthquakes and seismic intensity, pendulums and vibration [T] Programming, digital measurements [E] Architecture, creating scientific instruments [A] Architecture, disaster prevention [M] Read graphs, gather and analyze data
④ Get Creative	◎ Build scientific instruments ◎ Build propellers with optimal shapes and materials 	◎ Make a conductivity sensor ◎ Collect samples of local water and drinks (fieldwork) ◎ Compare different methods for checking for polluted water such as oil sheen 	◎ Build a seismograph ◎ Design and optimize the shape and size of a building 
⑤ Reiterate	Tie in non-science courses to inspire further learning	Compare water quality upstream and downstream and gain an interest in the chemical and physical aspects of conductivity	Get a hands-on experience with earthquake-resistant structures, engage in discussion with classmates, and bring awareness to this module's relationship with other subjects and to our daily lives

2022: Year Zero for STEAM Learning
Inquiry-Based Studies in High School

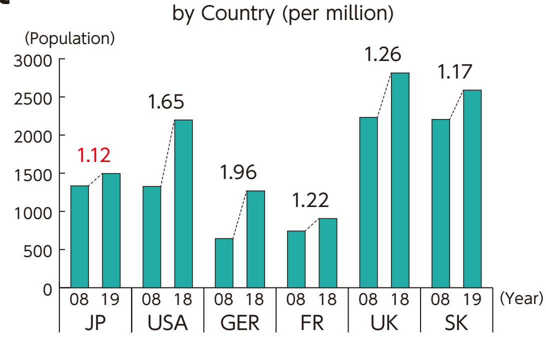
Seven New Ways to Explore

The new high school curriculum guidelines set to start in 2022 here in Japan focus on one key word: inquiry. While high school students previously had one free study period, this has been rebranded as a general inquiry period, with six additional subjects added which revolve around exploring classical literature, geography, Japanese history, world history, science, and mathematics. These math and science-related subjects in particular have a strong relationship to STEM and STEAM learning. While students' general inquiry period allows them to perform cross-disciplinary studies across a wide range of fields, math and science inquiries involve investigating various natural and social phenomena through a scientific and mathematical lens.

Math and Science Sow STEAM Talent

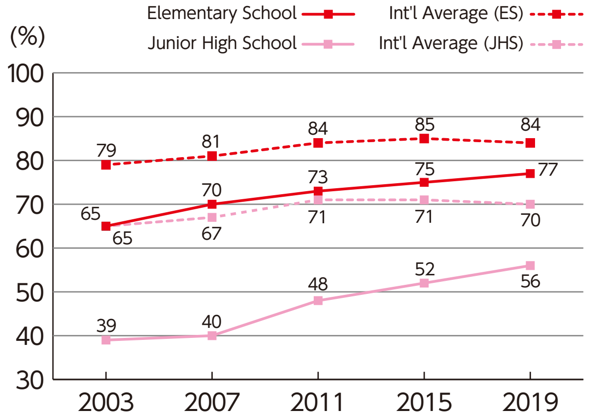
The driving force behind putting these math and science inquiries into the curriculum is Japan's own recent lack of talented workers in science and engineering combined with a serious case of science phobia. Compared to countries like Germany and the United States which have drastically increased the number of students studying science and engineering in the past 10 years, Japan has only shown a relatively modest growth of 112% during this same period as shown in the graph to the right. According to the results of 2019's Trends in Mathematics and Science Study shown in the graphs at the bottom of this page, there were drastically fewer Japanese students who enjoyed studying science and math in junior high school compared to those who found these subjects fun in elementary school. In the same survey, the number of students who would like to work in a math or science-related field has failed to climb above 50% of the international average since 2011. An invaluable ingredient in changing this trend is giving kids fulfilling experiences in making things for themselves as well as science starting from an early age and combining this with interdisciplinary studies and inquiries at the elementary and junior high school level with a special focus on math and science.

Natural Science Bachelor Degrees by Country (per million)

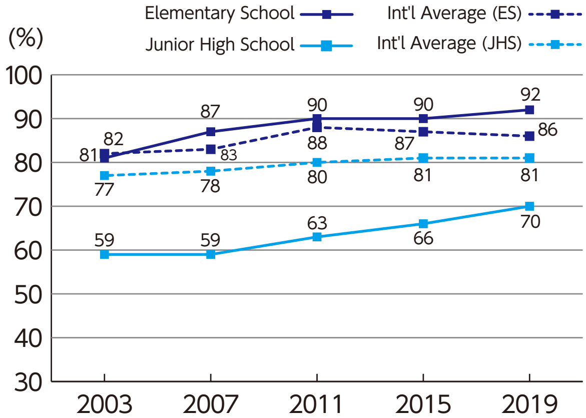


Created based on the Japanese Science and Technology Indicators, MEXT and NISTEP (2021)

Do you have fun studying math?



Do you have fun studying science?



Created based on Trends in Mathematics and Science Study, MEXT (2019)

Chapter 1

The Power of the Wind

Electrical Current and Energy
(Junior High Science)

STEAM Bits Case 1

"Today we're going to be working at a wind energy company. Our job is to use a limited number of materials to develop a propeller that can generate a lot of electricity!"

This module focuses on wind power, taking lessons on electrical current and its uses from the first unit of junior high science and tying it into energy conversion and measurement and control studied in technology classes. We challenged students to use a propeller to generate as much energy as possible, aiming to offer a STEM and STEAM class which ties existing science and technology studies into everyday situations and societal challenges.

Before You Start

Junior High Science: Electrical Current and Energy

Overview

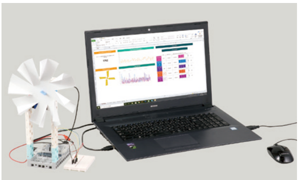
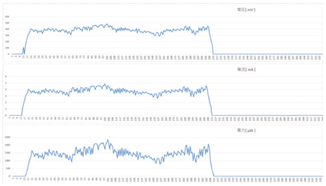
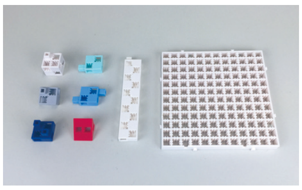
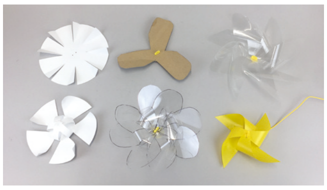
Modern society requires us to view life through the lens of science, actively questioning the world around us and fostering a proactive attitude towards finding the answers to those questions. There are some students, however, who have trouble linking what they learn in school with real life and the issues facing the world. This is especially true for science.

In our research, we aimed to create this cross-disciplinary module using Goal 7 of the Sustainable Development Goals: Affordable and Clean Energy, a social issue which also falls nicely into the category of science. It's critical that we find a way to work hand-in-hand with nature and the limited resources on our planet to build a sustainable society that remains in harmony with the natural world. This module challenges students to use a propeller to generate as much energy as possible. Its main goal is to get junior high school students working with concepts they already study in science such as electricity and its uses, experimenting with using electrical current to generate light and heat, and understanding how conditions can affect the amount of light and heat that you can make.

On the other end, the new technology and home economics curriculum ask students to consider energy conversion as a means to solve issues on a personal and societal level, finding the challenge in the issue, planning, designing, and then making electronic circuits or physical mechanisms then evaluating, improving upon, and correcting their manufacturing processes and results. Consequently, this module calls upon students to find better solutions for social issues by using engineering skills to find the issue, make the project, and then evaluate, improve, and correct it while using their knowledge and abilities acquired in science class to experiment and get the resulting data. The final step is to use their own reasoning, judgment, and expressive abilities to analyze their data for trends.

In order to explore the theme of this module, we used a computer and microcontroller to make a digital measurement tool for each piece of experimental equipment in a science lab. The experiment itself had students use science to record, analyze and interpret their results, technology to use their computer and program, engineering to design optimal fins for their propeller and build their measuring instrument, math to handle their data, and the Arts to view what they've learned from a social perspective. We chose to evaluate this module's worth as a STEAM course by seeing whether it truly allowed students to use what they've learned at school to solve the challenge at hand.

Making it STEAM

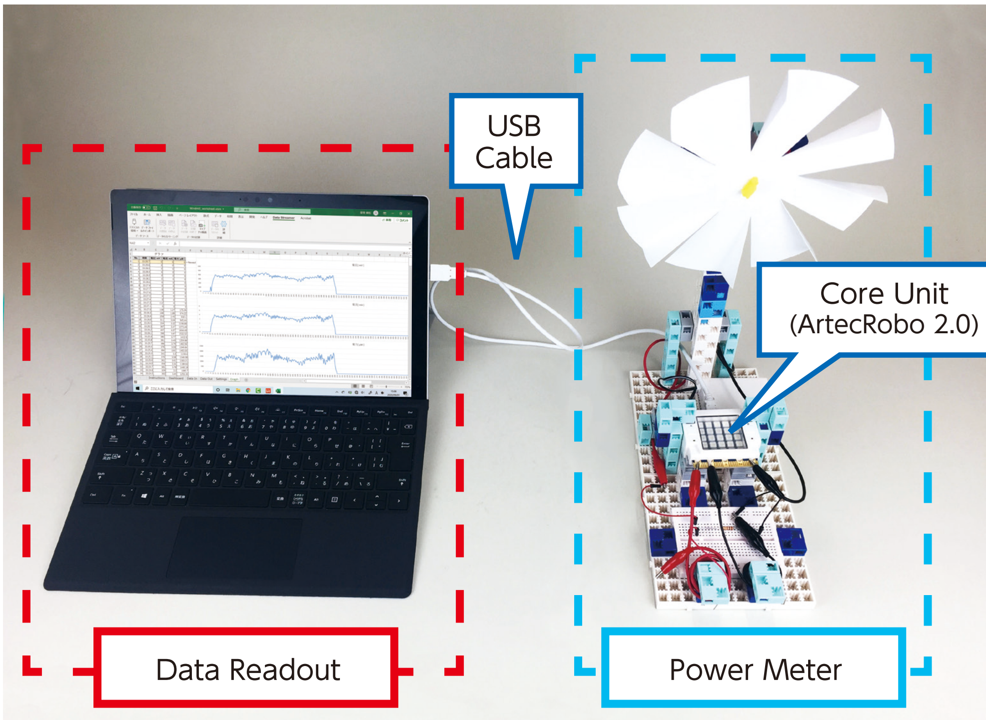
STEAM Element	Module Content
① Set the Theme	This module can be used in a junior high science unit on electricity and energy, using wind power as a source of renewable energy. It can also be used in a technology unit on measurement and control, or a social studies unit concerning energy in society. **Aligned to** SDGs 7 AFFORDABLE AND CLEAN ENERGY
② Apply ICT	・This module uses a DC Motor as a generator in a turbine sensor and the ArtecRobo 2.0 Core Unit to measure the amount of power generated. Analog values were converted into digital ones and shown as a graph on the ICT device. ・We also prepared a sample program in advance to cut down on the amount of time required for programming in Scratch.  
③ Mix Disciplines	**Science** Learn about electromagnetic induction **Technology** Learn about energy conversion as well as how to use computers for programming and spreadsheet software **Engineering** Design and make a propeller, troubleshooting, and solve problems in daily life and society at large **Math** Learn how to handle and process numerical data like graphs **Arts** View the studies in this module through a holistic and societal lens
④ Get Creative	・This module aims to get students to build an efficient power source using a range of materials and optimal shapes. ・In order to keep it within the constraints of a tight schedule, we used blocks to make a simplified measuring instrument and placed most of our focus on the experiment itself.  
⑤ Reiterate	The lesson here aims to bring an awareness to non-science courses to inspire further learning.

Chapter 1

Designing the Materials

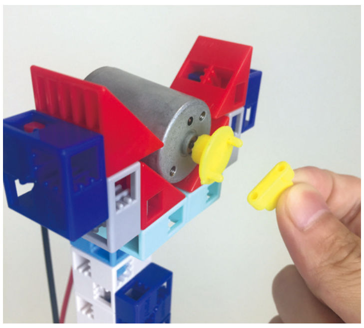
Power Meter

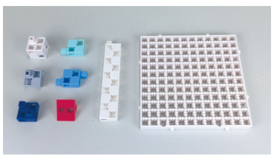
This meter uses the ArtecRobo 2.0 Core Unit to measure the amount of power generated by a DC Motor connected to a propeller. This data is put into a graph on your PC or other device, allowing you to compare the output.

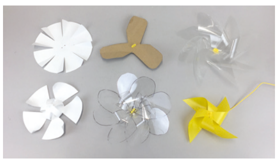


Press buttons on the Core Unit to start and stop the measurement

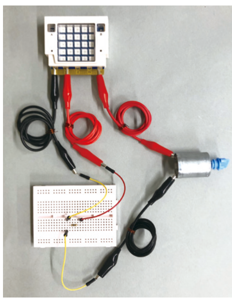
Making the basic structure of the power meter out of simple Artec Blocks parts allowed us to adjust different parts of the meter such as the size of the propeller or the meter itself according to the parameters of the experiment. We also used the ArtecRobo 2.0 Studuino:bit Software to prepare a sample program which could be adjusted on the fly.







Wiring the Meter

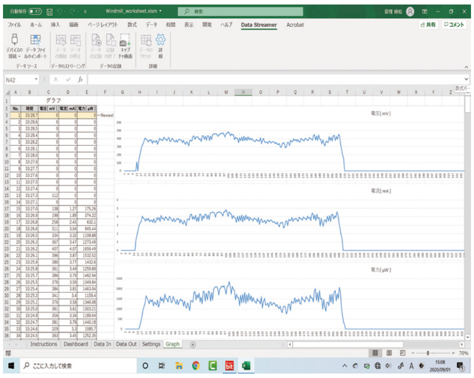


Showing the Data

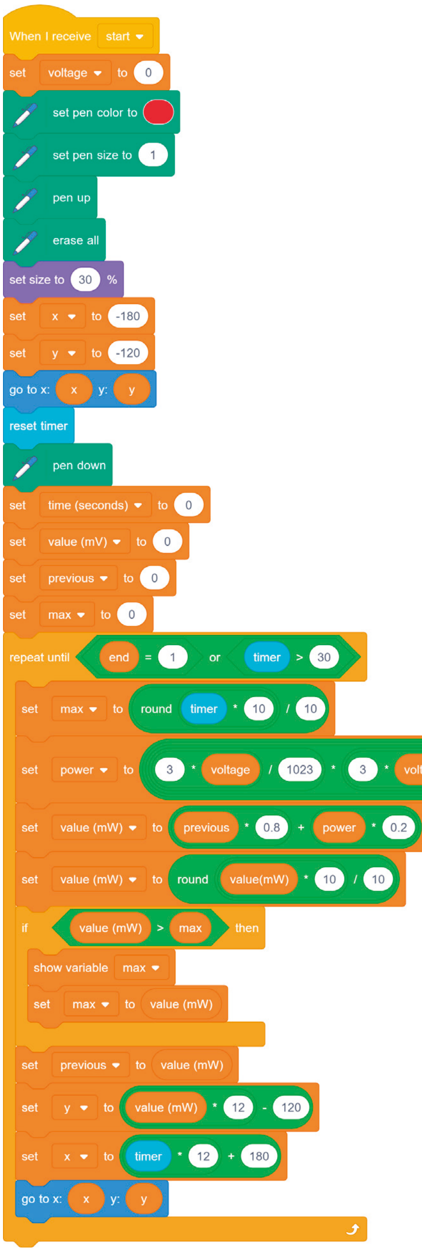
The data we log can be shown in multiple ways. Using a project Excel from ENG Windmill and Wind Turbine on Microsoft's Hacking STEM webpage (find out more in Teacher's Tips on page 24) allowed us to graph voltage in millivolts (mV), current in milliamperes (mA), and power in microwatts (μW)

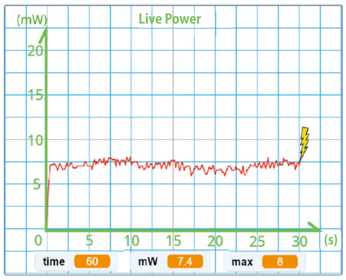
Using the software included with ArtecRobo 2.0 also allowed us to program a graph which can be displayed on any OS without the need for dedicated graphing software. We were also able to display the power output on the ArtecRobo 2.0 Core Unit's LED display.

Graphing Data Using Excel

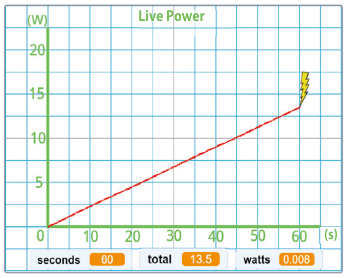


Scratch Program and Graphs





Real Time Output



Total Output

LED Power Display

Designing the Module
(Miyagi University of Education Junior High School)

This module tackles creating the energy-efficient power sources our society needs by combining trial and error with real measurements. This aligns with the goals of junior high science classes in cultivating skills, knowledge, reasoning, judgment and expression in addition to a motivation to learn and a sense of humanity in students. This is why this module in particular stresses the need to tackle societal issues as well as craft a narrative. We managed to get the total class time down to two hours to make it effective within the shortest amount of time possible.

Module Overview

Time	Content	Tips
Part 1 (60 minutes)	・Understand how to use propellers to spin turbines in order to produce power.	・Get students thinking about the material, size, shape, and mass of their propeller. ・Use the tools given to you to produce a maximally efficient design.
Part 2 (60 minutes)	・Take your propeller and measure the relationship between rotation and power, using your PC to observe the results.	・Experiment using the control parameters devised in part one.

Thoughts on Teaching

Yohei Nishikawa
Instructor
Miyagi University of Education Junior High School

While students may understand that wind power is a more environmentally-friendly way to get power, they may not be aware of its drawbacks. In an age where countless amounts of research and development are being done to overcome these hurdles, students will play the role of employees at a wind energy firm as they design, build, and evaluate their own propellers.

Even as I taught, I found myself thinking across disciplines: feeling grateful towards my math teacher, applying what I learned in technology classes during the course of the inquiry and my lessons from art as we summarized it all. We sincerely wish for the STEAM skills students pick up here will serve them just as well in the future.

Guidelines (Part 1)

1) Learning Goals Think | Judge | Express

- Learn how to create experiment parameters which can help you evaluate a propeller which generates energy.
- Use limited materials to create a source of wind power, then improve its efficiency.

2) Evaluation Criteria

Criteria	A (Excellent)	C (Needs Improvement)
Enable students to create parameters which allow them to evaluate their propeller's efficiency in generating energy.	Students are able to describe not just their measurement time, wind strength, and wind direction, but the distance between the propeller and the fan, airflow, and the fixed position of setup.	Have students observe their testing setup and visualize airflow by drawing it themselves.
Mentor Method 3 Guide students as they create an experiment to test their propellers.		
Use limited materials to create a source of wind power, then improve its efficiency.	Students can effectively explain the properties of materials used and how they devised the shape along with the optimal height and mass of their propeller.	Show students an example propeller as a reference.
Mentor Method 4 Guide students in making their propellers.		

3) Module Flow

For Instructors	For Students	Tips
1 Explain the Task	Understand the problem. • Explain to the class that today they will play the part of a project team in a company which hopes to use wind energy to solve our energy crisis.	This section touches on the energy crises and renewable energy. • Here students will learn that their task in the next part is to test their propeller. Explain that propellers can rotate to generate electricity. • Set the scene and goals for this part.
2 Find the Problem	Students should understand that they'll need to improve the propeller in order to make it rotate. • Think of how to turn a propeller which won't move into an energy-efficient power source. • Realize that an improved shape would work better.	Blow air onto an unmoving, square propeller to see that it doesn't move, then ask "what" and "how" to analyze and get to the root of the issue.
	How can you make an energy-efficient propeller?	
3 Find the Parameters	Think about the parameters. • Have students think of these by themselves before brainstorming in groups of four. The last step is to exchange information with other groups.	Have your class closely observe a test setup with the unmoving propeller. Evaluating Performance Give written or spoken feedback as to whether students have found a good set of parameters for evaluating their propeller.
4 Make the Propeller	Use the kit to make your propeller. • Students can make it out of any materials they wish.	Encourage students to pay attention to the material, size, shape, and mass to make an efficient propeller and give their design a name.
5 Prepare	Here students will learn that their task in the next part is to test their propeller.	Emphasize that thinking as you test the propeller is the first step in solving the problem.

Guidelines (Part 2)

1) Learning Goals Think | Judge | Express

・Measure the energy generated by the propeller and use the results to make it more efficient.

2) Evaluation Criteria

Criteria	A (Excellent)	C (Needs Improvement)
Measure the energy generated by the propeller, using the results to make it as energy-efficient as possible. Mentor Method 5 Guide students as they measure the energy generated by their propellers and work to optimize them.	Students compare their work with others as they find the common points in making a propeller energy efficient.	Have students observe different aspects of the propeller such as its material, size, shape, and mass.

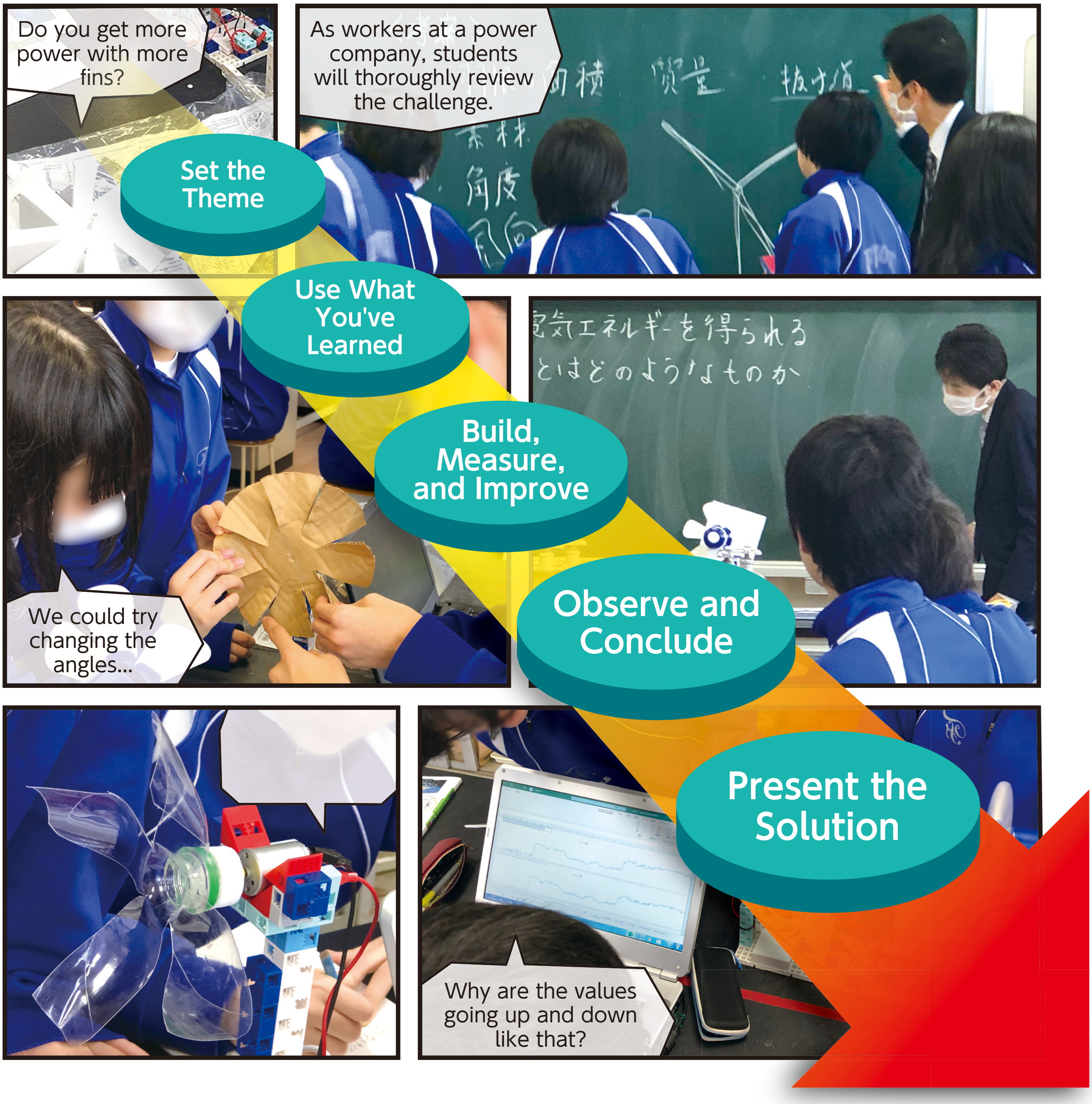
3) Module Flow

For Instructors	For Students	Tips
1 Review the Task	Understand the task.	Review what you did in the first part of the module.
2 Review the Test Process	Have group members share information including how to use the power meter as well as what parameters to set.	Question students to confirm that they know how to use their computer, set parameters for measurement, and read the graphs of their results.
3 Measure and Record	Students will measure the energy generated by their propellers.	Have students take notes on their observations as they measure. ・Allow students to improve their propellers as much as they can within the allotted time.
4 Share the Results	Allow students to get out of their seats and to observe and exchange information with other groups.	In addition to observing the propeller and taking measurements, sharing ideas and opinions with classmates is also an important step of improving the propeller.
5 Observe and Present	Students will use their own results as well as the observations they made of other groups to form even deeper observations on creating energy-efficient propellers.	Encourage students to focus on the material, size, shape, and mass of the different propellers. **Evaluating Performance** Guide students' written and spoken feedback as to whether they effectively measured energy and used their results to create a more efficient design.
6 Review	Think about how designing, measuring, and improving a propeller relate to society, daily life, and other school subjects.	Emphasize that thinking as you test the propeller is the first step in solving the problem.

The Module in Action

We conducted this module in a science classroom, splitting students into groups of four and giving each group their own power measurement kit and a set of small fans which they could use to test their propellers. We also had each group gather thick construction, pinwheel paper, cardboard, and plastic bottles to use as material for their propellers.

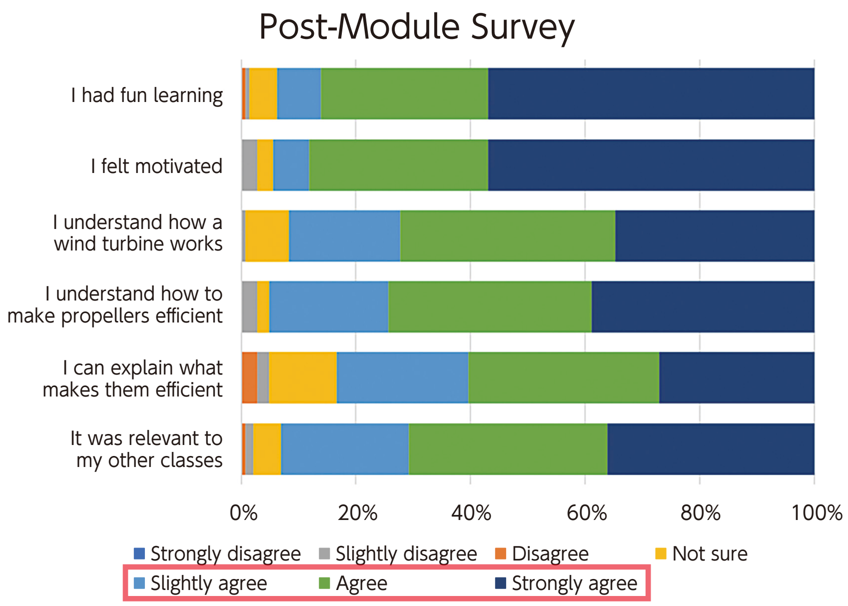
Scenes from the Module



Post-Module Survey and Observations

Once the module was over, we asked students to evaluate their own performance and write a free report on what they learned.

Having students respond to prompts such as, "I had fun learning" and "I felt motivated" allowed us to see that students were quite positive in their evaluations. We were also able to see that using data visualization and tying in technology allowed the module to cover a much broader scope than a simple science experiment.



Impressions on STEAM and Collaborative Learning

- Aside from having to think about area and mass to make the propeller, I had to know and think about a lot of different things besides just how to make it. Talking to different people helped me notice there are a lot of different ways to look at things. Taking this class helped me remember that it's more than just getting the propeller to spin. You have to think and look at it in different ways and try to relate it to other things.

- In this class I really had to use the knowledge I learned in math and science like angles and area, mass, wind direction, rotation and finding the center of a circle. Doing this helped me to realize how fun it is to actually use what you learn.

- It was also really cool how we could use a computer to measure current and voltage and get an instant power reading. Seeing other people with ones that spun a lot even though they were made out of thin paper showed me that it's less about the material than how you use it.

- I felt like a lot of different fields go into making power. Of course it takes electricity, but you also have to use engineering for the airflow and development and there was stuff which uses math like design. I felt like I could really use what I learned.

- I'd also like to use a computer to measure power sources like thermal and hydraulic power and experiment with efficient energy conversion in my technology class.

- I thought it was amazing how you have to think about the shape and weight of a propeller in order to get it to spin faster. At first I thought the shape wouldn't really matter, but doing the experiment to see that making a few small changes can get you a lot more power was really fun. I'm glad I was able to use what I learned in my other classes like math and social studies to make connections and build the propeller.

- I knew how you can make wind power, but I didn't know how changing the shape a little could change how much power you get. I've only ever seen windmills with three blades before, but now I think that there's an actual reason for the number, the size, the angles, and everything else about the blades.

- It made me realize that a lot of technology and thought goes into the stuff we really don't think much about.

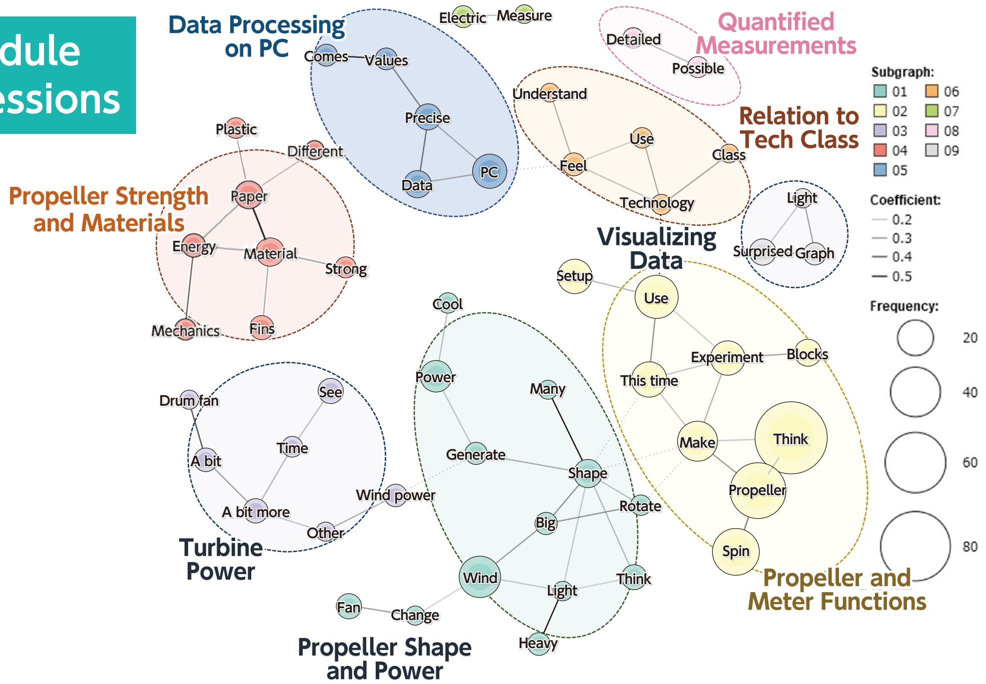
- Ours didn't work too well this time, but it really made me want to study science and other subjects a lot more.

More than Just a Science Experiment

Below is a word cloud made by text mining the reports of students' thoughts and evaluations of this module. Mining these reports showed us that the inquiries students made here went way beyond a simple science experiment.

The clusters in this cloud are grouped by category including Propeller Shape and Power, Processing Data on a PC, Quantifying and Visualizing Data, and Relevance to Tech Classes.

Module Impressions



Final Thoughts

Professor Akinobu Ando, Miyagi University of Education

This module uses a testing setup developed by our research team which allows junior high schoolers to take measurements on wind power when testing their turbines and propellers. As a result, we were able to confirm the efficacy of the materials we developed in a real classroom environment, and we believe it proved to be especially effective for learning within a STEM and STEAM framework. Instructor feedback on this module came in the form of who realized its strong connection with mathematics when seeing students figuring out exactly what to do with the bumpy graph as they measured in real time, as well as the importance of having students build their own power meter rather than just using an ammeter to take readings.

I believe that the world cloud above tells us that a mere two hours is still enough class time to allow students to broaden their horizons, make connections, and think deeply.

Citation "Developing an Instructional Testing Setup to Measure Wind Power Data Using ArtecRobo 2.0", Akinobu Ando (Miyagi University of Education), Yohei Nishikawa (Miyagi University of Education Junior High School), and Ippei Ohashi (Artec Co., Ltd.), 3rd Annual Meeting of the Japan STEM Education Society

EXTRA CREDIT

Digital Measurement with Microsoft Hacking STEM

Microsoft's Hacking STEM (https://education.microsoft.com/hackingStem) is a prime example of STEM and STEAM learning using ICT devices, including digital measurement.

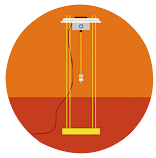
What is Hacking STEM?

- **Lesson Guide**
  Learn how to use cardboard and magnets to measure and experiment with a detailed guide that explains everything you need as well as how to make and use it.
- **Lesson Plan**
  Use this to guide and grade your classroom as a teacher.
- **Custom Excel Worksheet**
  Designed to show measurements in easy-to-understand charts and graphs.
- **Microcontroller Wiring Diagrams and Code**
  Sample programs allow you to use Arduino or other languages for data collection.

Lesson Content

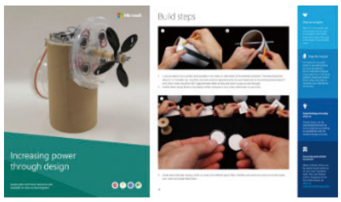
Analyze satellite images of the Earth to predict climate change

Visualize seismic data to analyze the effect of earthquakes

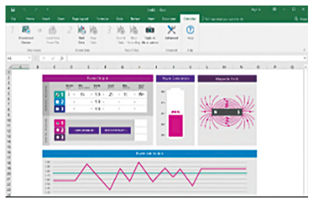


Use a robot to analyze the anatomy of a human hand

Lesson Guide



Excel Worksheet

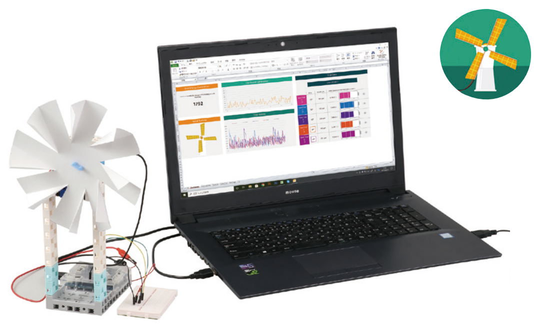


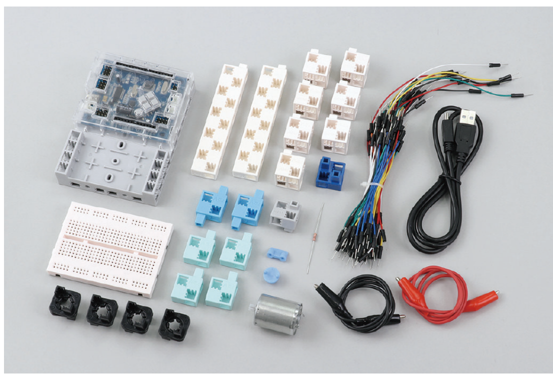
While the projects in Microsoft Hacking STEM are full-fledged lessons in which students spend quite a bit of time making their own instruments from real-world objects, our research focused on meeting the needs of the Japanese school system. This included cutting down on prep time, making improvements once the experiment was over, and keeping reusability in mind by using blocks which can be reconfigured as needed.

Additionally, the relatively limited graphs used in our research aim to run on all devices covered under GIGA School. However, schools which have access to Microsoft 365, Excel and other tools can download comprehensive worksheets to help guide them in their analysis.

Microsoft

Designed for
Hacking STEM projects





Artec, an educational company in Japan, produces its own Wind Power Meter using the Arduino-compatible ArtecRobo platform.

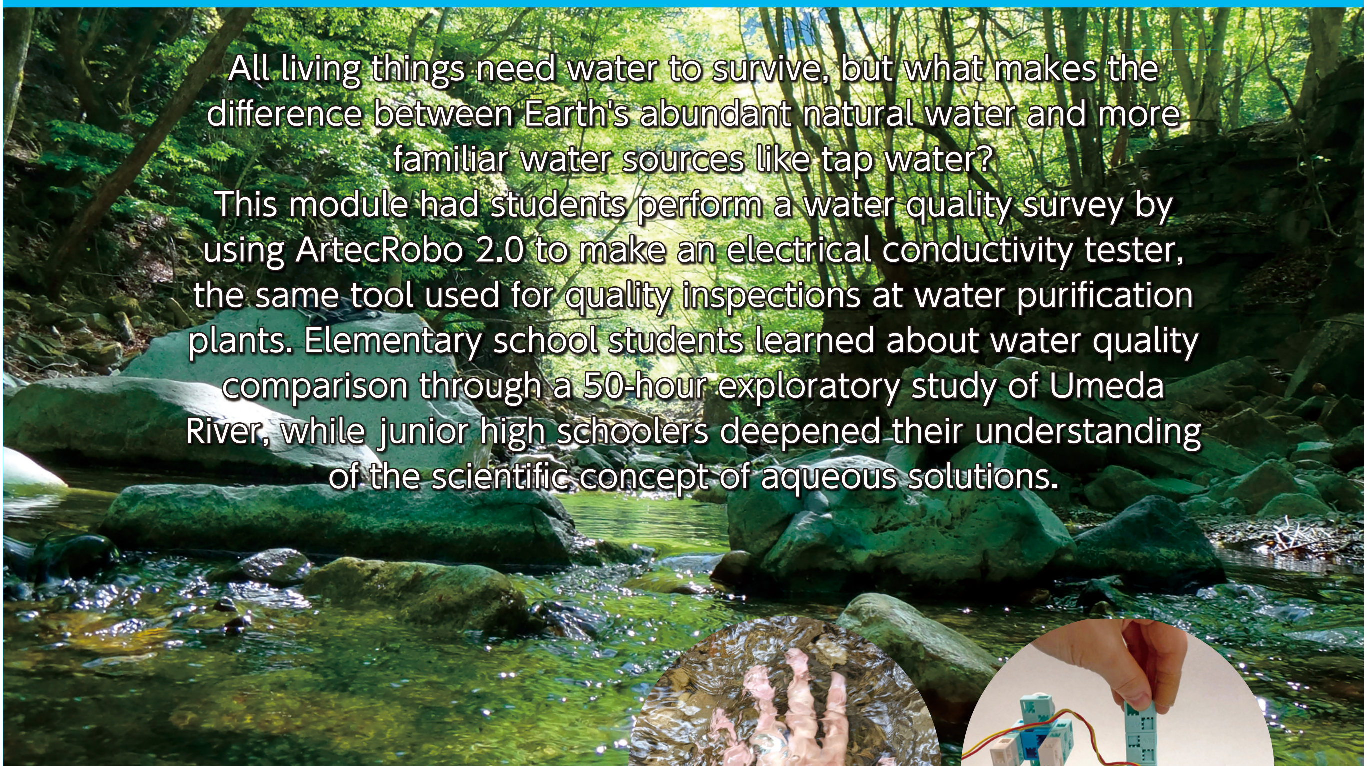
Chapter 2

The Secret of Clean Water

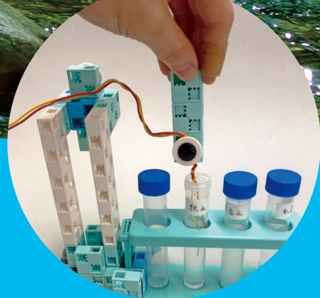
The Rivers of Sendai
(Elementary General Studies)

Aqueous Solutions
(Junior High Science)

STEAM Bits Case 2



All living things need water to survive, but what makes the difference between Earth's abundant natural water and more familiar water sources like tap water?
This module had students perform a water quality survey by using ArtecRobo 2.0 to make an electrical conductivity tester, the same tool used for quality inspections at water purification plants. Elementary school students learned about water quality comparison through a 50-hour exploratory study of Umeda River, while junior high schoolers deepened their understanding of the scientific concept of aqueous solutions.



Overview

This module involves digital measurement, turning the ArtecRobo 2.0 Core Unit into an electrical conductivity (EC) sensor to study aqueous solutions, a concept touched on in general studies in elementary school and in junior high science classes. Here we focused heavily on the introduction of STEAM education in low-integration subjects, using the same materials in both elementary and junior high school classrooms to gauge their effectiveness.

Comprehensive Studies in Elementary School

Tomoki Watabe
Instructor
Miyagi University of Education Elementary School

Centered around the Umeda river which flows through Sendai City, Miyagi University of Education Elementary School's fourth grade comprehensive studies class features 50 hours of inquiry-based learning to get students thinking about their connection to rivers and how to work towards sustainability.

Our 17th class allows students to understand how the Umeda river supports life by testing the quality of both the river itself and other local water sources. With that in mind, we incorporated digital measurement into the lesson.

Despite being visually identical to tap water, using a conductivity sensor to clearly see the difference in quality between the two led students to guess that the river is quite comfortable for living things. This was due to its similarity to water from the school pond, which is absolutely teeming with life. This exercise also helped us to see the value of a conductivity sensor as a STEAM learning tool in testing water quality.

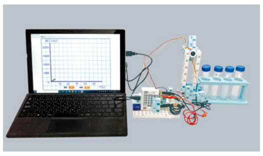
Studying Aqueous Solutions in Junior High Science

Isao Adachi
Instructor
Miyagi University of Education Junior High School

This module aimed to get students in a second-year junior high school science unit on aqueous solutions to incorporate digital measurement into an experiment and use it to tell the difference between solutions which conduct electricity and those which do not. Students took the lead in this experiment, creating their own experiment plan and breaking into groups to measure the conductivity of the solutions using a conductivity sensor. The lesson concludes with a three-hour deep dive into the differences between the conductivity in solutions intended to tie different units together.

Using an electric conductivity sensor in this experiment allowed us to successfully bridge the end of a second-year unit on the world of electricity to the beginning of a third year unit on chemical changes and ions. We teachers are incredibly grateful for this invaluable opportunity to try this out firsthand.

<table>
<tr><th>STEAM Element</th><th>[Elementary]
Comprehensive Studies Grade 4:
The Rivers of Sendai</th><th>[Junior High]
Science Grade 2:
Aqueous Solutions</th></tr>
<tr><td>① Set the Theme</td><td>The task here is to measure the water quality of a river, challenging students to understand how the Umeda river supports life by testing the quality of both the river itself and other local water sources.

Aligned to SDGs 6 CLEAN WATER AND SANITATION, SDGs 14 LIFE BELOW WATER</td><td>This challenge asks students to gather and investigate the conductivity values of aqueous solutions to find the difference between solutions which conduct electrical current and those which don't.</td></tr>
<tr><td>② Apply ICT</td><td colspan="2">Both cases use a PC or Tablet, ArtecRobo 2.0, and conductive wire as an electrode


This lesson aims to develop the following according to the Systematic Table of Information Literacy★5:
[Skills and Talent: Step 2]
・Gather basic information using surveys and documents
・Organize data using tables and charts with a solid outlook
・Find qualities, trends, and changes in data
[Think, Judge, and Express: Step 2]
・Turn data gathered from surveys and documents into simple charts and graphs with a solid outlook, using acquired thinking tools to organize the data
・Abstract data to capture the bigger picture and points, finding new ideas and meanings
[Motivate Learning and a Sense of Humanity: Step 2]
・Take in and consider fresh perspectives</td></tr>
<tr><td>③ Mix Disciplines</td><td>Science
Recall what you've learned about electrical pathways in science class, then see that, while purified water will not conduct electricity, adding an electrolyte to purified water will make it conductive.

Technology
Use a digital instrument made from ArtecRobo 2.0 and a conductivity sensor.

Engineering
This module is minimal on engineering due to there being less focus here on engaging in creative problem solving.

Math
Output the results to a graph which shows voltage over time.</td><td>Science
Use what you've learned about how electrical current works as well as chemical changes, molecules, and atoms as they investigate whether or not an aqueous solution will conduct electricity based on its molecular structure and chemical formula.

Technology
Use a digital instrument made from ArtecRobo 2.0 and a conductivity sensor.

Engineering
While this module doesn't focus on creative problem solving, we did see some students devising ways to obtain measurements in keeping with their predictions.

Math
Output the results to a graph which shows voltage over time.</td></tr>
<tr><td>④ Get Creative</td><td colspan="2">・Engage in fieldwork outside of the school and near rivers in order to collect samples.
・This can include devising, building, and programming the instrument.</td></tr>
<tr><td>⑤ Reiterate</td><td>Deepen interest by having students compare water quality upstream and downstream.</td><td>Heighten students' interest in the chemical and physical implications of conductivity.</td></tr>
</table>

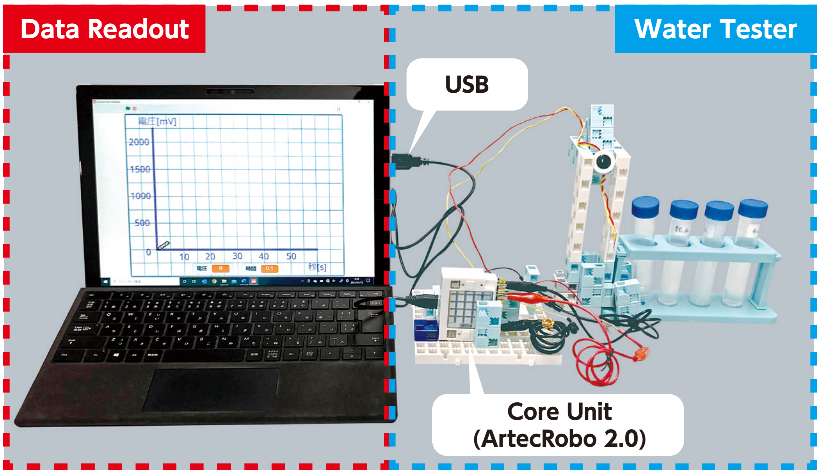
★ 5 "Systematic Table of Information Literacy", MEXT (2018)

Designing the Materials

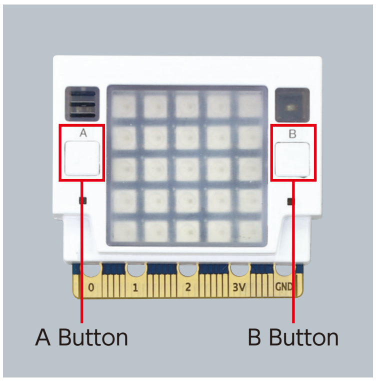
Overview

Conductivity sensors, also known as electrical conductivity (EC) sensors, have a wide range of uses in our society from checking the level of contamination in drinking water to the concentration of fertilizer in agriculture.

This module has students use a programmable ArtecRobo 2.0 microcontroller to make a water quality tester. The electrodes attached to the Core Unit's analog connector work as a conductivity sensor, measuring the voltage of an aqueous solution which is then displayed on the screen of your device.



The Testing Setup



This ESP32-based board has an analog edge connector.

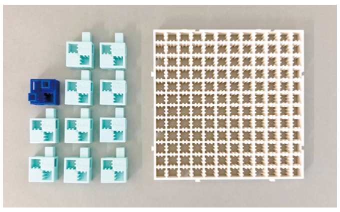
Press the A and B buttons to start and stop taking measurements.

The Water Tester

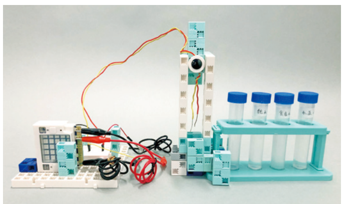
Just like an off-the-shelf conductivity tester, the water quality tester in this module can be used to show that purified water is low in conductivity. This means that higher quality water is more free of contaminants.

Measures are taken using the following steps: ① Attach two probes to the analog connector and immerse them in the solution you wish to test. ② Press the button to start the measurement and charge the solution with three volts of electricity from one probe. ③ The analog voltage picked up by the other probe will be converted to a digital value and sent to the PC via USB. ④ These values are then shown on the PC screen.

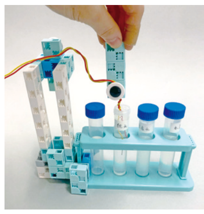
This tester shows lower voltages for higher quality water. This allows us to say that the cleaner water is, the less electricity it conducts.



Block Parts

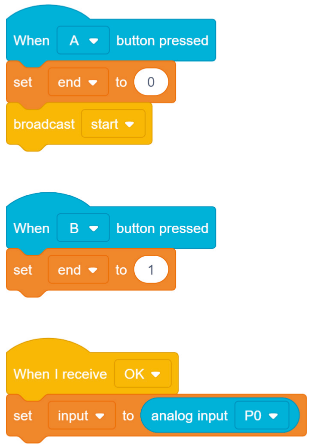


The Completed Tester



Dip the probe into the water to test it.

The Tester Program



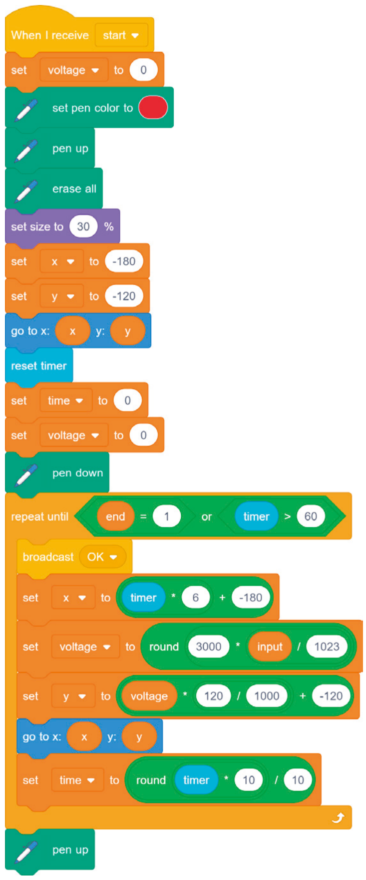
Starting and Stopping Measurement

Our tester uses the buttons on the ArtecRobo 2.0 to start and stop the measurement.

The portion of the program which does this is shown to the left. Pressing the A button on the Core Unit will send the message start to the graphing program shown below and begin taking measurements. You can stop the measurement by pressing the B button.

Our research involved creating a sample program prior to the start of the class and demonstrating to students that the tester operated according to the program.

The Testing Program

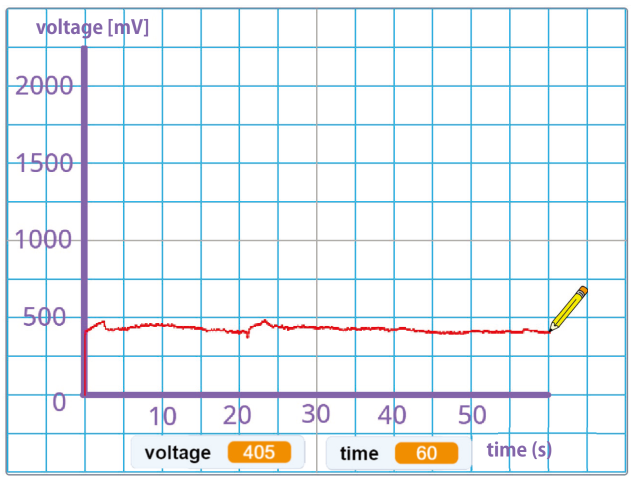


Programming the Readout

Converting Values

The data readout we prepared graphs changes in values over time.

The input measurement is taken from the probe once per second and converted into a voltage reading. The graph plots voltage on the Y-axis, continuing to graph the values for one minute or until you press the B button.



Data Readout

Chapter 2

Designing the Module

(Miyagi University of Education Elementary School)

We used the conductivity sensor in a fourth grade unit on the rivers of Sendai city at Miyagi University of Education elementary school. This unit is covered in lesson 17 of a 50-hour Comprehensive Studies class. The goal of this module is to have students test and compare the water quality of the Umeda river with other sources of water to understand how the river is hospitable to life. The table below shows the lesson flow we used. We focused largely on a demonstration experiment, seeing which results the conductivity sensor gave for tap water, river water, water from the school pond, and miso soup.

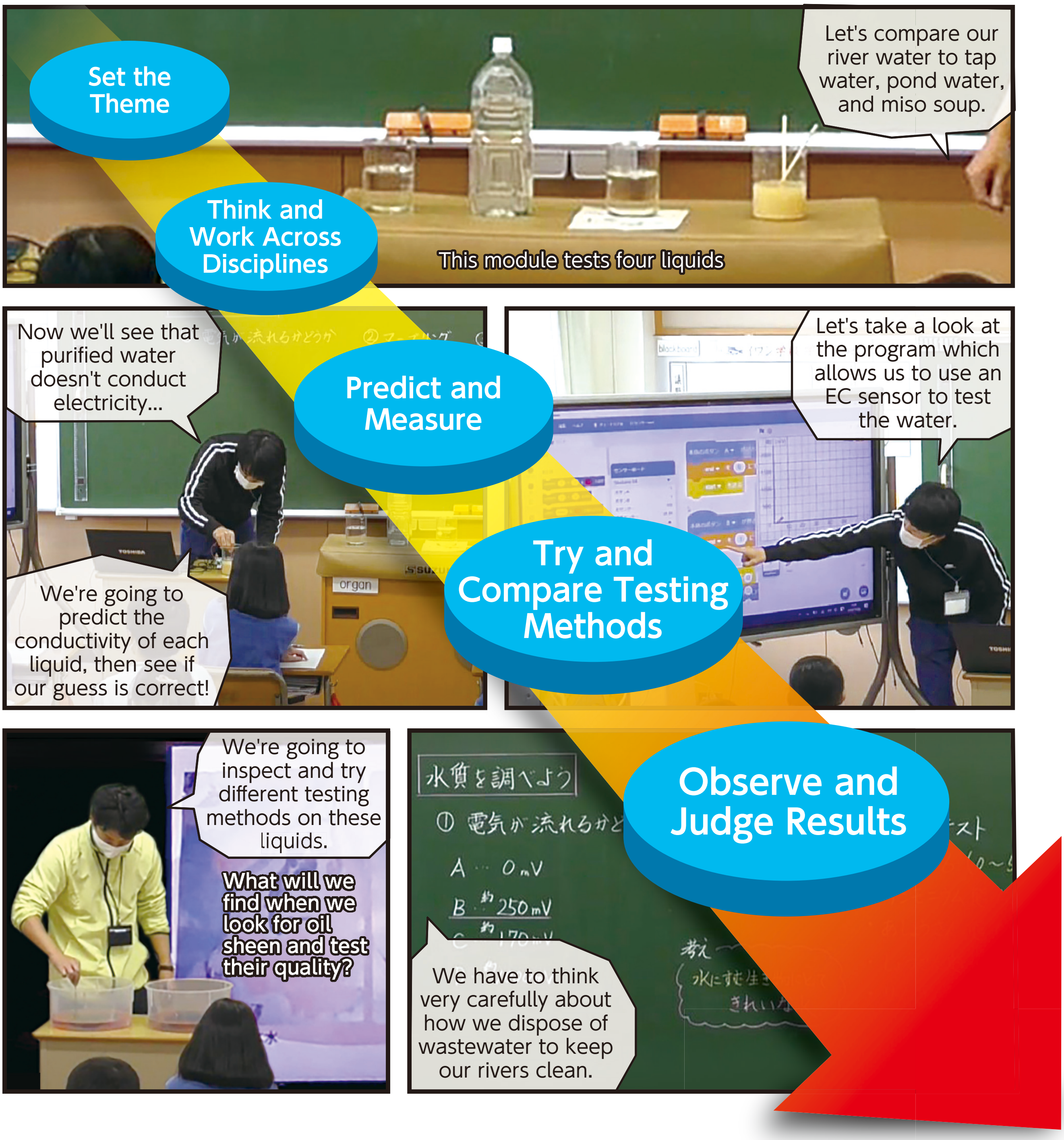
Lesson Flow

Step	Expected Student Respose	Notes (grading criteria are shown with a ★)
1. Review and Prepare	・"We took samples from the river last time, right?" ・"And today we're supposed to test them." What is the quality of the river water?	Have students recall how they collected river water samples before explaining that the challenge in this class is to test the quality of the river water.
2. Discuss the Samples [A] Tap water [B] River water [C] Pond water [D] Miso soup	・"Fish and other animals live in the pond, right?" ・"So if the quality of the river water is the same as the pond water, that means things can probably live in it." ・"We do throw soup away, don't we?" ・"I see. Flushing soup into the river isn't very good for it."	★ Comparing life-friendly pond water with products that are thrown into sewage systems like miso soup gives students an opportunity to think about whether river water is similarly life-friendly as well as the effects that wastewater has on our rivers.
3. Experiment and Think **[Evaluate Appearance]** Observe the visual aspects of the water like color and clarity. **[Test Quality]** Use a reagent test kit to check and compare the quality of each liquid. **[Marbling Test]** Drip liquids onto a piece of paper to investigate and compare how each one spreads. **[Check Conductivity]** Apply electric current to the liquids to check and compare the level of organic matter in each one.	[Evaluate Appearance] ・"Tap water is clear and has no color." ・"There's not much difference between the river and the pond water." ・"You can tell the miso soup is different just by looking at it." [Test Quality] ・"The river water is almost the same color as the pond water. That must mean they're both comfortable for living things." ・"We can't check the miso soup since it already has its own color." [Marbling Test] "The tap water must have spread so easily because there's not that much extra stuff inside of it." ・"The river and pond water spread pretty much the same way, and they're both pretty clear." [Check Conductivity] ・"The tap water doesn't conduct electricity. That means there isn't anything which conducts electricity in it." ・"We got 240 mV for the river water and 170 mV for the pond water which is pretty close. They must be similar in quality." ・"The miso soup is 1,000 which is almost four times higher than the river water. It has a lot of stuff that conducts electricity." ・"Comparing them this way makes it really easy to compare different liquids under the same conditions."	Have students take notes on what they've learned from the results of their experiments. As students test for conductivity, start by reviewing what they learned about electrical pathways in science class and how purified water will not conduct electricity until you add metallic substances to it. During the experiment, point out to students that using their ArtecRobo conductivity sensor combined with a Scratch program allows them to measure objective data. You should also note that the process of graphing results with voltage on the horizontal axis and time on the vertical axis like this is a skill they can use in math class, too. Get students to think across disciplines by relating the content in this module to different subjects. ★ Check whether students have understood that the similarity between the river and the pond water is an indicator that the river is also hospitable to life by having them think, judge, and express out loud or on paper.
4. Review the Content	・"The quality of water from the Umeda river was pretty close to the water from our pond, but I think flushing contaminated water like soup into the river would make the quality worse." ・"We have to do some serious thinking about the way we live in order to protect the river."	As students see for themselves that the quality of river water helps to support life, stress the importance of protecting rivers through rethinking how we live our lives, including how we dispose of wastewater.

The Module in Action

(Miyagi University of Education Elementary School)

This module involved a demonstration experiment on an electronic blackboard where we tested samples of tap water, water from the school pond, miso soup, and samples of river water collected by students.



Chapter 2

Designing the Module

(Miyagi University of Education Junior High School)

The goal of this module is to gather and investigate the electric conductivity values of aqueous solutions to find the difference between solutions which conduct electrical current and those which don't. Students took the lead in this experiment, creating their own experiment plan and breaking into groups to measure the conductivity of the solutions using a conductivity sensor.

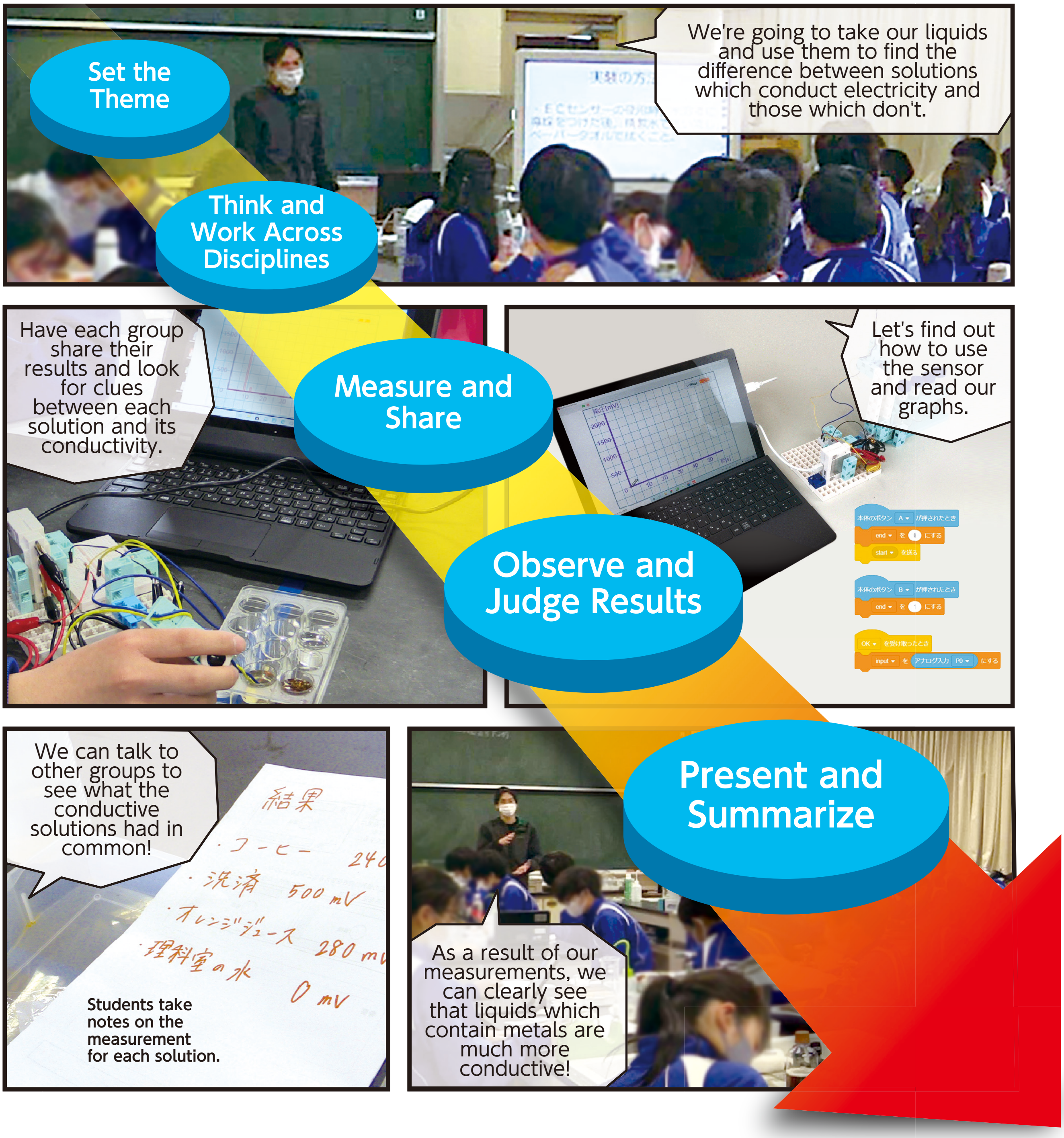
Lesson Flow

For Instructors	For Students	Tips
1. Review the Task	Understand the task. What makes solutions which conduct electricity different?	Introduce each group's hypothesis from the last class.
2. Review the Test Process	Use your testing plan from the last class as you discuss how to use and the role of your device with group members.	Question students to confirm that they know how to use their computer and read the graphs of their results.
3. Measure	Measure the conductivity of students' water samples.	Advise students to use the back of their experiment plan to take notes on their measurements and findings.
4. Share the Results	Allow students to get out of their seats and to observe the measurements and exchange information with other groups.	This should include sharing helpful information in addition to taking notes.
5. Observe	Investigate the difference between conductive and non-conductive solutions using the results of your and other groups.	Students should also feel free to use the Internet to research this. Evaluating Performance Use oral reports or written materials to evaluate whether students investigated the difference between solutions.
6. Review	Listen to the instructor's explanation.	Explain that dissolving substances which contain metal atoms in a solution will make that solution more conductive, giving it a higher value when you measure it with the sensor.
7. Written Review	Write a review of what you learned.	This includes questions, feelings, results, and impressions.

The Module in Action

(Miyagi University of Education Junior High School)

This module had students form groups of four and use a conductivity sensor to test the solutions they gathered to investigate what makes them different.



Post-Module Survey and Observations

In order to evaluate the efficacy of the equipment in both an elementary and junior high school environment, we had students write a free report regarding their understanding of the material as well as the effectiveness of the experimental equipment. After analyzing these reports to create the charts below, we saw that, despite being used in comprehensive studies in elementary school and science classes in junior high school, students were conducting richer inquiries relevant to each subject. We also believe that using digital measurement to get different results in numerical values which can then be compared is a great contributor to deeper learning.

[Q1] What did you learn from graphing sensor values?

Elementary

- When I first saw the Umeda river I thought it was really dirty. I was surprised when I used the tester and saw that it was clean because it got almost the same number as the tap water. The value of the soup was a lot higher than I thought it would be.
- Water becomes more conductive when something is in it. Regular water doesn't really conduct electricity at all.

Junior High

- It was a new kind of feeling turning the state of a solution into numbers and graphs. Turning something you just look at into concrete numbers you can visualize with a graph makes it easy to see its state and how it changes.
- It's a lot more accurate and hand drawn graphs so I can see the right answer. Not having to draw the graph also let me spend more time discussing our hypothesis with my group and think more deeply.

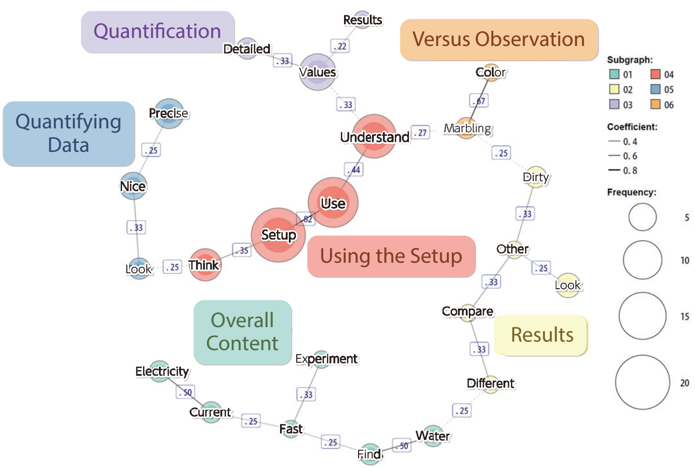
[Q2] How was using a testing setup with a program and sensors?

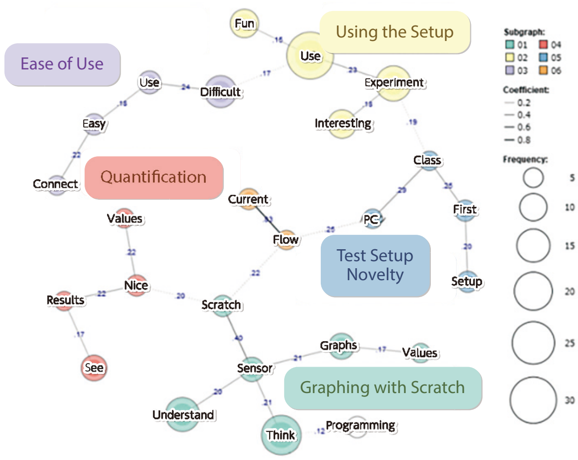
Elementary

- Marbling only tells you whether the color of the solution transfers to paper or not, but I thought using the tester was nice since you could see what would happen.
- Using it made it easy to see changes and differences, and I couldn't have noticed smaller changes without it.

Junior High

- I thought it was really cool that it was programmed. Seeing how it reacted to the sensor and graphed it made me think I want to program like that, too.
- In normal experiments you have to use your eyes to find changes in numbers, and I'm glad we were able to use a computer to see the right numbers. I was also wondering how it works since it's such a complicated machine.





Next, we surveyed students on how relevant what they learned here was to other subjects.

Taking the developmental stage of the fourth graders into account, we asked them to name subjects they thought were related, to which they responded science and math. We asked the junior high schoolers to write a free report on which points they thought tied into other subjects. These points fell under math, technology, social studies, language arts, and science. Junior high school students are at a state where they can see and think from the vantage points of multiple subjects, and our text mining showed us that having teachers actively tie the content into other subjects allows students to combine what they learn across different disciplines.

[Q3] Is what you learned related to other subjects?

Elementary

What subjects was it related to?
Math (4), science (19)
(out of a class of 29 students)

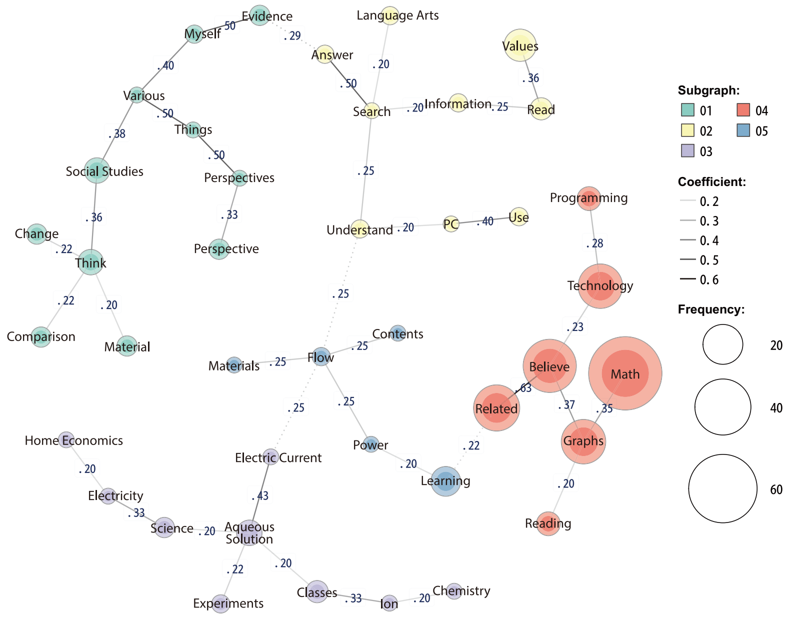
Junior High

[Math] "I thought it was related to math since we had to read the values and line up the solutions in order of conductivity."

[Technology] "We had to use programming."

[Social Studies] "We had to take a guess and then try to find evidence that supported it."
"It's similar to how we learned to think about things based on real life documentation."

[Language Arts] "Figuring out a way to find answers and clues for the question."
"Comparing and contrasting the information you know."
"Logical thinking like in language arts."



Final Thoughts

Professor Akinobu Ando, Miyagi University of Education

Using the STEAM learning materials we developed for this module to quantify and graph data allowed students to go considerably further in their investigations of the objectives in each class. As a result of considering the relationship of this module to other subjects, we also found that some students who tied the content into non-STEM classes like language arts and social studies, especially in junior high school.

This tells us that progression to the next level of school doesn't necessarily require more advanced materials, but rather guidance made more effective by integrating it with STEAM learning.

On the other hand, teachers should be extra careful not to fall into a shallow understanding that digital measurement is perfectly precise. The lack of IT-focused courses at the elementary level means that it is especially important to position this as a way to develop information literacy.

Citation "A Test Case and Observations on the Academic Efficacy of Using Shared Teaching Materials for STEAM Education in Elementary and Junior High School", Mako Saito and Akinobu Ando (Miyagi University of Education), Yohei Nishikawa and Isao Adachi (Miyagi University of Education Junior High School), Yoshitada Nitta, Tomoki Watabe, and Yasutaka Uesugi (Miyagi University of Education Elementary School), Takeo Miyake and Kentaro Hayakawa (Artec Co., Ltd.), 4th Annual Meeting of the Japan STEM Education Society

EXTRA CREDIT

Solving Social Issues with STEAM
SDGs: A Treasure Trove of Topics

What are SDGs?

The SDGs, or Sustainable Development Goals, were adopted by the United Nations in 2015 as a means of tackling issues around the globe to create a more sustainable society. With 169 targets across 17 goals, the SDGs aim to realize a sustainable world with no one left behind by the year 2030. While its predecessor the Millenium Development Goals focused primarily on developing nations, the SDGs set targets for all countries including developed ones. With environmental challenges on the rise, the SDGs also call not just on governments, but private industry and us as individuals to do our part.

From the United Nations website: https://www.un.org/sustainabledevelopment/

SDGs through a STEAM Lens

Viewing the global challenges targeted by the SDGs through the perspective of STEAM education makes them easier for students to grasp, and taking a look at complex issues like the energy crisis and climate change through this cross-disciplinary lens allows us to consider them more deeply and motivates us to do what we can for our planet's future.

In March of 2021, Japan's Ministry of Economy, Trade, and Industry published the first version of the STEAM Library[★6], a digital STEAM learning library open to the public completely free of charge. Developed by a collection of 24 universities, research institutes, and educational companies, the STEAM Library offers videos and materials across 63 topics tied directly to the 17 SDGs with a focus on integrated, cross-disciplinary social issues unbound by traditional learning frameworks as well as those encountered by students in their daily lives. The curriculum guidelines and teaching plans included with each piece of content makes them easy to integrate in classes, making them a rich source of information when it comes to expanding the scope of STEAM learning. You'll also find that this book also uses icons which indicate the SDG relevant to the chapter.

★ 6 STEAM Library homepage (https://www.steam-library.go.jp/), METI (2021)

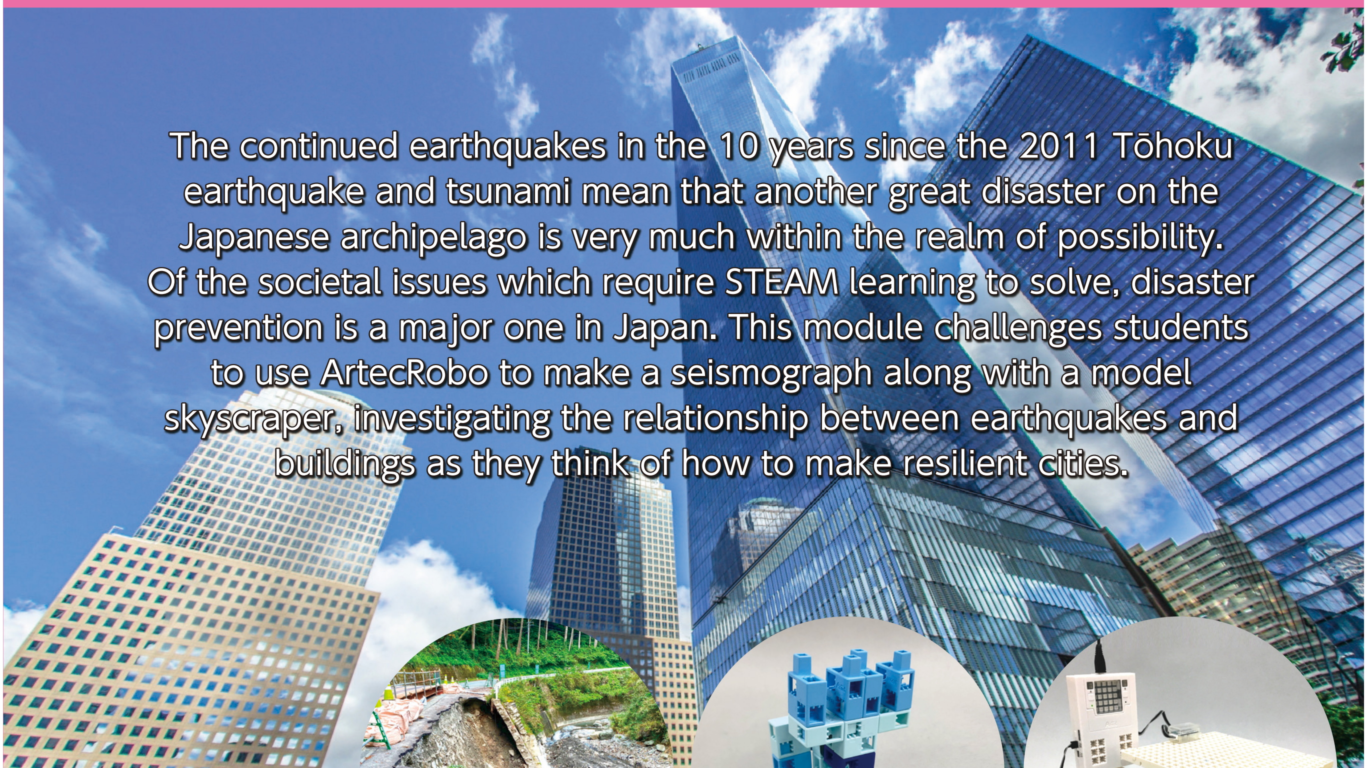
Chapter 3

Shake Resistant Skyscrapers

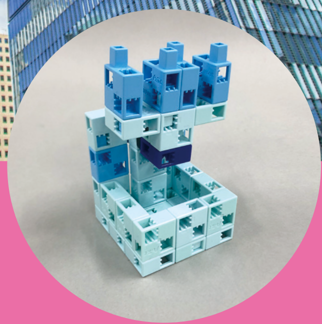
The Ever-Changing Earth
(Elementary Science)

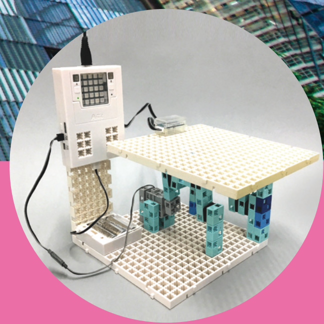
Also compatible with elementary general studies and junior high science classes

STEAM Bits Case 1



The continued earthquakes in the 10 years since the 2011 Tōhoku earthquake and tsunami mean that another great disaster on the Japanese archipelago is very much within the realm of possibility. Of the societal issues which require STEAM learning to solve, disaster prevention is a major one in Japan. This module challenges students to use ArtecRobo to make a seismograph along with a model skyscraper, investigating the relationship between earthquakes and buildings as they think of how to make resilient cities.





Overview

Elementary and junior high school guidelines include quite a bit about disaster prevention regardless of grade level or subject, and this is especially true for social studies and science classes.

Social studies classes ask that elementary students learn how society works to keep people safe from accidents and disasters as well as the role local organizations and Japan's government plays when disasters occur, while classes in junior high schools require students to understand how important prevention measures are in a comparatively disaster-prone country like Japan. Science curricula state that elementary schoolers should study changes in the landscape due to earthquakes, while junior high students use earthquake records and their own experience with earthquakes to discover that there is a regularity to the size and movement of tremors. This is in addition to researching nature, grasping its positives and negatives in a multifaceted and comprehensive way to investigate the relationship between the human and the natural world.

These guidelines ask students to learn about disasters from multiple angles in every subject, including everything from first aid and injury prevention in health and physical education to creating comfortable living spaces in technology and home economics★[7].

This module gives students a STEAM challenge of building an earthquake-resistant building in an elementary school science unit on the ever-changing Earth. In order to explore this issue we used ArtecRobo 2.0 as a seismograph, built a block skyscraper on top of it, and used an accelerometer attached to the skyscraper to turn the shaking into digital values. We then made the building more earthquake resistant by using a pendulum and weight to make a tuned mass damper just like those used in real world buildings. Along with using computers and thinking about how the content here relates to other subjects, we guided students in discussing how to prepare for and protect life during disasters from the perspective of disaster prevention education.

Thoughts on Teaching

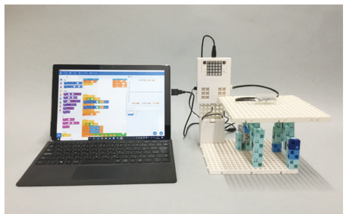
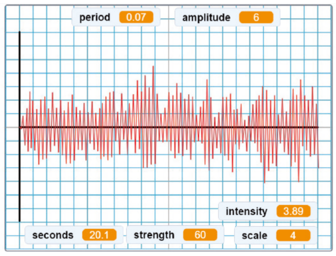
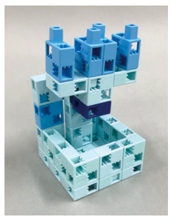
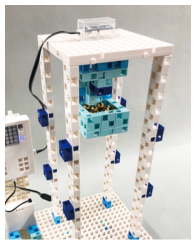
Naoya Kuriki
Instructor
Nakayama Elementary School, Sendai

Our school focuses on developing students' information literacy by using Chromebooks in various subjects and activities, and this module gives children an opportunity to demonstrate their literacy by solving problems on their own.

As students used ArtecRobo to see for themselves how earthquakes shake builds, I felt signs of deeper learning. This included students thinking about how science works in the world around us and experiencing the fun of finding the solution to a problem. Especially in an age where every child has their own device, I believe that children found the value in experimenting and thinking for themselves rather than thinking you can find all of the answers on the Internet. It was also quite impressive seeing children enthusiastically calling on things they've studied elsewhere as we tied the content here into other subjects.

★ 7 (1) "In-School Disaster Prevention Education, 1. Disaster Prevention Education in Curriculum Guidelines, Attachment 1: Disaster Education Prevention in Curriculum Guidelines (Elementary School)"

Making it STEAM

STEAM Element	Description
① Set the Theme	[Elementary] Earthquakes and natural disasters (science) [Junior High] Volcanoes and earthquakes, humans and nature (science), nature in Japan (social studies), disaster prevention and earthquakes (general studies) **Aligned to** SDGs 11 SUSTAINABLE CITIES AND COMMUNITIES
② Apply ICT	◎ PC or Tablet ArtecRobo 2.0 Servomotor Accelerometer ◎ Developing Information Literacy (Sendai Goals in Learning Information Literacy)★8 [A1] Record and Edit [B1] Select [B8] Evaluate and Improve [C2] Classify Data [C6] Finding Trends 
③ Mix Disciplines	**Science** Earthquakes and seismic intensity, pendulums and vibration **Technology** Use computers, programming, and digital measurements **Engineering** Build an earthquake-resistant skyscraper **Math** Read graphs, gather and analyze data  **Arts** Make a skyscraper and use units from social studies natural disasters around the world and protecting life from disasters
④ Get Creative	◎ Build a seismograph ◎ Create a model skyscraper and adjust the position of the pendulum ◎ Change the shape and size of the skyscraper if class time allows 
⑤ Reiterate	◎ Inspire interest in how the content relates to science and social studies and motivate further learning

Chapter 3

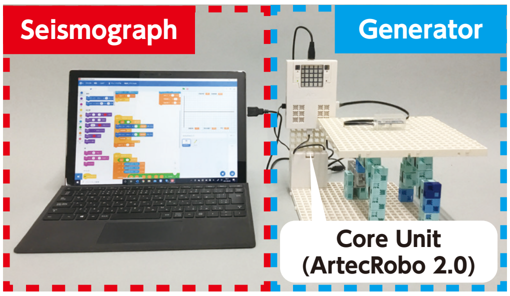
★ 8 "Sendai Goals for Learning Information Literacy", Sendai City Education Center

Designing the Materials

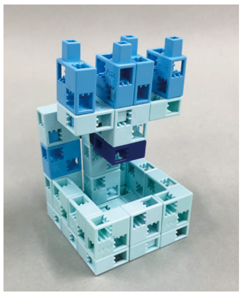
The Design

In keeping with the new curriculum guidelines, we used ArtecRobo 2.0 as an educational programming tool to make a seismograph which can measure tremors. This seismograph is composed of three main parts:

① A load generator which uses a Servomotor to simulate constant tremors
② A seismograph which shows Accelerometer values in a computer graph
③ A tuned mass damper like those used in real skyscrapers



① The load generator and ② seismograph

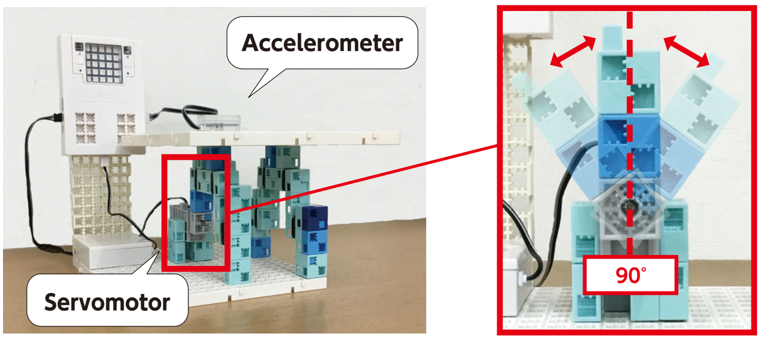


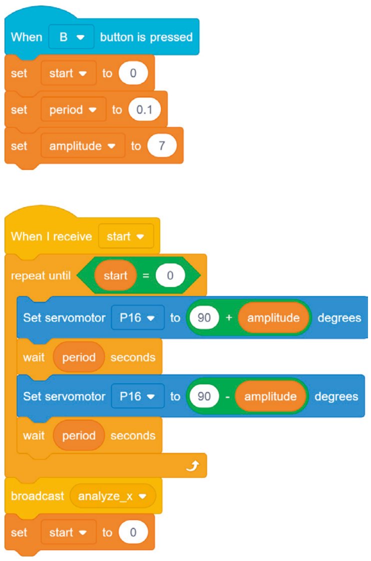
③ Tuned mass damper made from Artec Blocks

The Load Generator

This generator uses an ArtecRobo 2.0 Servomotor to produce regular movement, simulating an earthquake. You can start or stop these tremors simply by pressing the buttons on the ArtecRobo 2.0 Core Unit.

As shown below, the Servomotor turns regularly from side to side, shaking the plate horizontally to generate tremors.





Programming the Load Generator

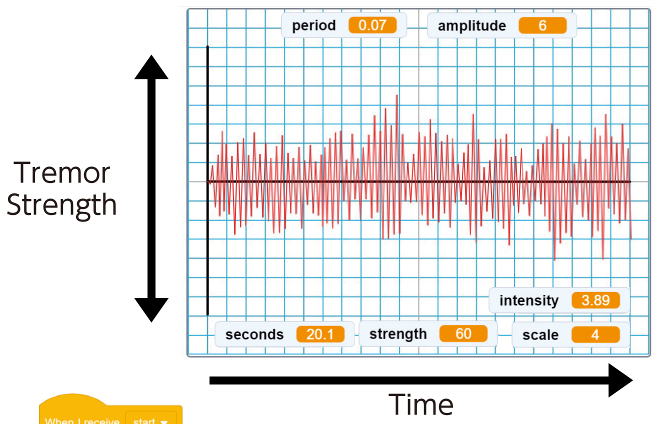
The Servomotor is programmed to start at a default position of 90 degrees and rotate to generate tremors. You can also easily adjust the settings for these tremors, customizing both their frequency and magnitude to match the parameters of your experiment.

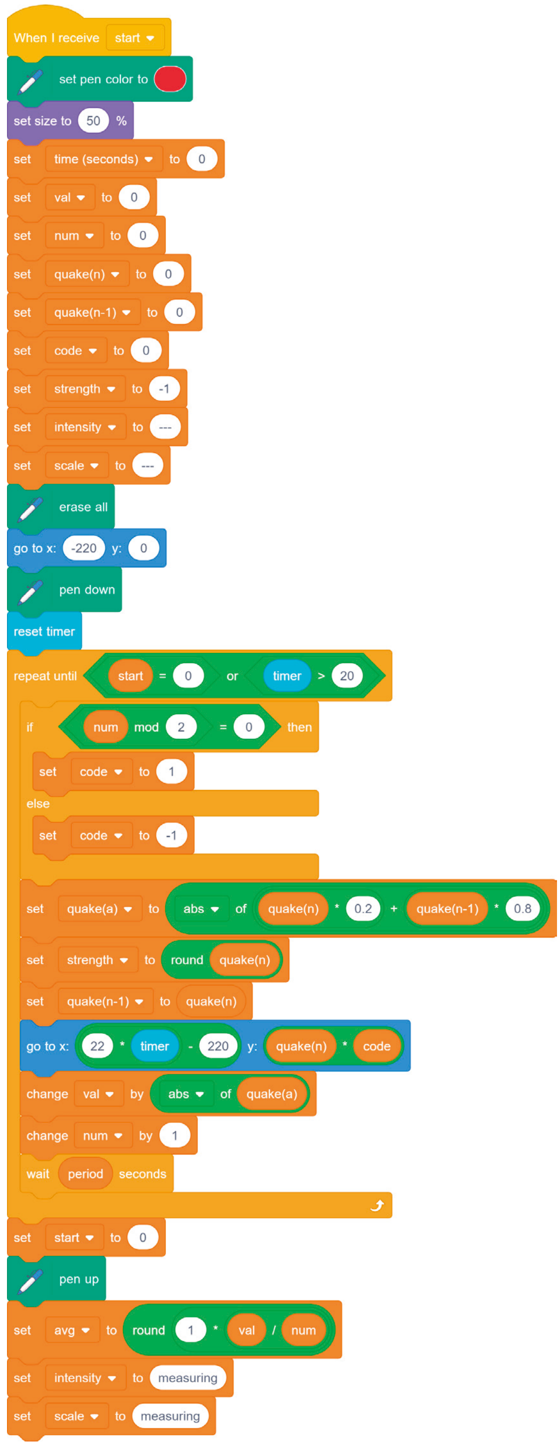
Programming the Seismograph

This seismograph takes the Accelerometer's initial values at the start of the recording, then gathers data on how much these values change along each of the three axes. It then uses this data to gauge the intensity of the earthquake using the Japan Meteorological Agency Seismic Intensity Scale

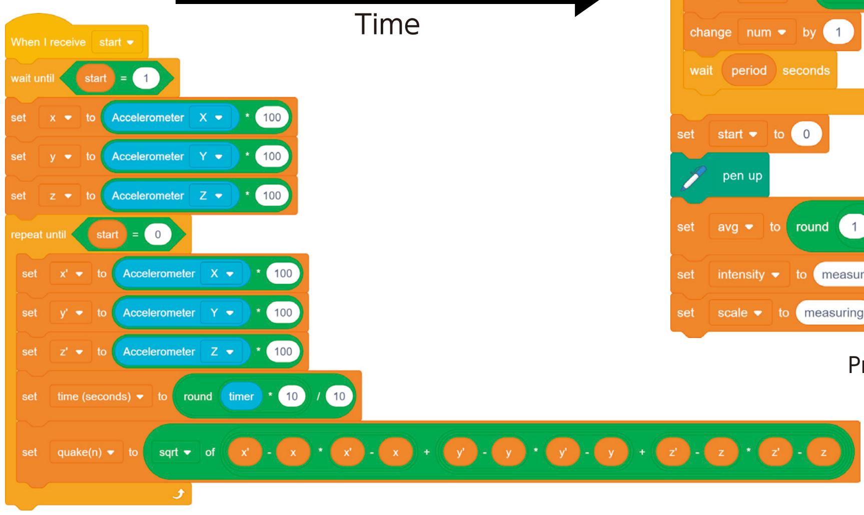
The Data Readout

Using an Accelerator plugged in the Core Unit, this seismograph graphs the acceleration along the x, y, and z axes caused by the earthquake. The top of the graph shows the settings for the tremors, while the bottom shows the elapsed time and strength of the tremors. It also shows the seismic intensity and scale based on 20 seconds of data.





Programming the Graph

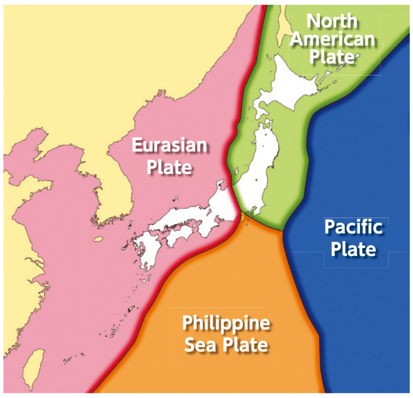


Measuring Tremors

Chapter 3

Earthquake-Resistant Buildings

The Japanese archipelago straddles four tectonic plates: the North American Plate, the Eurasian Plate, the Pacific Plate, and the Philippine Sea Plate. This makes the country extremely prone to earthquakes and has led to no small number of major disasters. A prime example would be the Great Hanshin earthquake, a disaster which destroyed 105,000 homes, damaged 144,000 more, and was the catalyst for a review of the country's earthquake resistance standards. Conversely, Japan's cities are home to multiple skyscrapers known to be greatly affected by earthquakes. This module teaches children about the load generators and tuned mass dampers used to protect these buildings.

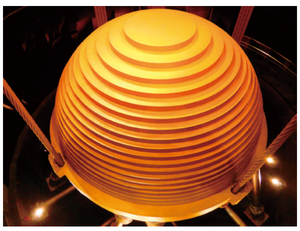


What are Tuned Mass Dampers?

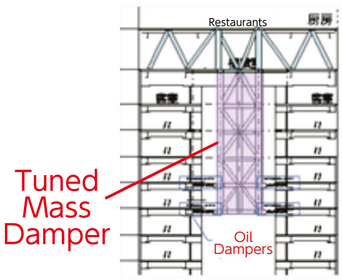
These materials allow you to check how effective your tuned mass damper is by using the load generator along with the data generated by the seismograph. While the upper floors of a skyscraper will sway quite a bit in the wind or during an earthquake, you can keep this movement in check by giving the building a tuned mass damper. Skyscrapers like Taipei 101 or Burj Khalifa are great examples of buildings which use these devices, though they each work in different ways.

Dampers come in different shapes and can be installed in a variety of ways, but this module focuses on a suspended damper which hangs from the inside of a building. Suspended tuned mass dampers are used both in Abeno Harukas, Japan's tallest building, as well as in Taipei 101, the world's second tallest building located in Taiwan. When a building sways in the wind or shakes in an earthquake, tuned mass dampers shake in response to settle the building down. This module has students explore and learn about this mechanism by making a model damper of their own.

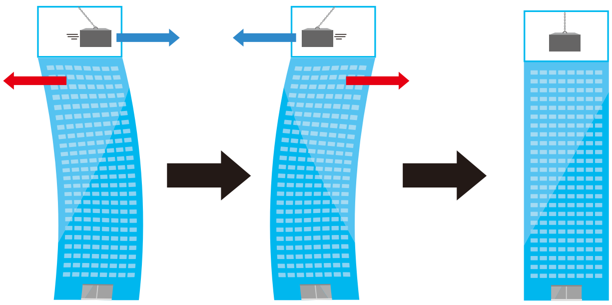
Taipei 101



Abeno Harukas

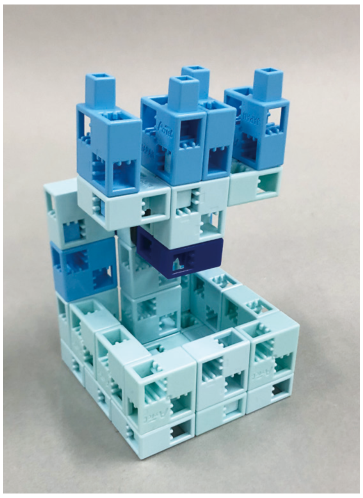


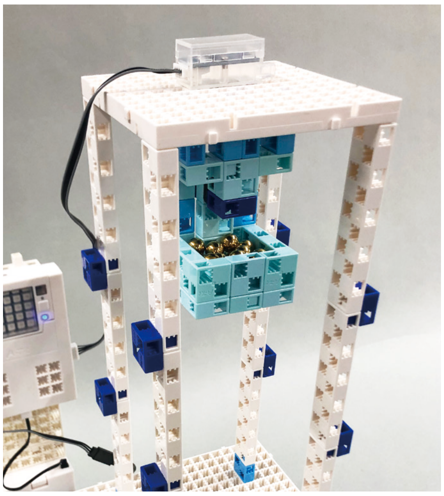
Suspended tuned mass dampers use hanging weights



Modeling a Damper

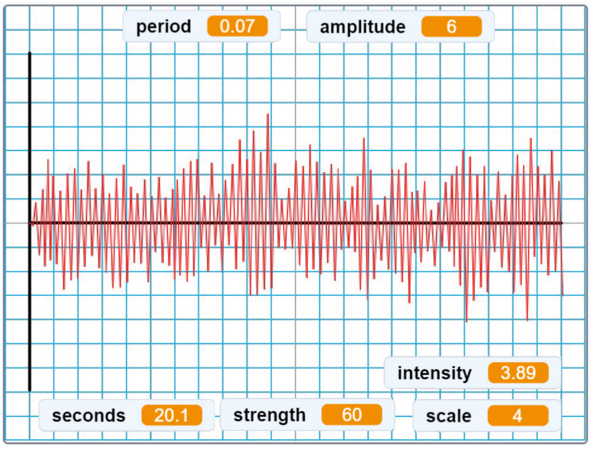
This model damper in this module is a pendulum made from Artec Blocks which uses ball bearings as a weight to help keep the building from shaking too much. As shown in the picture to the right, this damper can be easily hung from the roof of the building to test how much the building shakes with and without it. Changing the number of ball bearings inside of the damper also allows you to investigate how the weight of the damper affects how much the building shakes.



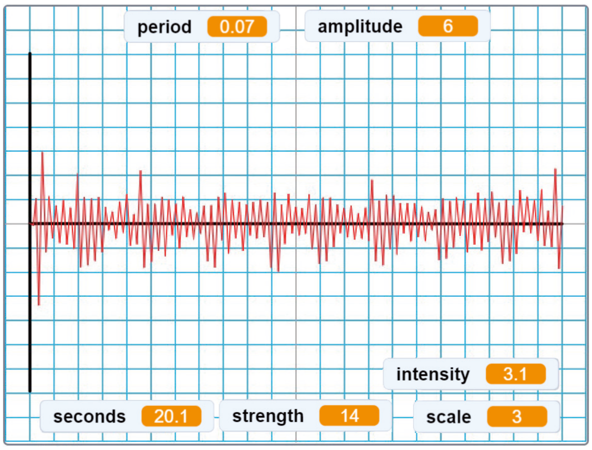


Below you'll find the results from one of our experiments on earthquake resistance. These results clearly show that the building shook less with the damper installed. Rather than working the same way every time, the effectiveness of a damper can be greatly affected by the number of weights that it has, the length and swing of the pendulum, and even the height of the building itself. This makes it possible to adjust challenges to more closely align with real world issues. This includes finding how a building's height affects the way it shakes or how effective a single damper is with earthquakes of different magnitudes.

Normal Earthquake



Earthquake with a Tuned Mass Damper



Designing the Module (Nakayama Elementary School, Sendai)

This module teaches students how to use the pendulums they studied in science class to keep buildings from shaking, then use the values from their seismograph to find an optimal weight and length for the device.

Guidelines

Learning Goals	① Build an earthquake-resistant skyscraper by using a pendulum to reduce shaking and analyzing data to find characteristics and trends, solving the challenge by using your own knowledge and life experiences. ② Learn about the tuned mass dampers which are used to control shaking, sharing results and observations with classmates to broaden your own understanding and applying what you've learned here to other classes as well as your personal life.
Relevant Information Literacy	[A1] Record and Edit: Record and edit photographs, pictures, and sound. [B1] Select: Select and explain your rationale. [B8] Evaluate and Improve: Evaluate your work and use it to improve your next challenge. [C2] Classify Data: Classify data from specific perspectives. [C6] Finding Trends: Find and explain changes in data.
Assumed Information Literacy	◎ Use of computer basics such as starting up and shutting down a computer, typing, and creating graphs. ◎ Finding connections between data and adopting fresh perspectives when considering problems. ◎ Respecting the value in your own and others' information. ◎ Applying your knowledge of computers and what you've learned here in your daily life and future studies.
Module Goals	① Look at volcanoes and earthquake hotspots in Japan and across the world as you think of problems related to earthquakes and volcanic eruptions. ② Investigate and present changes to the earth as a result of earthquakes and volcanic eruptions before tying these changes into the bigger picture. ③ Investigate and think about disaster preparedness as it relates to earthquakes and volcanic eruptions. ④ Think and discuss methods you can use to keep life safe from natural disasters. ⑤ Module: Build an earthquake-resistant skyscraper by testing anti-earthquake devices and analyzing data to find characteristics and trends, solving the challenge by using your own knowledge and life experiences.

Lesson Flow

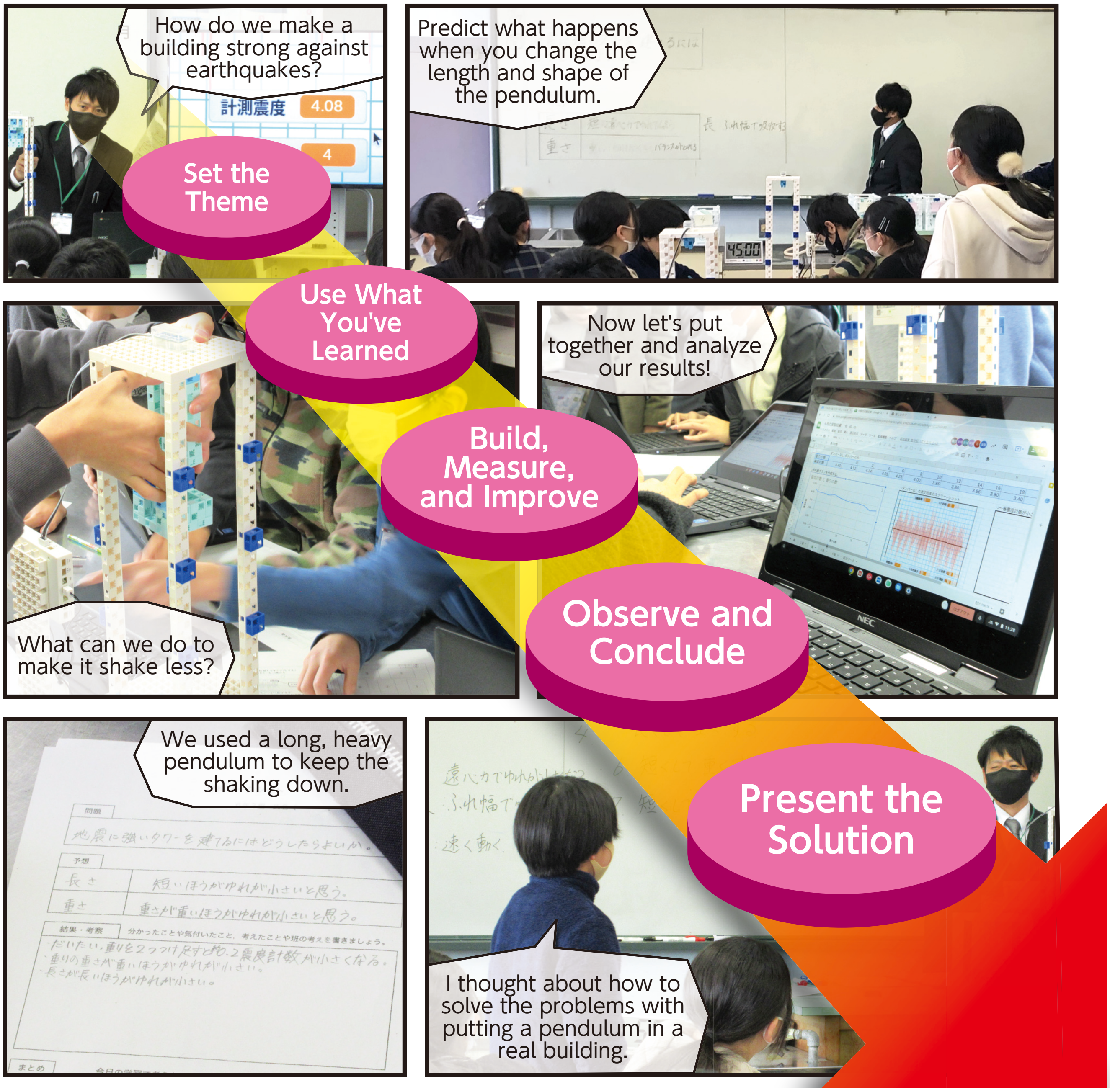
Step	Expected Student Response	Notes
[1] Review previous science lessons.	◎ What kind of earthquake countermeasures do you think the statue of Kannon has? ・“Strong, sturdy pillars.” ・“A reinforced structure.” ・“They modified it to make it earthquake resistant.” ・“It has rebar inside of it.”	This module ties in the frequency of earthquakes during this season to the reason why the Goddess of Mercy Kannon is the symbol of Nakayama Prefecture as a means to get students to think about what earthquake countermeasures her statue uses.
[2] Demonstrate the experiment in front of the class to show the task.	◎ What do you think is causing the tremors' values to go down? ・“Swaying like a pendulum makes the building shake less.” ・“The building is heavier now.”	Point out to students that this draws not only on lessons from this year, but lessons from previous years as well. When it's time to start the experiment, explain that the testing setup here uses a block programming environment which they may already be familiar with. Combining an ArtecRobo Accelerometer with a program and other elements will allow them to get data on the intensity of an earthquake using the same seismic intensity measurement methods as the Japan Meteorological Agency.
[3] Grasp the challenge at hand.	How do you keep a skyscraper from shaking too much?	
[4] Make predictions.	◎ Focus on the length and weight of the pendulum as you predict how each one affects the building's movement. ・“Make the pendulum longer.” ・“Add more weight.”	

[5] Experiment to find what you need to do to make an earthquake-resistant skyscraper. ① Form groups. ② Each group has a pendulum of a different length. Add weight to it to see how it affects the intensity. ③ Put your results into a spreadsheet. ④ Use measured values to create and organize graphs of seismic intensity. ⑤ Return to your group. ⑥ Introduce the results of your experiment and discuss and commonalities, features, and trends you find. ⑦ Work as a group to find and present solutions to the challenge. ⑧ Find problems with the conditions as well as ways to solve them. ⑨ Present the full picture.	◎ Organize the results of your experiment and look for characteristics and trends in your graph. ・“The more weight there is, the less it shakes.” ・“The building shakes less when the pendulum is longer.” ◎ Use the results of your experiment to find clear reasons why a building can be earthquake resistant. ・“The low measured intensity here means that the optimal damper is a long one with 14 weights.” ・”I think it's better to use more weight with a longer pendulum.” ◎ Search for potential issues when applying these optimal conditions in the real world and explain your reasoning. ・“The damper might affect the walls and other parts of the building if it's too heavy.” ・“The damper might hit the walls of the building.” ◎ Use what you've learned as you think about potential solutions to these issues. ・“You could reinforce the walls.” ・“We could use two pendulums.” ・“The pendulum's length could be changed.”	Create a spreadsheet to record and compare the intensity of the tremors without the damper with the smallest possible values when using the damper. Have students put their conclusions from their results into a worksheet. Putting the results into a line graph and searching for features and trends also allows students to use the skills in forming conclusions from features in data that they picked up in math class. Have students consider whether their results can work when building skyscrapers in the real world before pointing out potential drawbacks. They should then review their data and what they've learned so far as they try to think of realistic conditions, finding clear reasons and explaining them in their own words.
[6] Learn that this experiment is used in the real world.	・“We could try using multiple pendulums.” ・“Maybe we can program the pendulum to not hit anything.”	Introduce Taipei 101 as an example of a skyscraper with a tuned mass damper. Show them a video of this building's damper as you explain that the damper is controlled by a computer program.
[7] Put your thoughts and observations together.	・“When you do things in the real world you have to account for things you didn't test for.” ・“I learned that besides reinforcing buildings, you can use the pendulums from science class to keep them from shaking.”	Have students use the worksheet to write down their thoughts, then offer your class a range of perspectives by calling on students to share theirs.
[8] Look back on what you learned here and think of how you can use it in other classes and situations.	◎ Ask students if they found themselves thinking of their studies in other classes as they worked here, then see if there's anything they wish to explore further or try in a different situation. ・“I learned that there are useful things in the world which use mathematical graphs and programming.” ・”I want to find out what kind of anti-earthquake measures the Kannon statue uses.”	Aside from the pendulums that students used in science class, have them think about connections this module has to other classes and find interest in the innovations humanity uses to coexist with nature. This activity is also an opportunity to stimulate students' interest and curiosity in the things that are common in daily life.
Evaluation	① Think, Judge, and Express: In their attempts to use a pendulum for earthquake resistance, the student uses features and trends in their data to find the necessary conditions and potential issues, using their own knowledge and life experiences to propose and present a well-grounded solution in a written and oral format. ② Proactive Participation: The student shows persistence in testing their pendulum as an earthquake countermeasure, basing their conclusion on results and discussing with classmates to broaden their own perspective and proactively solve the issue in addition to making use of their studies in multiple subjects and their own life experiences.	

The Module in Action
(Nakayama Elementary School, Sendai)

This module had students work in groups to predict what would happen when they made changes to their pendulum, then perform the experiment as a team to see how the weight of the pendulum affected how much the building shook.

Scenes from the Module



Student Impressions

[Q1] Do you feel your work here was connected to other subjects?

- We learned about earthquakes and the damage they do in science class, but this was my first time learning about how we can control that damage.
- Aside from science, I thought about language arts and design. For language arts, it was our unit on language for community development. For design, it was our unit on building structure.
- There was a lot of science since we used so much of what we learned in our class on pendulums, but it's thanks to people like designers who can make things from scratch that we have these anti-earthquake measures, which made me think of what I learned in social studies.
- It used graphs and other stuff from my math class so I thought it was similar. I learned that graphs can be pretty useful for stuff like this.

[Q2] Is there anything you'd like to learn more about?

- I'd like to look up other earthquake-resistant buildings and how they resist earthquakes.
- I'd like to research the best way to make something like a damper in smaller spaces like a house.
- I'd like to learn about how other famous buildings in Miyagi prefecture are made to be earthquake resistant.
- I want to find out more about countries with lots of earthquakes and countries where big earthquakes happen.

[Q3] What did you think of the class?

- It was nice trying out new stuff and doing graphs which you normally don't get a chance to do.
- It was a lot more fun than a normal class because it used programming and robots. It was nice talking to my group to make it more efficient. We also used teamwork during the experiment by discussing things like whether the building was shaking more or less than before.
- I was surprised that you can use programming to figure out how to make a building strong against earthquakes. I never knew you could use a pendulum to control shaking.
- We're going to continue to be members of society, so if we can take this to other grades I think that, even if it's not a complex program like the one here, we can make use of it when we start working in the future.

Final Thoughts

Professor Akinobu Ando, Miyagi University of Education

While we can use rigid frames, trusses, and other structures to make a structure more shake-resistant, this module teaches children another technique used to reduce shaking. In addition to seeing and sensing the tremor, introducing digital measurement allowed students to quantify the size of it and use the Japan Meteorological Agency's method of calculating the intensity of an earthquake to relate it to the earthquakes they feel in real life.

Seeing students who had been unaware that their studies on pendulums could be applied to preventing buildings from shaking enthusiastically diving into the experiment left quite an impression.

While the experiment in Mr. Kuriki's class combines both length and weight, this experiment can be reworked according to the children and learning goal to explore the relationship between height and weight or even changes in weight alone.

EXTRA CREDIT

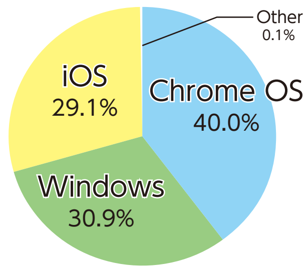
GIGA School: No OS Left Behind

Bringing STEAM Learning to GIGA School Devices

The new school curriculum guidelines implemented in the year 2020 named information literacy as an ability which sets the foundation for all literacy in addition to setting out how to develop that literacy. In response, MEXT developed the GIGA School Program in 2019. This program aims to provide a device for every student as well as a high speed network to every elementary, junior high, and special needs school in Japan. Despite a planned five year deployment ending in 2023, the critical need for an online learning environment in the face of the COVID-19 pandemic led to a rapid introduction of devices. According to a MEXT survey conducted at the end of July 2021, a total of 9,459,698 devices have been shipped so far, with 96.2% of public elementary and 96.5% of junior high schools using devices in at least some if not all grade levels. The upcoming adoption in every subject of ICT in cross-disciplinary frameworks like STEAM and the full adoption of digital textbooks in 2024 is expected to give students an even wider range of things to do with their devices.

GIGA Devices by OS

OS by Shipped Unit



Created based on "Fact-Finding Survey on Device Usage as of July 2021 (confirmed numbers)", MEXT (2021)

As of July 3, 2021 Chrome OS, Windows, and iOS hold roughly the same share of the devices which have been introduced to schools. While these operating systems have different functions and support different applications, these we see an ever-increasing number of cloud-based and multi-platform teaching materials which cater to every device. In addition to Chrome OS, Windows, and iOS which are recommended for GIGA Devices by MEXT, the ArtecRobo platform used in this casebook supports a wide range of operating environments. This is especially true for ArtecRobo 2.0, which comes with wireless Bluetooth support. See the table below to find out which environments are supported:

OS	ArtecRobo		ArtecRobo 2.0	
	Wired (USB)	Wireless (Bluetooth)	Wired (USB)	Wireless (Bluetooth)
Windows (XP or later)	○	-	○	○ (web app)
Chrome OS / Chromebook	○	-	○	○ (web app)
iOS / iPad OS	-	○	-	○
Android (5.0 or later)	-	○	-	○
Mac OS X (10.6 to 10.13)	○	-	○	○ (web app)
Raspberry Pi OS	○	-	-	-

▷ Learn more about ArtecRobo in chapter 4!

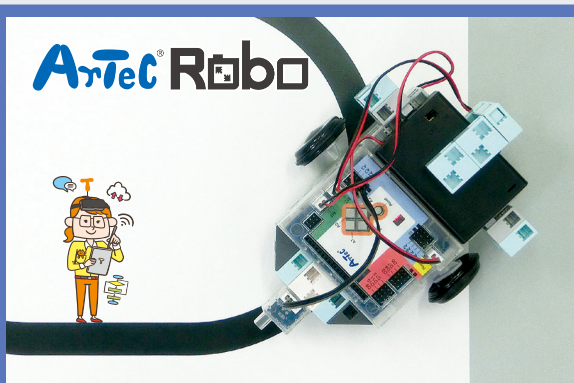
Source ・"Fact-Finding Survey on Device Usage as of July 2021 (confirmed numbers)", MEXT (2021)
・"The Path to GIGA School: Standards", MEXT (2021)

Chapter 4

More STEAM Bits

A collection of lessons in digital measurement and programming using Artec Logger and ArtecRobo

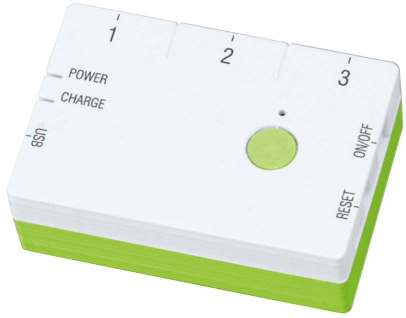
Artec's STEAM learning tools are the optimal way to teach STEAM and exploratory learning, cultivating students' skill in using information, solving problems, and more. Our tools support children to experiment, observe, plan and execute ideas, create through trial and error, and put their results together using a wealth of features and parts, including blocks. In this chapter, you'll find a wealth of ideas for STEAM lesson plans using the Artec Logger and ArtecRobo.



Observations Made Easier

The Artec Logger is a digital measurement tool which lets you collect data for your experiments and observations simply by connecting sensors.

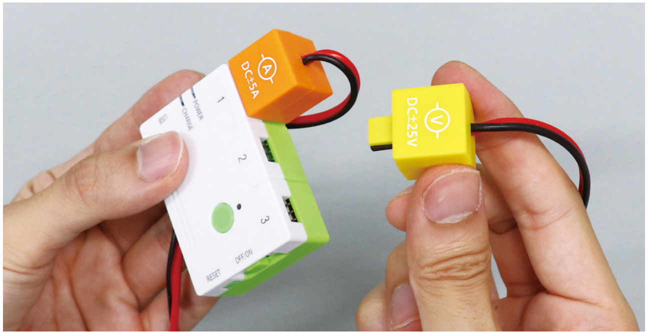
Pairing it with a PC or other device allows you to graph and visualize your data for use in a variety of situations, including general or inquiry-based classes. When in comes to using the Artec Logger for STEAM learning, you can find a wealth of ideas starting on the next page.



Find out more details on page 68!

Choose Your Sensor

Every sensor uses a simple plug and play design, allowing you to use up to three according to your needs.



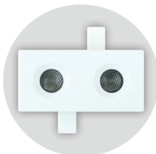
Climate

Current

Voltage

Water Temp

Oxygen



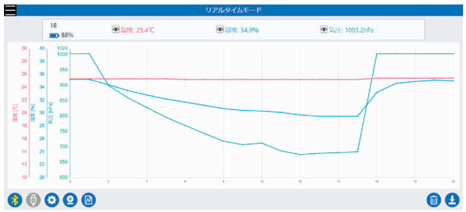
Ultrasonic

Wireless

Use Bluetooth to connect to your PC or tablet wirelessly and view your data in real time!

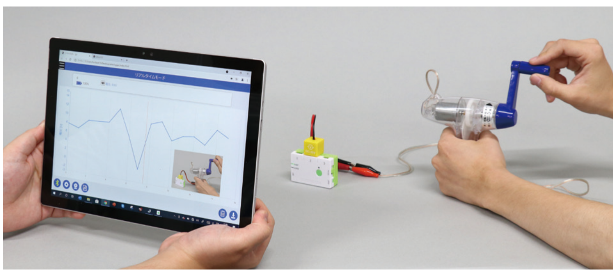
Multilogging

The software shows up to three sensors at once, letting you compare pressure and humidity and more.



Live Capture

The software allows you to overlay graphs with live footage of your experiment.



Simple Export

Export your data as an image or even as a CSV for easy management using spreadsheet software.

	A	B	C	D
1	時間	温度[℃]	湿度[%]	気圧[hPa]
2	5:43:50 PM	28.1	12	1005.7
3	5:43:55 PM	28.3	14.8	1005.7
4	5:44:00 PM	28.5	28.3	1005.6
5	5:44:05 PM	28.5	38.3	1005.5
6	5:44:10 PM	28.5	43.5	1005.5
7	5:44:15 PM	28.8	44.3	1005.5
8	5:44:20 PM	29.5	18.3	1005.7
9	5:44:25 PM	29.3	12.2	1005.6
10	5:44:30 PM	28.1	11.1	1005.7

Topic ① Changes in Movement and Energy

Sensors: Ultrasonic, Current, Voltage

Use sensors to measure and quantify movement and energy in the world around you, then use your data to think about how to use energy efficiently.

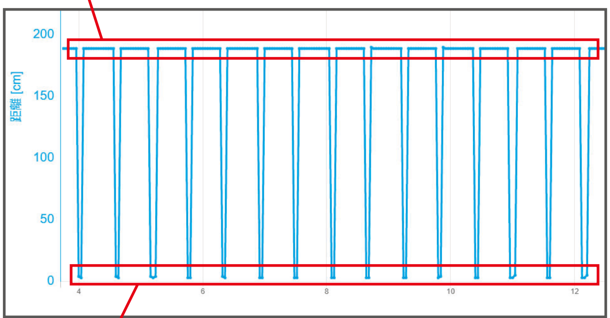
1. The Swing of a Pendulum
(Ultrasonic Sensor, Artec Blocks)

Live Mode

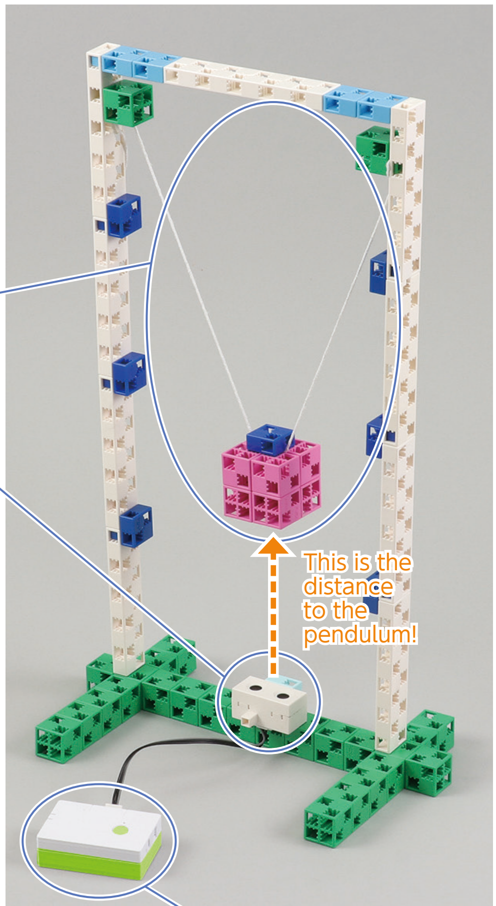
SDGs 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Swing a pendulum over your sensor as you measure the distance between them. Using a sensor in this way allows you to analyze the swing of the pendulum using concrete numbers of graphs.

These values show the distance to the ceiling because the pendulum is no longer in the way!



These values show when the pendulum is at its closest: right in front of the sensor.



Choose from two modes!

Logging Mode: Logging Mode allows you to store measurements on your Artec Logger and transfer them to your PC or tablet, making it perfect for long term or overnight data logging.

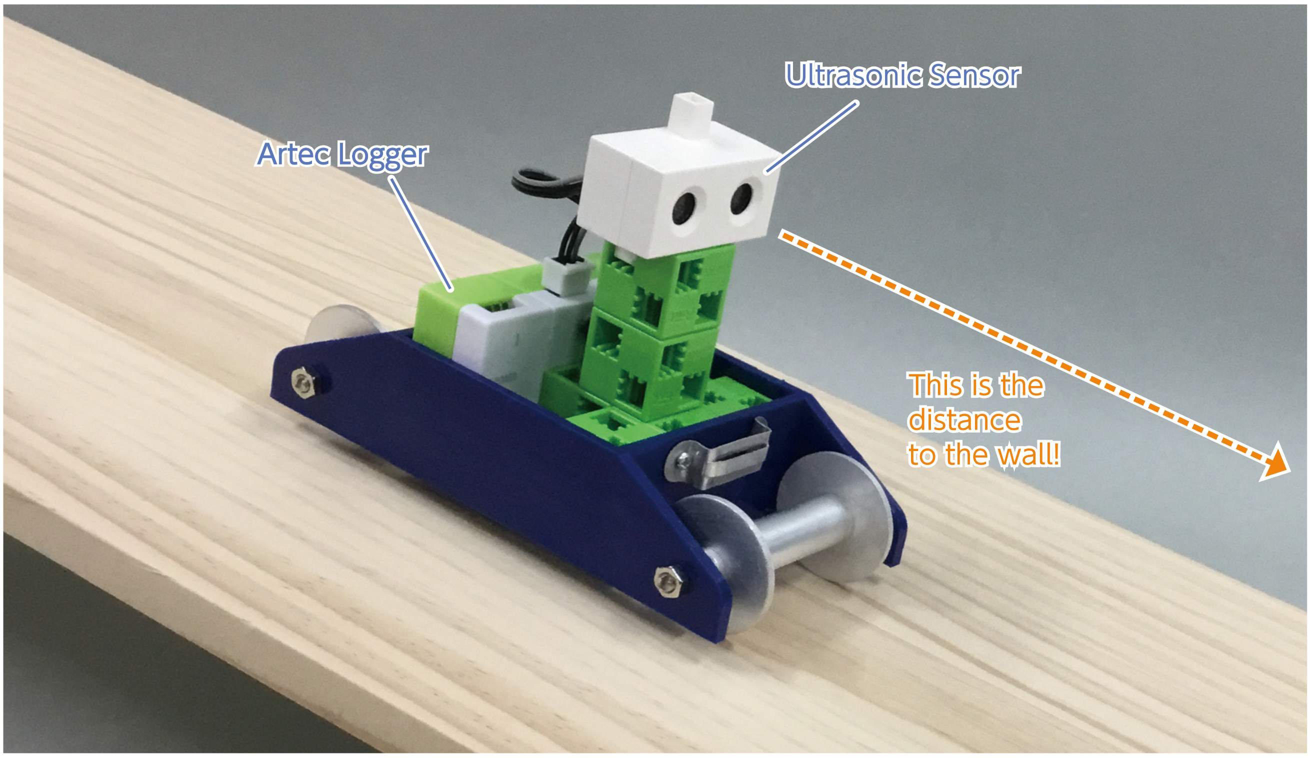
Live Mode: Live Mode uses Bluetooth to give you a live view of measurements as you take them, allowing you to observe the subject and changes in your data in real time.

2. Objects in Motion
(Ultrasonic Sensor, Artec Blocks)

Live Mode

SDGs 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Attach your Ultrasonic Sensor to a car and set it on an incline, measuring the change in distance to the wall to see how the speed of a moving object changes. The logging interval can be set to a minimum of 0.04 seconds, and putting this data into a manageable format allows you to perform basic experiments in mechanics like investigating the relationship between speed and the angle of a slope with ease!



What does it use?

Ultrasonic Sensor (Distance)

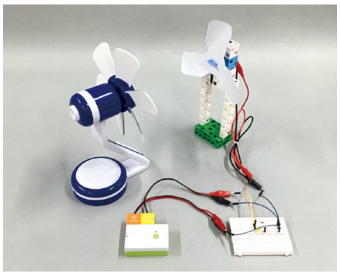
Plug it into port 2 or 3 on your Artec Logger and use it to measure distance using ultrasonic waves! Requires a separate Sensor Connecting Cable (sold separately).

Measurement Distance	2-250 cm
Angle	< ~15°
Frequency	40 kHz

Sensor Connecting Cable

3. The Power of the Wind
(Current Sensor, Voltage Sensor, Artec Blocks)

Measure current and voltage to make an energy efficient wind turbine!



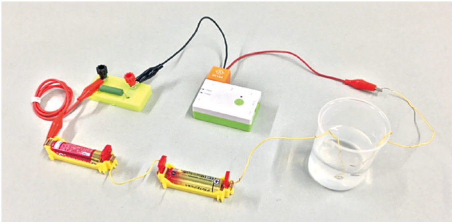
SDGs 7 AFFORDABLE AND CLEAN ENERGY

Live Mode

◎ See Chapter 1 for more details!

4. The Secret of Clean Water
(Current Sensor)

Apply electric current to a variety of aqueous solutions to measure their conductivity, using tap water's lack of conductivity to perform your own water quality survey!



◎ See Chapter 2 for more details!

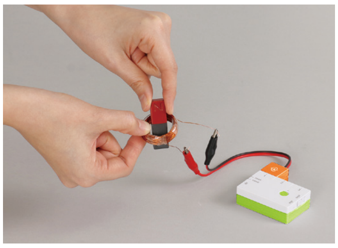
SDGs 6 CLEAN WATER AND SANITATION

SDGs 14 LIFE BELOW WATER

Live Mode

5. Sticky Electricity
(Current Sensor)

Log measurements of electrical current to see how magnetic induction can generate electricity.

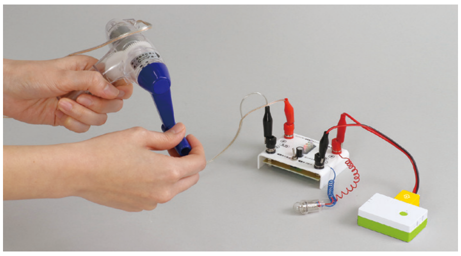


SDGs 7 AFFORDABLE AND CLEAN ENERGY

Live Mode

6. Handmade Power
(Voltage Sensor)

Measure voltage from a hand-crank generator, graphing your data in real time to see changes in the amount of power you generate!



SDGs 7 AFFORDABLE AND CLEAN ENERGY

Live Mode

What does it use?

Current Sensor

Plug it into port 1 on your Artec Logger and use it to measure electrical current!

Cable Length	20 cm (incl. alligator clips)
Range	± 5 A (DC)
Resolution	1 mA
Accuracy	1%

Voltage Sensor

Plug it into port 2 or 3 on your Artec Logger and use it to measure voltage!

Range	±25 V (DC)
Resolution	0.01 V
Accuracy	0.1V

Topic ② Exploring the World

Sensors: Climate, Water Temperature

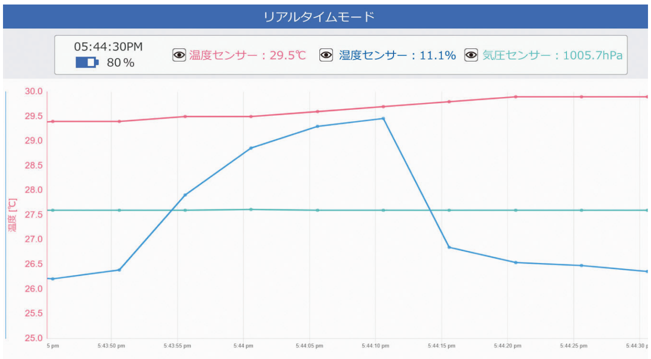
Measure air and water temperature, atmospheric pressure, and humidity to gain a deeper understanding of the natural world, considering what we can do to stop global warming and preserve our natural ecosystems.

7. Measuring Weather (Climate Sensor)

Logging Mode

SDGs 13 CLIMATE ACTION

Perform long-term observations on the weather by logging changes in temperature, atmospheric pressure, and humidity, even overnight. These logs can be taken as many times as you wish. Once done, transfer your data to your PC or tablet to observe these changes for yourself!



8. Exploring Pressure, Temperature, and Humidity (Climate Sensor)

Live Mode

SDGs 13 CLIMATE ACTION

Perform your own indoor meteorological experiment by placing your Artec Logger into a vacuum chamber and observing how the pressure and humidity inside of the container changes as you pump air out, or even adding a bit of moisture to see how temperature and humidity change as clouds are generated. The values are all plotted to one graph in real time, allowing you to easily find correlations between them.

9. A Home for Life
(Climate Sensor, Water Temperature Sensor)

Logging Mode

SDGs 14 LIFE BELOW WATER

SDGs 15 LIFE ON LAND

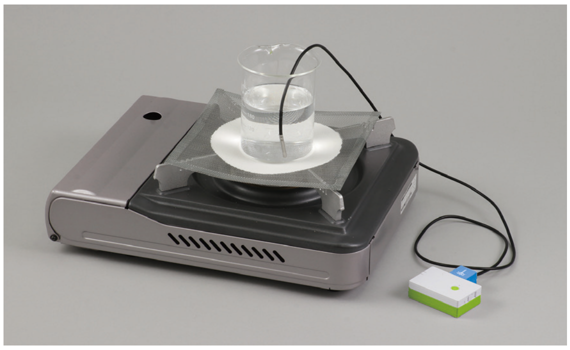
Explore to find the plants and animals which call your school and neighborhood home as you think about the relationship between living creatures and the temperature and humidity of their environment. Lessons can be further expanded by using the Water Temperature Sensor and tablet camera to observe the temperature of aquatic environments as well as the creatures which live in them, even taking long-term measurements as necessary.

10. The States of Water
(Water Temperature Sensor)

Live Mode

SDGs 6 CLEAN WATER AND SANITATION

The Earth is a water planet, and the nature of water causes changes to our seas at atmosphere which lead to all manner of meteorological phenomena. Heat up and cool down water and other aqueous solutions, observing how they change temperature as you investigate their properties. These changes are logged automatically, meaning that you can spend time seeing these changes yourself rather than keeping a watchful eye on the thermometer.



What does it use?

Climate Sensor

Plug it into port 1 on your Artec Logger and use it to measure atmospheric pressure, temperature, and humidity!

	Temperature	Humidity	Pressure
Range	-40-85℃	0-100%	300-1100 hPa
Resolution	±1℃	±3%	±1 hPa
Accuracy	0.1℃	0.1%	0.1 hPa

Water Temperature Sensor

Plug it into port 2 or 3 on your Artec Logger and use the thermistor to measure the temperature of water!

Range	-40-105℃
Resolution	0.1%
Accuracy	±1%

Topic ③ The Secrets of Life

Sensors: Oxygen Sensor

Respiration is an essential for all living things, including plants and animals. Measure changes in oxygen and carbon dioxide concentration under different conditions to observe how air is exchanged when we breathe.

11. How We Breathe
(Oxygen Sensor)

Live Mode

SDGs 3 GOOD HEALTH AND WELL-BEING

While traditional in-school experiments used gas detector tubes to measure oxygen concentration, using the Artec Logger with an Oxygen Sensor offers a convenient, reusable alternative. Just like with other sensors, simply plug it in to measure and view the oxygen concentration in your breath in real time.

12. Photosynthesis and Climate Change
(Oxygen Sensor)

Live Mode

Logging Mode

SDGs 15 LIFE BELOW WATER

This Oxygen Sensor is particularly useful in an inquiry on plant photosynthesis. You can use it to investigating whether the oxygen a plant releases through photosynthesis changes depending on whether the plant is in the sunlight or the shade, and even the position of a single leaf on a tree. What's more, unlike a glass test tube, taking it outside is no problem.

You can also turn this into a solid STEAM topic by relating your measurements to climate change and food-related issues. It's also possible to use real-time measurements and overnight logs to compare the differences in plant respiration during the night and day!

13. The Breathing Harvest
(Oxygen Sensor)

Logging Mode

SDGs 15 LIFE BELOW WATER

While some students may be aware that plants create oxygen through photosynthesis, they may not know that plants breathe, too.

Try taking your class on a trip and using the Oxygen Sensor to check whether supermarket produce respirates. The Artec Logger's compact design and wireless features means that you can keep it in a sealed bag as you measure!

14. Heating Up
(Oxygen Sensor, Water Temperature Sensor)

Live Mode

SDGs 7 AFFORDABLE AND CLEAN ENERGY

Oxygen Sensors can be used for more than just living creatures. Another handy way to use it is to observe iron oxidation by measuring the changes in oxygen concentration and temperature of a disposable heat pack, graphing the value of both in real time to find correlations between the two!

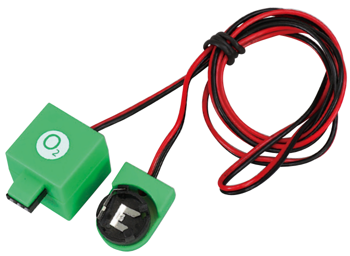
What does it use?

Oxygen Sensor From Professor Mitsuo Takahashi of Otsuma Women's University

This sensor measures oxygen concentration. It's powered by zinc-air batteries. You can use a tester to measure oxygen concentration by plugging it into the tester output terminal on the back of the sensor and adjusting the calibration dial to 20.9 mV. Connect it to port 2 or 3 on your Artec Logger!

Cable Length	80 cm
Range	5-50%
Resolution	0.1%

Zinc-Air Batteries



Chapter 4

Connecting Artec Logger to Japan's Elementary School Curriculum

Grade	Subject	Unit	Experiment	Sensors
4	A	The Nature of Light and Sound (reflection and condensation)	· Use a mirror to focus sunlight and measure the temperature.	Climate (T★3)
	B	The Sun and the Earth (differences in ground warmth and moisture)	· Measure temperature and humidity of the ground in sunlight and in the shade.	Climate (TH) ★1
	A	How Current Works (battery number and connection)	· See how changing the direction of a battery changes the direction of a current. · See how changing the number and connection of batteries affects the size of the current.	Current
		★ The Temperature of Metal, Water, and Air (the three phases of water)	· Measure temperature changes in water my heating it up and cooling it down.	Water
	B	Seasons and Organisms (seasons and plant growth)	· Measure how temperature and humidity changes each season as you consider how this affects plant life.	Climate (T) ★1
		★ Seasons and Organisms (seasons and the lives of animals)	· Measure how temperature and humidity changes each season as you consider how this affects animal life.	Climate (T) Water ★2
		★ Watching the Weather (temperature during the day)	· Measure changes in temperature over a single day.	Climate (T) ★1
5	A	★ Pendulum Movement (how pendulums move)	· Measure how the period, weight, and length of a pendulum affects its swing.	Distance
		Dissolving Solids (saturation points in water, changes in soluble amounts in water)	· See how the temperature of water or a solution affects how much of a substance it can dissolve.	Water
		Magnets from Current (electromagnet strength)	· Place a sensor in a circuit and measure the strength of an electromagnet as you adjust the amount of current and number of coils.	Current
6	A	How Combustion Works (the mechanisms of combustion)	· Place a sensor into a container with a burning object and measure changes in oxygen concentration.	Oxygen
		★ Uses of Electricity (generating electricity)	· Place a sensor in a circuit and the amount of current created by a hand-crank generator.	Current
		Uses of Electricity (storing electricity)	· Compare the amount of current generated by circuit with a capacitor versus a circuit without one, making a motion-sensing light and temperature-sensitive fan as you consider how to use electricity efficiently.	Current
	B	★ The Human Body (respiration)	· Measure oxygen concentration during inhalation and exhalation.	Oxygen
		Plant Nutrients and the Flow of Water (the flow of water)	· Place a plant and Climate Sensor into the same container to observe changes in temperature and humidity due to transpiration.	Climate (TH)
		★ Life and the Environment (plants and air)	· Use an Oxygen Sensor to measure oxygen concentration due to photosynthesis.	Oxygen
		Life and the Environment (life, water, and the air)	· Place an insect and your Oxygen Sensor into a sealed container to measure changes in oxygen concentration due to respiration.	Oxygen

◇ A: Materials and Energy, B: Life and the Earth
◇ The sensors shown here are just examples. Feel free to pick any sensor which fits the content of your class.
◇ You can find experiments for units with a ★ on pages 51-57.

★ 1 You can also use an ArtecRobo Temperature Sensor for this.
★ 2 The Climate Sensor can't be used in conjunction with other sensors.
★ 3 T = Temperature, H = Humidity, A = Atmospheric Pressure

Logger

Connecting Artec Logger to Japan's Junior High School Curriculum

Grade	Subject	Unit	Experiment	Sensors
1	Physics and Chemistry	★ The Shape of Substances (materials in the world around us)	· Observe what happens when you bring water and ethanol to a boiling point.	Water
		The Shape of Substances (creating and describing gases)	· Measure changes in oxygen concentration during chemical reactions.	Oxygen
		★ Phase Changes (melting and boiling points)	· Observe what happens as you heat up and boil a mixture of water and ethanol.	Water
		Phase Changes (melting and boiling points)	· Add water to a simple vacuum chamber to see how lower air pressure will also cause a lower boiling point.	Climate (A), Water ★2
2	Physics and Chemistry	Electrical Current (current and voltage in circuits)	· See how the paths of a circuit affect current and voltage.	Current, Voltage ★3
		Electrical Current (electricity and its energy)	· Apply a heated wire to water and use a sensor to measure changes in temperature as well as current and voltage.	Water, Current, Voltage ★3
		★ Current and Magnetic Fields (electromagnetic induction and power generation)	· Measure electricity created through magnetic induction.	Current, Voltage ★3
		★ Chemical Changes (chemical changes and heat)	· Measure changes in oxygen concentration around a heat pack as it heats up.	Oxygen, Water
		Chemical Changes (chemical changes and heat)	· Measure temperature changes when ammonia is created during an endothermic reaction.	Water
	Life Science	★ Changing Weather (fog and clouds)	· Add moisture to a sealed container and measure changes changes in temperature and humidity as you change the air pressure.	Climate (THA)
		Watching the Weather (meteorological elements)	· Think about the relationship between elevation and barometric pressure as you measure pressure on each floor of a building.	Climate (A)
		★ Watching the Weather (meteorological observations)	· Take long-term measurements outside to understand the relationship between weather and changes in temperature, humidity, and pressure.	Climate (THA)
		Watching the Weather (meteorological observations)	· Measure how humidity changes in response to temperature.	Climate (TH)
		The Workings of Plants (roots, stems, leaves, and their functions)	· Place plants and the Artec Logger into a bag and measure changes in oxygen concentration during the day and night.	Oxygen
3	Physics and Chemistry	Aqueous Solutions and Ions (neutralization reactions)	· Measure changes in current and voltage during a neutralization titration to determine when a solution has neutralized.	Current, Voltage ★3
		★ Regularity in Motion (force and motion)	· Understand the regularity in an object's motion by attaching a sensor to a car or other moving object and measuring the distance it travels over time.	Distance
		Chemical Changes (chemical changes and batteries)	· Measure the strength of current and voltage generated by a battery made of metal and electrolytes.	Current, Voltage ★3

◇ The sensors shown here are just examples. Feel free to pick any sensor which fits the content of your class.
◇ You can find experiments for units with a ★ on pages 51-57.

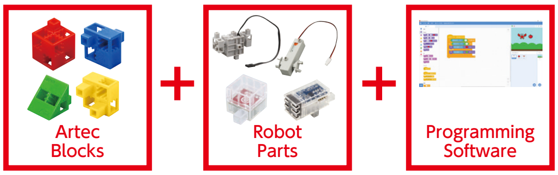
★ 1 You can also use an ArtecRobo Temperature Sensor for this.
★ 2 The Climate Sensor can't be used in conjunction with other sensors.
★ 3 You can also use an ArtecRobo's analog ports to measure voltage.

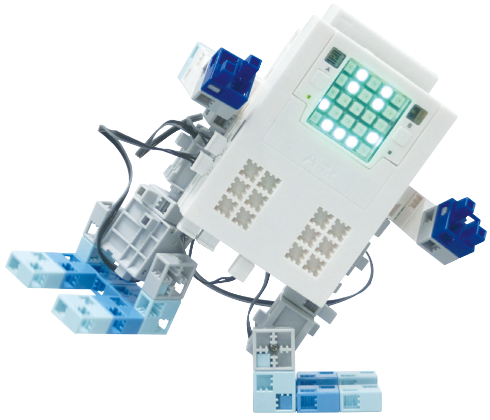
ArTeC Robo

From the First Step to Full-Fledged STEAM

ArtecRobo is an educational programming platform centered around programmable microcontrollers. Combining these with a wealth of blocks, electronic parts, and programming environments allows you to freely build robots suited to any task.

But far from being limited to programming, let's take a look at how we can use ArtecRobo to take on the social issues envisioned by STEAM learning.





Find out more details on page 68!

What Makes ArtecRobo Stand Out?

Lasting Real programming education starting from preschool through college and beyond

Versatile Support for multiple operating systems online and off

Simple Less prep time for teachers and students

Advanced A rich variety of parts for use in general and inquiry-based STEAM learning

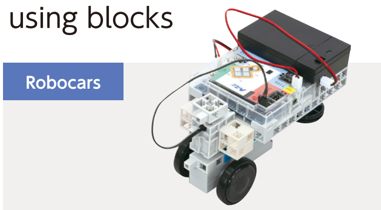
Accessible Easy-to-use kits and cases ready to use in your classroom

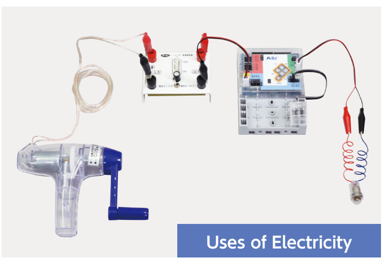
ArtecRobo

Studuino + ArTeC Blocks

- Connect parts like LEDs, motors, and sensors
- Build with ease using blocks


Traffic Signals


Robocars

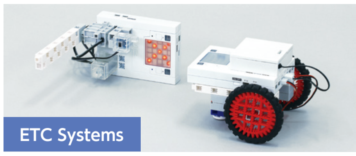

Uses of Electricity

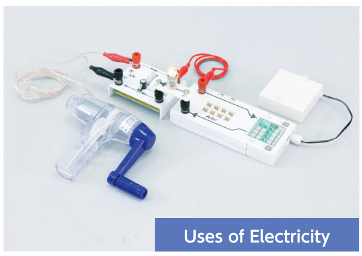
ArtecRobo 2.0

Studuino:bit + ArTeC Blocks

- Onboard sensors and LED display
- Built-in Bluetooth and Wi-Fi connectivity


Traffic Signals


ETC Systems


Uses of Electricity

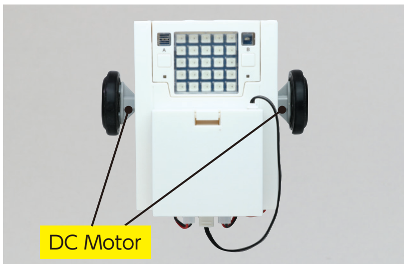
Topic ① Safer Streets

SDGs 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
SDGs 11 SUSTAINABLE CITIES AND COMMUNITIES

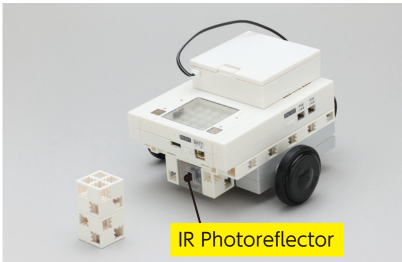
Deepen your understanding of traffic safety and systems by learning about the systems and devices used to keep us safe on the road and programming them yourself.

[1] Avoiding Accidents ArTeC Robo 2.0

Program a self-driving car, a car which can hit the brakes before an accident happens, and investigate other systems which help keep us safe as we drive.

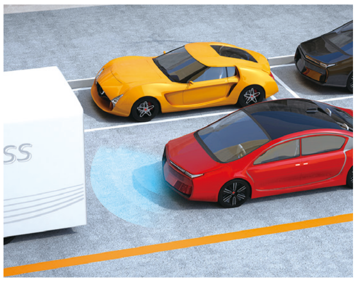


Use two DC Motors to make a robot car which can drive forward, reverse, and turn.



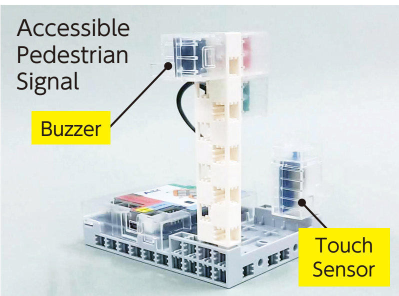
Make a collision-avoiding car which uses an IR Photoreflector to stop when it detects an obstacle and plays a sound when it does.

Uses
DC Motor
IR Photoreflector

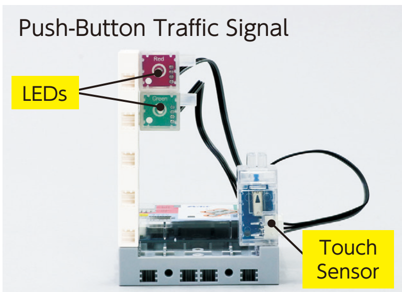


[2] Stop and Go ArTeC Robo

Investigate and think about how accessible traffic signals are designed in order to build and program a signal which lets anyone and everyone cross the road safely.



This accessible signal turns from red to green and plays a sound from its Buzzer when you press the Touch Sensor, allowing visually-impaired pedestrians to cross in safety.



Press the Touch Sensor on this signal to extend the green light, giving elderly and disabled people enough time to cross.

Uses
Touch Sensor
LEDs
Buzzer

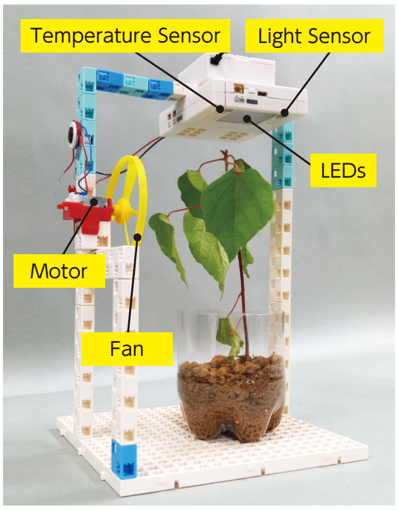
Topic ② The Plant Factory

Think about agriculture in a sustainable future as you create a plant factory which can grow plants in an optimal environment by automatically adjusting light, temperature, and water.

SDGs 2 ZERO HUNGER
SDGs 6 CLEAN WATER AND SANITATION
SDGs 13 CLIMATE ACTION
SDGs 15 LIFE ON LAND

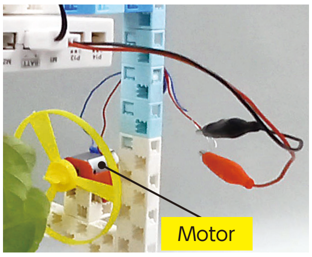
[3] A Reliable Crop ArTeC Robo 2.0

Control temperature and light to create a plant grower which can reliably produce crops without having to worry about changes in climate.



- **Managing Lighting**
  Use a Light Sensor to measure brightness in the room and turn on the LEDs when it gets dark.
- **Climate Control**
  Use a Temperature Sensor to monitor the temperature, turning a motor to spin the fan and cool things down when it's too hot.

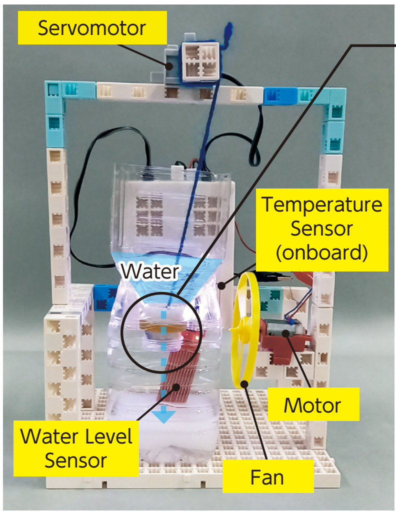
Uses
Light Sensor
Temperature Sensor
LEDs
Motor
Fan



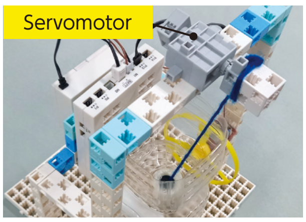
Connect the leads from the fan's motor to the DC Motor output terminal and program the DC Motor to turn.

[4] Watering without Waste ArTeC Robo 2.0

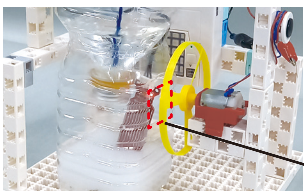
Make a device which controls both the climate and saves water by only dispensing the necessary amount.



The stopper keeps the water at the top from leaking out and is tied to the Servomotor with a thread.



When the Water Level Sensor has detected a low water level, the Servomotor will turn in order to unplug the stopper. This allows the water stored at the top to replenish the water at the bottom.



The fan will cool things down when the Temperature Sensor detects that it's too hot. The opening in the side of the plastic bottle allows the air in.

Uses
Motor
Water Level Sensor
Temperature Sensor
Servomotor

Chapter 4

Topic ③ Disaster Resistance

Make a device which can measure earthquake tremors, using it to compare how a building's height and structure can affect how much it shakes. As you do this, you'll deepen your understanding of these disasters by learning about the technologies we use to reduce damage from earthquakes as well as the mechanisms of earthquakes themselves.

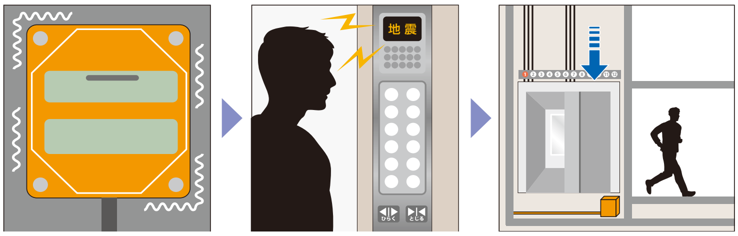
SDGs 11 SUSTAINABLE CITIES AND COMMUNITIES
SDGs 13 CLIMATE ACTION

[5] Quake Detection ArTeC Robo 2.0

This earthquake detection mechanism is used in machines like elevators, stopping the movement of the machine after the first small tremors but before the big tremors begin.

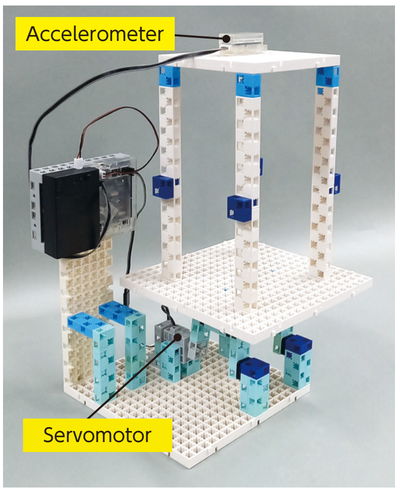
Use the onboard Accelerometer to detect shaking, then use the Buzzer and LED Display to alert people in the area.

Uses
Accelerometer (onboard)

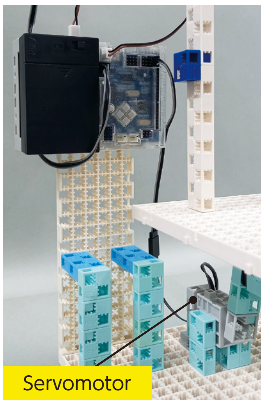


[6] Earthquake-Resistant Buildings ArTeC Robo

Make a device which can measure how much a building shakes during an earthquake, then see how the size and structure of the building affects these values.



The Accelerometer on the top the building measures how much it shakes.



Making small changes to the Servomotor's angles will shake the building to simulate an earthquake.

Uses
Accelerometer
Servomotor

◎ See Chapter 3 for more details!

Topic ④ A Better Society

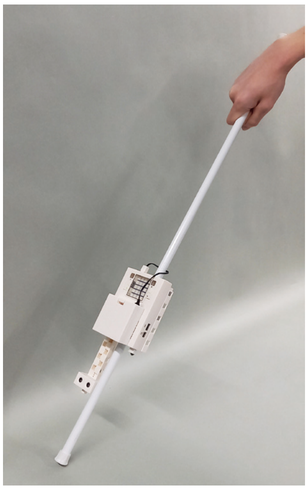
Design devices which make life easier for the elderly and disabled, then use ArtecRobo to build them. Deepen your understanding of and use your own experiences with social safety nets to spot issues and use programming to solve them.

SDGs 3 GOOD HEALTH AND WELL-BEING

SDGs 11 SUSTAINABLE CITIES AND COMMUNITIES

[7] Safer Canes ArTeC Robo 2.0

Create a device which attaches to a white cane, allowing the visually impaired to walk safely by alerting them before the cane hits an obstacle.



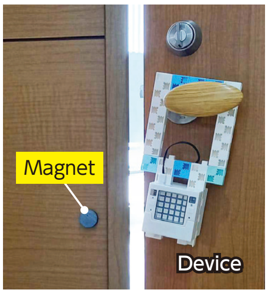
Uses

Ultrasonic Sensor

The Ultrasonic Sensor will detect any obstacles and an alert will sound from the Buzzer if one is present.

[8] Safety from a Distance ArTeC Robo 2.0

Make a device which you can hang from a door. This device will send an alert when the door opens, even when you're away from home. This can be incredibly useful for elderly relatives who live alone.



Hang the device from a doorknob and its Accelerometer will detect when the door moves. Attaching a magnet to the wall will also allow the Magnetometer to detect changes in the door's distance to the wall as it opens and closes. Each sensor value will be transmitter to the receiving device.

Set thresholds based on the values of the Accelerometer and Magnetometer when the door is open. The receiver will take values send from the device. If the values are over the threshold it will use light and sound to alert the user.

Uses

Accelerometer
Magnetometer

Topic ⑤ Making Life Easier

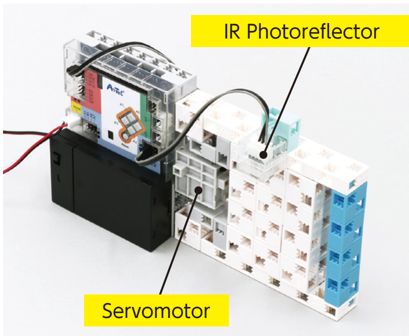
Learn how computers make our lives more convenient, and how we use programs to make them work. From preventing the spread of disease to helping us use energy more efficiently, these technologies help to make our lives richer.

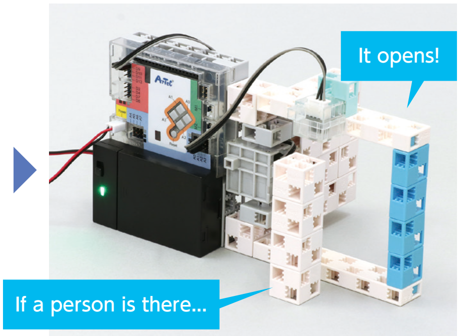
SDGs 7 AFFORDABLE AND CLEAN ENERGY

SDGs 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

[9] Automatic Doors ArTeC Robo

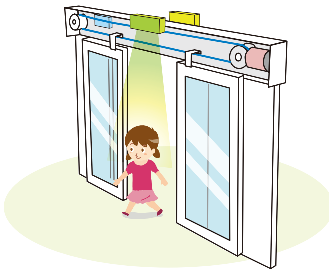
Make a model automatic door as you consider the need for contactless products to help prevent the spread of disease.





Uses

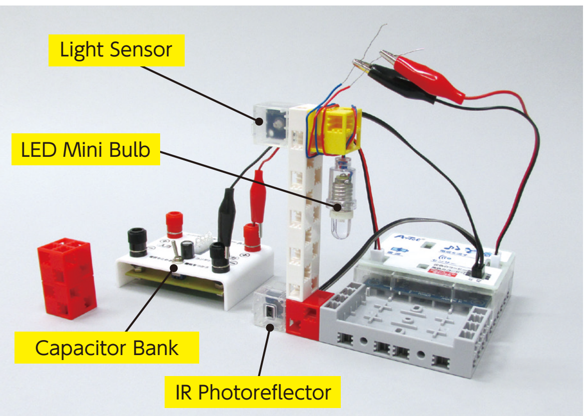
IR Photoreflector
Servomotor

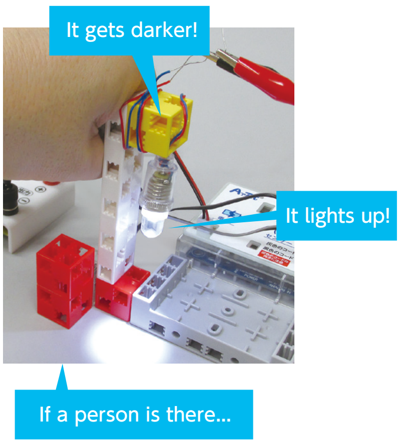


The IR Photoreflector will detect a person standing in front of the door, then the Servomotor will turn to open it.

[10] Efficient Lighting ArTeC Robo

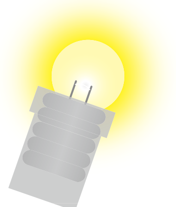
Cut down on energy waste by making a light which doesn't need a human-operated switch.





Uses

IR Photoreflector
Light Sensor
LEDs



Energy created by a generator is stored in the capacitor. The light will turn on or off depending on the level of light and the presence of humans.

The IR Photoreflector checks for humans while the Light Sensor measures brightness.

Akinobu Ando
Professor, Miyagi University of Education

Closing Conversations

STEAM: Where Do

This casebook started by defining exactly what we mean when we say STEAM learning before exploring three modules and their associated learning materials.

To wrap it all up, our Editor-in-Chief Takeo Miyaku asked Professor Akinobu Ando to share his thoughts on the future direction of STEAM education.

Problem-Solving with Peers: Raising Programming Natives

Miyake How was it seeing students take on the work in this casebook?

Ando Firstly, it seemed like they were enjoying themselves. It's true for today's class as well, but I thought that students were really putting their focus into learning. They figured out what they had to do and really took the experiments into their own hands, didn't they?

Miyake There would be claps every time they did something and cheers when they got the results on their computer. It seemed like they were having a ball.

Ando It really did. It was also nice seeing that kids were solving smaller problems like how to take screenshots among themselves.

Miyake With programming education in effect and students starting to learn it as soon as they hit elementary school, we're going to see more and more kids who are programming natives.

Ando All eyes are on STEAM and programming as new initiatives, but my hope is that they'll become more and more mainstream. Just like this, I'd like to see more kids who use programming as a means to solve all those little inconveniences, and I feel like programming natives might catch on as a good way to describe them.

Miyake But what about the teachers? Surely there are some things they might struggle with?

Ando Even teachers who feel that way might want to give it a shot after seeing kids like they were today. Seeing children really trying on their own is fun for teachers, too.

Even for those who think they're more the artsy type or for those who feel like they're just bad at it, the fact that there's not a huge focus on the science content overall means that, even with the programming, teachers can enjoy themselves without feeling like there's this huge barrier they have to overcome.

Miyake Is there something you consider especially important when it comes to advancing STEAM education?

Ando The first would be to put teacher's fears to rest by defining what exactly STEAM is. While you can find any number of magnificent examples through a web search, I would say it starts by teachers being able to broaden the scope of their rigidly-defined subjects. It would be great for teachers to keep the STEAM focus

We Go from Here?

Editorial Postscript

in mind, getting their students to use what they've learned to solve smaller problems by tying the content to a subject the teacher is already familiar with and seeing how it can be related to other STEAM fields.

Miyake Which would mean starting with STEAM Bits. And how would this fit in with junior high and high school entrance exams?

Ando While we can't exactly say that STEAM is the key to instantly unlocking better academic performance, it might be a catalyst for students to start using more and more of their existing knowledge to tackle problems they haven't encountered before. Rather than solving problems with a single right answer, I think this is a surefire way for students to find the power to orient themselves and figure out what they need to do on their own.

Richer STEAM Learning: Departmentalized Teaching in Elementary Schools

Miyake Will we see STEAM learning move down from high school to the elementary and junior high levels?

Ando 2022 will see an increase in full-time math and science faculty in the upper grades of elementary school, and it's been clearly stated that one of the reasons for this is to promote STEAM learning. However, I doubt this will go all that well given that STEAM is written in high school curriculum guidelines but missing from elementary and junior high school guidelines. The reason why we need this sort of learning is to teach kids starting in elementary that what they learn in class can be used in any number of places. This is why, as early as possible, I'd like for students to learn that we can use technology to solve problems that can't be solved using our hands alone.

Miyake And is there something that makers of educational materials can do to help with that?

Ando I think it's rather important for something to be applicable to a whole range of things rather than just being a one-and-done. Knowing this should make it easier for students to start asking, "Can we use this here, too?" during the inquiry process in STEAM classes as well. With that in mind it would be great to have materials that get children excited about a whole range of things.

Miyake And we at Artec will do our best for these kids' futures as well. Thanks for today.

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