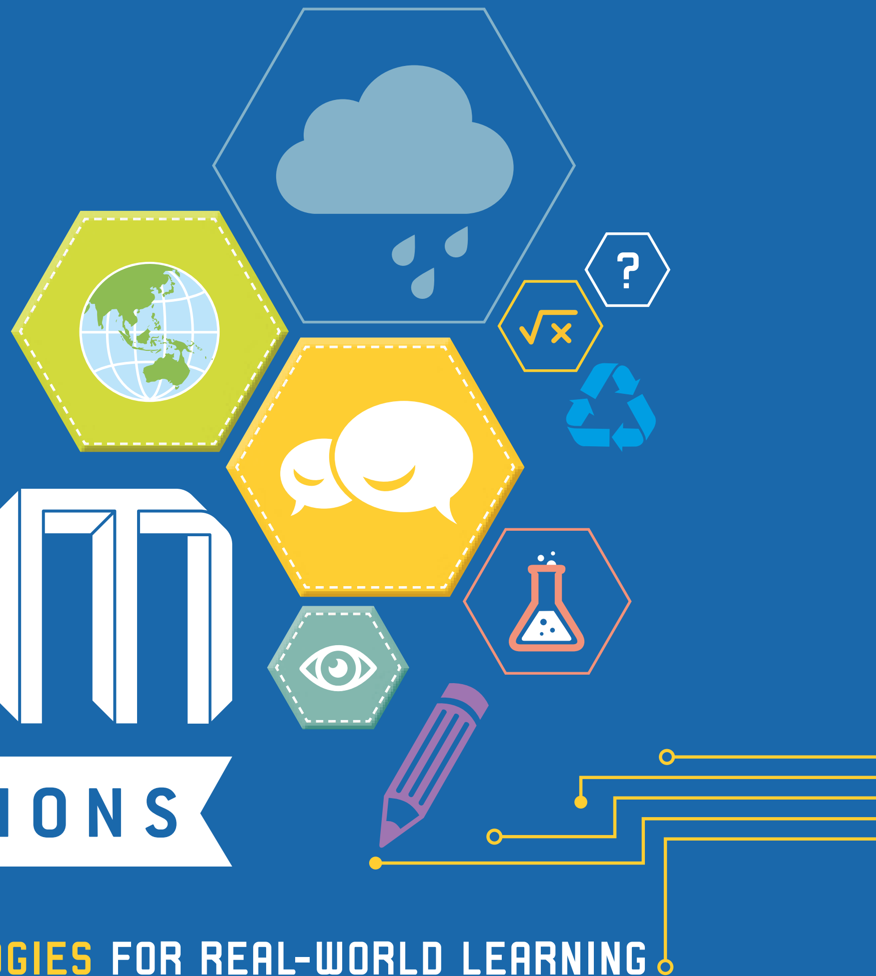
STEM INVESTIGATIONS



INTEGRATING SCIENCE, MATHS AND TECHNOLOGIES FOR REAL-WORLD LEARNING

macmillan education

A RESOURCE DESIGNED FOR YOUR CLASSROOM

No matter where you are on your STEM journey, you can feel confident and supported using *STEM Investigations*. Our expert authors have done the hard work for you so you can explore the amazing world of STEM education with your students at the pace and depth of your choice.

Tick every box with ***STEM INVESTIGATIONS***:

- ✓ **Easy to use**
- ✓ **Highest quality**
- ✓ **Expert authors**
- ✓ **Supports classroom differentiation**
- ✓ **Extremely good value**
- ✓ **Curriculum aligned**
- ✓ **For Middle and Upper Primary**

WHAT'S IN THE BOX?

- **120 laminated student cards (A4 size):**
  - → 20 different investigations organised into five themes
  - → Six copies of each card (and you can print more)
- **A comprehensive, full-service Teacher Resource Book with digital resources**

STEM Investigations for Middle Primary

AVAILABLE FROM JUNE 2018

Ideal for Years 3–4

ISBN 978 1 4202 4319 2

$295

Full site licence provided for digital content

STEM Investigations for Upper Primary

AVAILABLE FROM MARCH 2018

Ideal for Years 5–6

ISBN 978 1 4202 4154 9

$295

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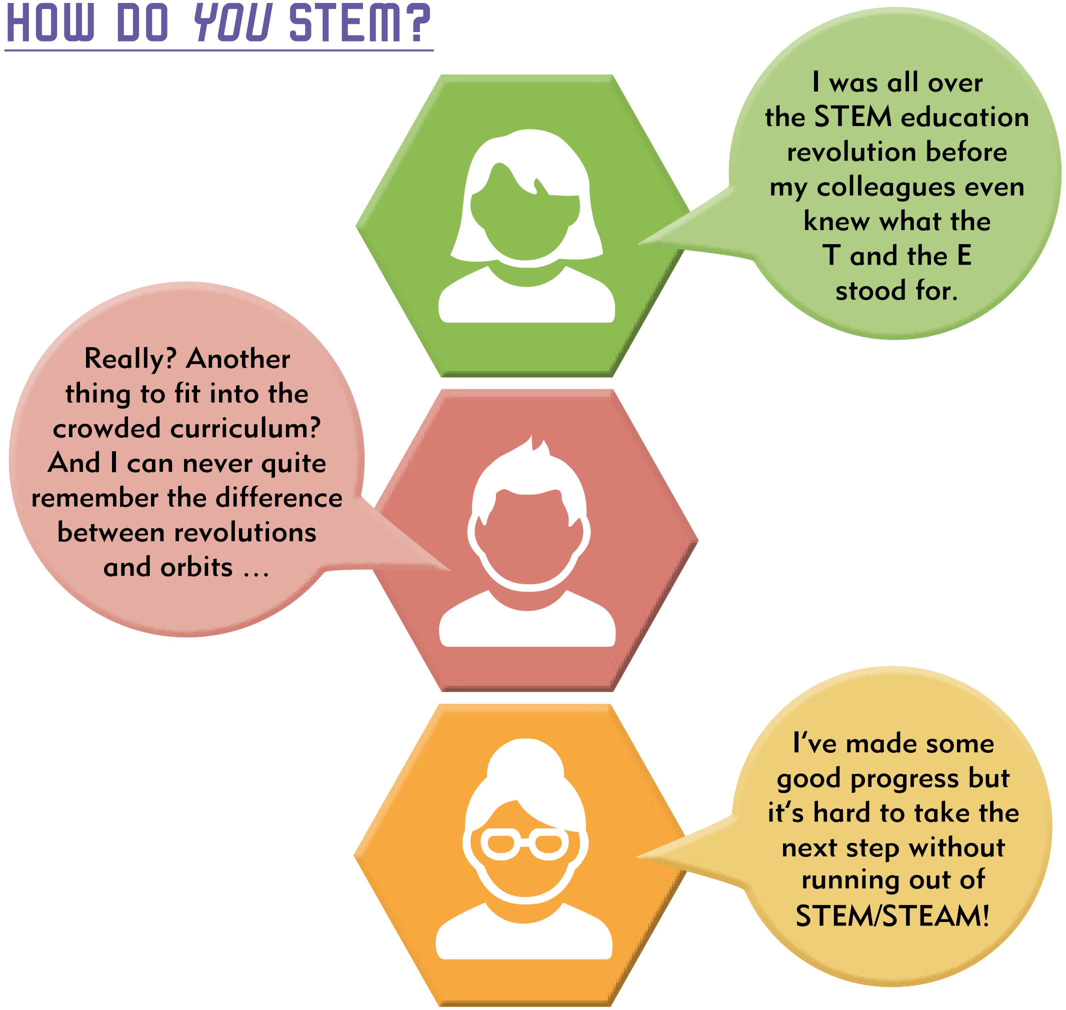
Prices are subject to change without notice.

NO MATTER WHERE YOU ARE ON YOUR STEM JOURNEY, *STEM INVESTIGATIONS* WILL ...

- allow you to access content authored by highly accomplished STEM educators in the comprehensive, full-service Teacher Resource Book with digital resources
- integrate STEM simply and easily by providing tools such as reproducibles, templates, graphic organisers, glossary of STEM terms, key vocabulary, pre-teaching ideas and MORE.

HOW DO *YOU* STEM?



STEM INVESTIGATIONS WILL ...

- push your STEM game to the next level with new ideas and resources written by fellow STEM innovators using a robust five-step Design Thinking Process
- make it EASY for you to bring your colleagues on board, no matter what their level of STEM experience
- connect you to a range of curated online resources, saving you research and vetting time

- fully support you and give you confidence from Day 1 of STEM implementation in your school
- offer you suggested pacing schedules to help you plan your STEM teaching and learning experiences
- provide you with extensive underpinning science concept 'refresher' notes, including the explicit knowledge and skills required for each task

- offer you an easy, supported and fun STEM roadmap to follow
- help you move between STEM and STEAM with ease (many investigations in this resource require artistic or visual design input!)
- give you even more confidence to take the next steps in your STEM journey using curated online resources – rather than relying on unverified information and resources from the internet

STUDENT CARDS:

INQUIRY-BASED INVESTIGATIONS WITH A DIFFERENCE

The Student Cards present authentic learning experiences. Each card presents a real-world situation and problem, and students work towards a solution to this problem through a guided inquiry approach. Students can work individually, in pairs or in groups. Every investigation requires the application of science, technologies and maths knowledge and skills, following a design thinking process. Each investigation also focuses on literacy, particularly science literacy and vocabulary.

THE 20 STEM INVESTIGATIONS ARE ORGANISED INTO FIVE THEMES:

BUILT WORLD
Topics such as simple machines, design of buildings, town planning and transportation

MANAGED WORLD
Topics such as human-made systems, communities and manufacturing

NATURAL WORLD
Topics such as animal and plant life cycles, animal adaptations, geological changes, extreme events and chemical science

SUSTAINABLE WORLD
Topics such as sharing finite resources, interactions between the natural world and human societies, and global sustainability issues

WHO WE ARE
Topics such as human rights and responsibilities, community and cultural beliefs and values, social organisations, health issues, and art and creativity

BUILT WORLD

STEM INVESTIGATION 3

DESIGN A QUAKE-RESISTANT BUILDING

THE CHALLENGE

The main risk to life during an earthquake is the collapse of poorly built buildings. After a devastating earthquake, volunteer organisations often work with local communities, helping them to rebuild. You want to join a junior volunteer team, but first you must impress the selection panel.

Your challenge is to design and build a model of an earthquake-resistant building. You may choose the type of building: a house, a public building such as a school or perhaps an apartment block. As part of your STEM investigation, you will find out about the structure of the Earth, the cause of earthquakes, flexible buildings and important features to think about when designing earthquake-resistant buildings.

KEY UNDERSTANDINGS

This challenge will help you understand:

- The Earth has five layers: inner core, outer core, lower mantle, upper mantle and crust.
- The Earth's crust is made up of many pieces, called tectonic plates.
- Tectonic plates move against each other.
- The surface where one plate slips past another is called the fault or fault plate.
- When plates slide against each other, this creates earthquakes.
- The hypocentre is the location below the Earth's crust where an earthquake starts.
- The epicentre is on the Earth's surface, directly above the hypocentre.
- Buildings that are flexible are more likely to withstand an earthquake.

KEY SKILLS

This challenge will help you:

- Make careful observations.
- Transform an idea into something that can be seen.
- Consider different points of view.
- Develop research skills.

These buildings in Nepal collapsed due to a major earthquake. How could you make sure a building won't collapse?

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KEY ACTIONS

During this challenge, you will perform the following tasks:

- Find out information from eyewitnesses of earthquakes.
- Experiment with different shapes and materials.
- Explore ways of making a structure strong and flexible.
- Design a way to create a building that can stay standing when the ground vibrates.

KEY VOCABULARY

- earthquake-resistant
- epicentre
- fault
- hypocentre
- magnitude
- tectonic plate

BIG PICTURE

The wooden palace buildings of the Forbidden City, in Beijing, China, were built to last. They have survived more than 200 earthquakes in the past 600 years.

DESIGN THINKING STAGES

As part of your challenge, you need to follow the five-step design thinking process.

EMPATHISE Gather information, consider points of view and identify eyewitness responses.

DEFINE Work out the main issues that relate to buildings surviving an earthquake.

IDEATE Come up with some creative ideas for building an earthquake-resistant building.

PROTOTYPE Choose one or two of your ideas and create them. Spend time making changes and trying new ways to create your idea.

TEST Check which ideas work best. Choose a final design to share.

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The challenge
Gives the challenge parameters and general guidance, including questions to consider. Also outlines the key scientific learning linked to the topic.

Big Picture
A relevant quirky or light-hearted snippet of information that will spark student interest

Key vocabulary
Lists key terms that are important for understanding the concepts explored in the investigation. Definitions and ideas for developing investigation-related vocabulary are provided in the Teacher Resource Book.

Key understandings
Identifies the key curriculum-linked understandings associated with the challenge

Key actions
Gives an overview of the main actions students will be expected to perform. Actions may also form part of student assessment.

Design thinking stages
Gives an overview of the main activities associated with each stage of the design thinking process.

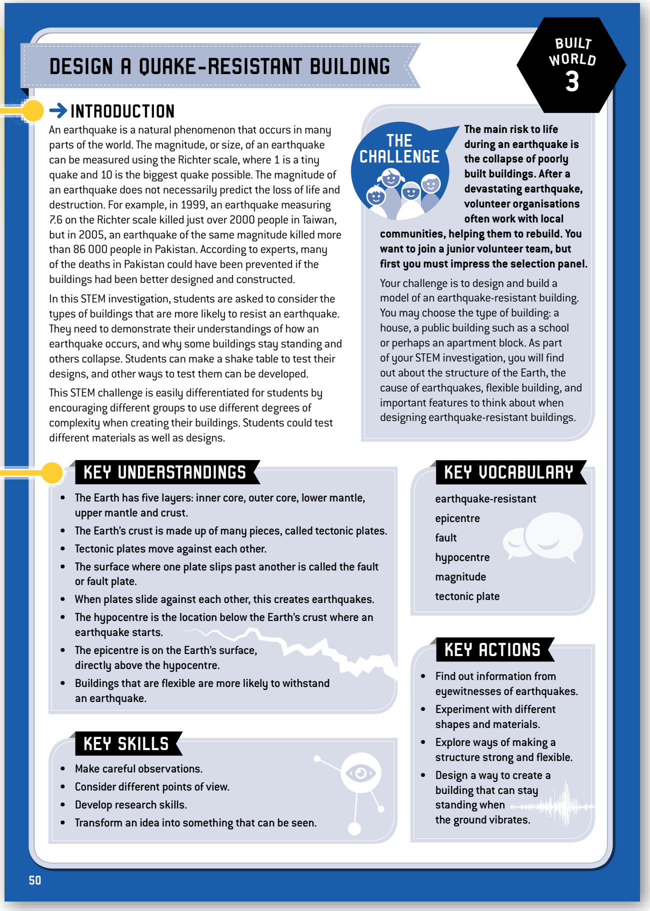
TEACHER RESOURCE BOOK AND DIGITAL RESOURCES: UNPARALLELED SUPPORT

The Teacher Resource Book contains detailed support for completing the 20 investigations, including the explicit background knowledge and skills required. Additionally, the book and digital resources provide:

- information about how to implement STEM effectively in your school
- curated links to useful resources including videos, learning objects, apps and websites
- detailed curriculum links for each investigation, to support curriculum planning
- extensive science concept 'refresher' notes for the teacher
- multiple opportunities for differentiation, due to the open-ended nature of each STEM investigation
- a suggested pacing schedule for each investigation
- resources for assessing students at different stages of the investigation, including rubrics and opportunities for student self-assessment
- reproducibles and graphic organisers for recording investigations and observations
- PDFs of Student Cards and the Teacher Resource Book
- editable Student Card and support templates to create your own STEM investigations
- glossary of technical science and maths terms.

Introduction
Gives background information relating to the challenge, including the focus of the investigation

Key understandings, **Key skills**, **Key actions**, **Key vocabulary** and **The challenge** from the student card are repeated, for ease of use.



DESIGN A QUAKE-RESISTANT BUILDING

BUILT WORLD 3

INTRODUCTION

An earthquake is a natural phenomenon that occurs in many parts of the world. The magnitude, or size, of an earthquake can be measured using the Richter scale, where 1 is a tiny quake and 10 is the biggest quake possible. The magnitude of an earthquake does not necessarily predict the loss of life and destruction. For example, in 1999, an earthquake measuring 7.6 on the Richter scale killed just over 2000 people in Taiwan, but in 2005, an earthquake of the same magnitude killed more than 86 000 people in Pakistan. According to experts, many of the deaths in Pakistan could have been prevented if the buildings had been better designed and constructed.

In this STEM investigation, students are asked to consider the types of buildings that are more likely to resist an earthquake. They need to demonstrate their understandings of how an earthquake occurs, and why some buildings stay standing and others collapse. Students can make a shake table to test their designs, and other ways to test them can be developed.

This STEM challenge is easily differentiated for students by encouraging different groups to use different degrees of complexity when creating their buildings. Students could test different materials as well as designs.

THE CHALLENGE

The main risk to life during an earthquake is the collapse of poorly built buildings. After a devastating earthquake, volunteer organisations often work with local communities, helping them to rebuild. You want to join a junior volunteer team, but first you must impress the selection panel.

Your challenge is to design and build a model of an earthquake-resistant building. You may choose the type of building: a house, a public building such as a school or perhaps an apartment block. As part of your STEM investigation, you will find out about the structure of the Earth, the cause of earthquakes, flexible building, and important features to think about when designing earthquake-resistant buildings.

KEY UNDERSTANDINGS

- The Earth has five layers: inner core, outer core, lower mantle, upper mantle and crust.
- The Earth's crust is made up of many pieces, called tectonic plates.
- Tectonic plates move against each other.
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- The epicentre is on the Earth's surface, directly above the hypocentre.
- Buildings that are flexible are more likely to withstand an earthquake.

KEY VOCABULARY

earthquake-resistant
epicentre
fault
hypocentre
magnitude
tectonic plate

KEY SKILLS

- Make careful observations.
- Consider different points of view.
- Develop research skills.
- Transform an idea into something that can be seen.

KEY ACTIONS

- Find out information from eyewitnesses of earthquakes.
- Experiment with different shapes and materials.
- Explore ways of making a structure strong and flexible.
- Design a way to create a building that can stay standing when the ground vibrates.

50

Suggested schedule
Helps teachers timetable the investigation. The initial sessions tune in the students to the investigation and introduce and/or develop the key science concepts required for the investigation. The rest of the sessions involve exploring and creating via the design thinking process, and then sharing and evaluating solutions.

Curriculum links
Lists major STEM links, along with the links to other parts of the curriculum.

Overview of stages
Gives an overview of the design thinking stages, with key actions for the investigation highlighted. Also gives an overview of the main components of the tune-in stage, plus a final sharing and evaluation stage.

→ OVERVIEW OF STAGES

TUNE IN:

- Share an introductory video about earthquakes.
- Discuss students' understandings of what an earthquake is, how it occurs and the impact it can have, and establish prior knowledge.
- Explore the structure of the Earth, how earthquakes occur, the types of structures that can survive earthquakes and the science behind this.
- Provide students with the STEM Investigation challenge card.

EMPATHISE – Students find out information about earthquakes and buildings through eyewitness accounts.

DEFINE – Students consider the main issues with designing buildings that need to be earthquake-resistant. The parameters of the challenge are defined.

IDEATE – Students generate creative ideas for a building that is earthquake-resistant.

PROTOTYPE – Students transform some of their ideas into physical representations. These are created rapidly, using simple materials. Students can role-play, make storyboards or use sticky notes when they prototype.

TEST – Students share their prototypes and provide feedback to each other. They use a shake table or similar to test their buildings. They are given the opportunity to cycle through the Prototype and Test stages again.

SHARE AND EVALUATE:

Final prototypes are shared and evaluated, with opportunities for expert feedback.

→ SUGGESTED SCHEDULE

LESSON	STAGE
1–3	**Tune in**: share information about earthquakes; explore the structure of the Earth, how earthquakes occur and the features of buildings that survive earthquakes; introduce the student challenge
4–5	**Empathise**: learn about earthquakes through different eyewitness accounts over time; empathise and write/record in journal
6	**Define**: define the main issues and write/record in journal
7	**Ideate**: develop ideas and write/record in journal
8–10	**Prototype** and **Test**: conduct prototyping and testing cycles, and write/record in journal
11–13	**Share and evaluate**: share and evaluate designs and prototypes

→ CURRICULUM LINKS

The following tables show the key Science, Technologies and Mathematics curricula with which this STEM investigation is aligned.

SCIENCE

YEAR	STRAND	SUB-STRANDS AND CONTENT
6	Science Understanding	Earth and space sciences: • Sudden geological changes and extreme weather events can affect Earth's surface
6	Science as a Human Endeavour	Use and influence of science: • Scientific knowledge is used to solve problems and inform personal and community decisions
5 & 6	Science Inquiry Skills	Questioning and predicting Planning and conducting Processing and analysing data and information Evaluating Communicating

TECHNOLOGIES

YEAR	STRAND	CONTENT
5 & 6	Design and Technologies Knowledge and Understanding	• Investigate characteristics and properties of a range of materials, systems, components, tools and equipment, and evaluate the impact of their use
	Design and Technologies Processes and Production Skills	• Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions • Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques • Select appropriate materials, components, tools, equipment and techniques, and apply safe procedures to make designed solutions • Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions • Develop project plans that include consideration of resources when making designed solutions individually and collaboratively

MATHEMATICS

YEAR	STRAND	SUB-STRANDS
5 & 6	Measurement and Geometry	Using units of measurement Geometric reasoning

→ OTHER CURRICULUM LINKS

GENERAL CAPABILITIES

- Literacy
- Numeracy
- Information and Communication Technology (ICT) Capability
- Critical and Creative Thinking

→ ASSESSMENT

The following resources are provided for assessing students at different stages of the STEM investigations:

- Generic reproducible 1 (Key vocabulary table), for assessing understanding of vocabulary
- Generic reproducible 2 (Self-evaluation), for student self-evaluation of the learning process
- Generic reproducible 3 (Responding to the investigation), for assessing student engagement in the challenge, and the collaboration and skills involved in the design thinking stages
- Generic reproducible 5 (Design thinking assessment rubric), for evaluating student engagement in the design thinking stages
- Learning journal templates 1, 2, 3 and 4, for incorporating student reflection and evaluation

Assessment
Lists the many resources for assessing students at different stages of the investigation.

Getting ready for the investigation
A checklist to consider before beginning the investigation with students. Includes considerations for organisation, grouping of students, storage of materials for construction, sourcing of materials and preparation of resources.

Useful links
Provides links to third-party resources, including texts, images and videos that can be incorporated into activities.

Useful apps
Suggests specific apps, but alternatives can be substituted. Most recommendations are free, although some require sign-up.

Resources provided
Lists all generic reproducibles, investigation-specific reproducibles and learning journal templates uses in the investigation.

Materials needed
Lists materials required for activities and to make prototypes or models.

→ GETTING READY FOR THE INVESTIGATION

You can prepare yourself and students for this STEM investigation in the following ways:

- Identify groups of students who will work well together.
- Investigate the **Useful apps**.
- If possible, open a class account for an app that creates multimedia presentations, such as Adobe Spark Video. (Students are not old enough to use an individual account so a class account should be used.)
- Review the **Key science knowledge** that supports this investigation, and look at the **Useful links**.
- Gather materials for the shake table, if building one.
- Start collecting materials for prototyping (as shown on the **Materials needed** list).
- Determine where prototypes will be kept between lessons.
- Create a wall space where students can share their ideas during the Ideate stage.
- Organise the class into pairs.
- Start thinking about:
  » how the buildings will be evaluated, if not building a shake table
  » who will view the designs
  » who will provide expert feedback about the designs, and whether it will be provided in person or in digital form
  » who could assist with building a shake table.

USEFUL APPS

- App for creating semantic maps (links between different words and/or concepts), such as Popplet
- App for creating multimedia presentations, such as Adobe Spark Video and iMovie
- App for creating interactive links (for example, between descriptions, videos, images and websites and a main image), such as ThingLink
- App for creating infographics, such as Canva

USEFUL LINKS

- Information about where earthquakes happen, such as information about the US Geological Survey at usgs.gov
- An introduction to earthquakes, such as at video.nationalgeographic.com.au/video/101-videos/earthquake-101?source=relatedvideo
- Information about the San Francisco earthquake of 1906, such as at sfmuseum.org/1906/06.html
- Information about earthquake-safe buildings and structures, such as at strucalc.com/designing-earthquake-safe-buildings-and-structures/
- Discussions about whether you can earthquake-proof a city, such as at bbc.com/news/science-environment-35810317
- Earthquake shake table instructions, such as at youtube.com/watch?v=6HgxiYBkh3U
- Information about how earthquakes are measured, such as at bbc.co.uk/schools/gcsebitesize/geography/natural_hazards/earthquakes_rev2.shtml
- Japanese pagodas during earthquakes, such as at youtube.com/watch?v=0tFWn_e71qc
- Information about the structure of the Earth, such as at natgeokids.com/au/discover/geography/physical-geography/structure-of-the-earth/

RESOURCES PROVIDED

- Generic reproducibles 1, 2, 3, 4, 5
- Reproducibles 3.1, 3.2, 3.3
- Learning journal templates 1, 2, 3, 4 (on disc)

MATERIALS NEEDED

- Sticky notes (half a pad per pair)
- Paper
- Coloured card
- Pens and markers
- Sticky tape
- Pipe-cleaners
- Cardboard
- Paperclips
- Other building materials, such as recyclable packaging, boxes, tubes
- For the shake table (link to instructions at **Useful links**):
  » Cardboard box
  » Strong card
  » Rubber bands
  » Zip tags (cable ties)
  » Scissors
  » Double-sided foam tape
  » Battery pack with batteries
  » Motor
  » Gear
  » Sticky foam circles
  » Foam circle with the middle cut out
  » Washer
  » Craft sticks/icypole sticks

Key science knowledge

An overview of the key science knowledge that is required for the investigation. Provides descriptions and elaborations of key concepts as well as images, diagrams and infographics.

KEY SCIENCE KNOWLEDGE

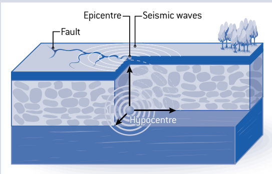
This section provides an overview of the key science concepts and vocabulary needed for this unit.

WHAT CAUSES EARTHQUAKES?

The Earth is made up of several layers. One of these is the core, which is at the centre of the Earth and consists of molten lava. The crust is the surface layer of the Earth and consists of many pieces, called plates or **tectonic plates**.

An earthquake occurs when plates slide past each other along a break in the crust called a **fault**. Energy is transferred from one plate to another, causing the plates to vibrate. The **hypocentre** is the location beneath the Earth's crust where the earthquake started. The **epicentre** is the location on the Earth's surface (crust) directly above the hypocentre.

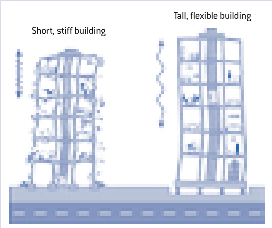
The most common way to measure earthquakes is the Richter scale. This scale measures their size, or **magnitude**.



An earthquake starts at a hypocentre beneath the Earth. The epicentre is on the surface of the Earth.

HOW DO EARTHQUAKES CAUSE DAMAGE?

Many buildings collapse during an earthquake due to the way they were constructed and how tall they are. Some buildings are more **earthquake-resistant** than others. When the Earth vibrates, a structure made of rigid materials will vibrate quickly, like the earthquake vibrations, and it can snap. Tall buildings and those made with less rigid materials are more flexible. They sway more slowly than an earthquake's movement, so they are more likely to remain standing. Very tall buildings contain dampers, which help to control the shock of the vibrations. A damper reduces vibration, which occurs when there is an earthquake. There are different types of dampers. Some might be a large mass at the top of a building (a tuned mass damper). Others could be a series of plastic rings at the base of a building that absorb shock waves.



Taller buildings made with flexible materials and rubber springs sway slowly and are better at withstanding earthquakes. Short buildings made with stiff materials and concrete foundations vibrate quickly.

KEY VOCABULARY

earthquake-resistant – more likely to survive an earthquake than standard structures
epicentre – the point on the Earth's surface directly above the underground focus of an earthquake
fault – a break in the rocks that make up the Earth's crust (outer layer)
hypocentre – the point underground where an earthquake begins
magnitude – the size of an earthquake
tectonic plate – a massive slab of solid rock (part of the Earth's crust) that moves and sometimes fractures

Key vocabulary

Definitions of key terms

Design thinking stages

Each stage includes activities, including reproducible activity sheets and prompts.

Tune-in

Establishes students' prior knowledge and understanding of key concepts and vocabulary. Introduces the key understandings involved in the challenge.

→ TUNE IN

1. Ask students to complete **Generic reproducible 1 (Key vocabulary table)** using the key vocabulary for this unit: epicentre, fault, hypocentre, magnitude, earthquake-resistant, tectonic plate. This reproducible will also be used at the end of the unit to demonstrate changes in understanding.
2. Watch the National Geographic online video 'Earthquakes 101' (see **Useful apps/links**), or a similar introduction to earthquakes.
3. Discuss what students observed and learned.
4. Before engaging in the challenge, students need to have an understanding of the Earth's structure, how an earthquake occurs and some of the scientific concepts behind earthquake-resistant buildings. Set up the following three activities (or similar) for students.

ACTIVITY 1: THE EARTH'S STRUCTURE

1. Provide students with a link to information about the structure of the Earth (see **Useful apps/links**).
2. Ask students to create an infographic explaining the key features of the Earth's structure. They could draw the structure on paper, create their own diagrams on the computer, or use an app such as ThingLink to annotate an image found online and share their understandings.
3. Ask pairs of students to take turns explaining different features of the Earth's structure (for example, the core, the crust).

ACTIVITY 2: A PAGODA'S EARTHQUAKE-RESISTANT FEATURES

1. Watch an online video about what happens to Japanese pagodas during earthquakes (see **Useful apps/links**).
2. Discuss the key information presented in the video, focusing on the flexibility of the pagoda.
3. Provide students with paper, scissors and tape to experiment with simple, flexible designs.

ACTIVITY 3: SHAKE TABLE

1. Provide students with a link to an online video explaining how to make an earthquake shake table (see **Useful apps/links**). Give them the materials required to create the shake table (as shown in the online video). Decide how many shake tables to construct and group students accordingly.
2. Ask students to follow the instructions in the video. Remind them to pause the video at the end of each instruction, and replay to check they understand the instruction.
3. If students are not able to complete this activity, brainstorm some ways that the class could create a machine to test the earthquake resistance of the buildings they are going to design.

5. Introduce the STEM investigation and challenge to the students. Provide them with the student card and read the information together.
6. Introduce the design thinking process by reviewing the stages on the student card.
7. Explain that students will keep a journal about their learning at the different stages of the design.

TOP TIP! During the Tune-in sessions, conduct vocabulary activities to highlight and develop key vocabulary knowledge. Activities could include drawing semantic webs, creating a word wall or paired discussions. Check **Key vocabulary** definitions or read the **Key science knowledge** if you need a refresher on the key terms and concepts.

USEFUL APPS/LINKS

- Japanese pagodas during earthquakes, such as at youtube.com/watch?v=0tFWn_e71qc
- Information about the structure of the Earth, such as at natgeokids.com/au/discover/geography/physical-geography/structure-of-the-earth/
- Instructions to make an earthquake shake table, such as at youtube.com/watch?v=6HgxiYBkh3U

Activities

Used to develop understanding of the key concepts required for the challenge

→ PROTOTYPE

At this stage of the design thinking process, students are asked to create a physical prototype of a solution. It is the stage where students need to get their ideas out of their head and presented in a way that engages other students and helps them to understand the concept. When students create, it helps them to think and solve problems and disagreements. Students can role-play, make storyboards or use sticky notes when they prototype. The most important feature is that viewers can interact with whatever is produced.

ACTIVITY: TRANSFORM IDEAS INTO PROTOTYPES

1. Ask students to choose one idea, and perhaps one aspect of that idea, to prototype.
2. Provide students with a range of materials to use to create their prototype. Remind students that a prototype should be created rapidly and is not meant to look 'nice'.
3. After a prototype has been created, ask students to see if it works and get feedback from others.
4. Students then use the feedback to prototype again.

Ask students to fill in the Prototype part of **Learning journal template 4 (Prototype and test page)**. See the **Journal tip** for further student guidance.

TOP TIP! The Prototype stage is often very messy. It is important that students are focusing on their ideas, rather than the end product. Provide them with lots of materials – recycling depots can be a useful source of resources. Students may add labels to prototypes to explain some of the main features. Photographing and annotating pictures of prototypes can be useful.

To gain feedback, students could ask each other some of the following questions:

- What is the main feature of your prototype?
- How does your prototype work?
- Which aspects work best? What will you keep?
- Which aspects need changing? How might you do this?
- What other materials might you need?

PROMPTS

- What worked?
- How could it be improved?
- What else do you need to know, do or have?
- What other suggestions do you have?

MORE VOCABULARY

- feedback – information about, for example, a person's performance or the design of a product, which can be used to make improvements
- prototype – an initial version of a model of a product or process that is used to develop a final model

JOURNAL TIP

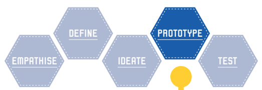
Remind students to highlight the main features of their prototype. If students are creating an electronic journal, they can insert a photo of their prototype and annotate it.

USEFUL APPS/LINKS

- App that can be used for a learning journal, allowing students to draw, link, type and record information, such as Notability
- App that can be used to create an interactive annotation of the prototype, such as ThingLink

ASSESSMENT

Observe students as they make changes to their designs. Are they able to consider feedback, make modifications and move rapidly through this process? Or do they have difficulties with holding on to an idea and accepting feedback?

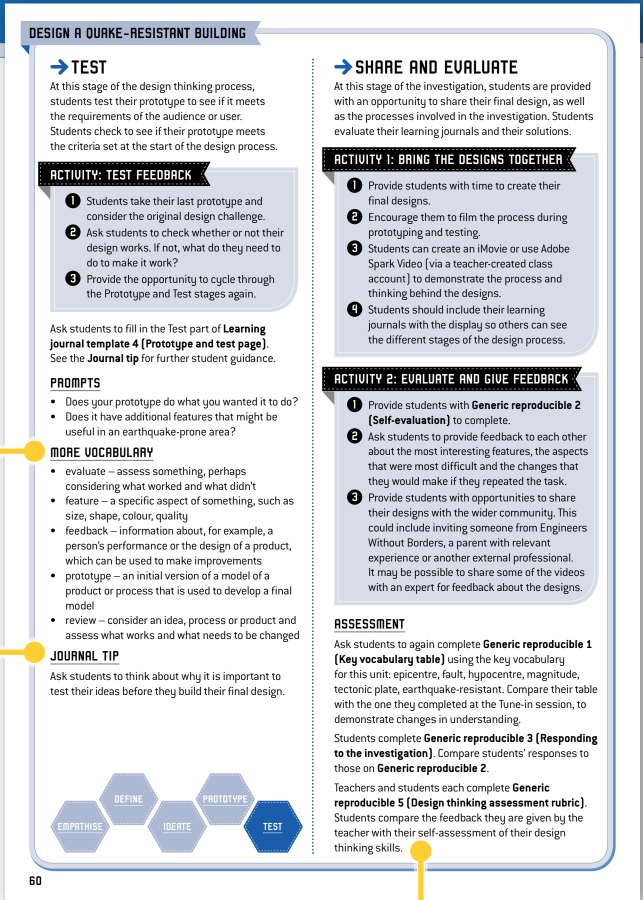


Top tip

Offers advice and tips, such as further activities and helpful resources

Design thinking diagram

Shows what stage the student is at in the design thinking process



DESIGN A QUAKE-RESISTANT BUILDING

TEST

At this stage of the design thinking process, students test their prototype to see if it meets the requirements of the audience or user. Students check to see if their prototype meets the criteria set at the start of the design process.

ACTIVITY: TEST FEEDBACK

1. Students take their last prototype and consider the original design challenge.
2. Ask students to check whether or not their design works. If not, what do they need to do to make it work?
3. Provide the opportunity to cycle through the Prototype and Test stages again.

Ask students to fill in the Test part of **Learning journal template 4 (Prototype and test page)**. See the **Journal tip** for further student guidance.

PROMPTS

- Does your prototype do what you wanted it to do?
- Does it have additional features that might be useful in an earthquake-prone area?

MORE VOCABULARY

- evaluate – assess something, perhaps considering what worked and what didn't
- feature – a specific aspect of something, such as size, shape, colour, quality
- feedback – information about, for example, a person's performance or the design of a product, which can be used to make improvements
- prototype – an initial version of a model of a product or process that is used to develop a final model
- review – consider an idea, process or product and assess what works and what needs to be changed

JOURNAL TIP

Ask students to think about why it is important to test their ideas before they build their final design.

EMPATHISE DEFINE IDEATE PROTOTYPE TEST

SHARE AND EVALUATE

At this stage of the investigation, students are provided with an opportunity to share their final design, as well as the processes involved in the investigation. Students evaluate their learning journals and their solutions.

ACTIVITY 1: BRING THE DESIGNS TOGETHER

1. Provide students with time to create their final designs.
2. Encourage them to film the process during prototyping and testing.
3. Students can create an iMovie or use Adobe Spark Video (via a teacher-created class account) to demonstrate the process and thinking behind the designs.
4. Students should include their learning journals with the display so others can see the different stages of the design process.

ACTIVITY 2: EVALUATE AND GIVE FEEDBACK

1. Provide students with **Generic reproducible 2 (Self-evaluation)** to complete.
2. Ask students to provide feedback to each other about the most interesting features, the aspects that were most difficult and the changes that they would make if they repeated the task.
3. Provide students with opportunities to share their designs with the wider community. This could include inviting someone from Engineers Without Borders, a parent with relevant experience or another external professional. It may be possible to share some of the videos with an expert for feedback about the designs.

ASSESSMENT

Ask students to again complete **Generic reproducible 1 (Key vocabulary table)** using the key vocabulary for this unit: epicentre, fault, hypocentre, magnitude, tectonic plate, earthquake-resistant. Compare their table with the one they completed at the Tune-in session, to demonstrate changes in understanding.

Students complete **Generic reproducible 3 (Responding to the investigation)**. Compare students' responses to those on **Generic reproducible 2**.

Teachers and students each complete **Generic reproducible 5 (Design thinking assessment rubric)**. Students compare the feedback they are given by the teacher with the self-assessment of their design thinking skills.

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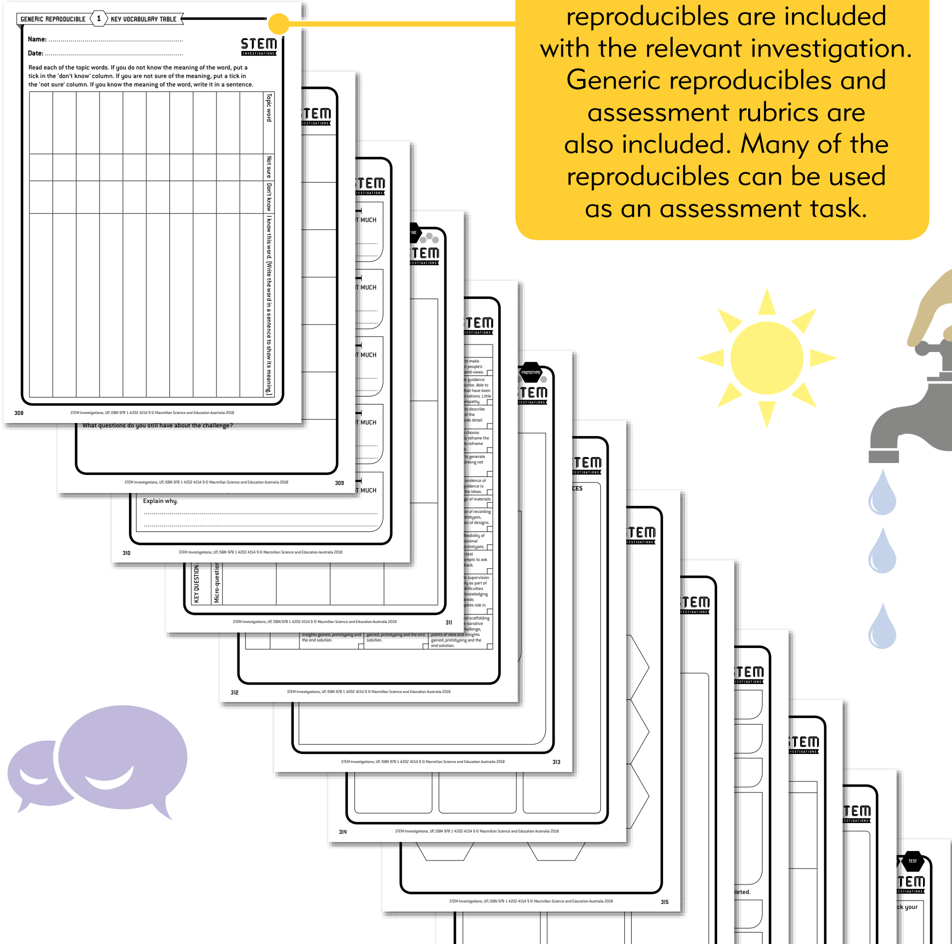
More vocabulary
Defines design thinking vocabulary

Journal tip
Students complete a learning journal template at each stage to show what they are learning and how they are reflecting on their learning.

Assessment
Suggests opportunities for observation and assessment, including student self-assessment



Reproducibles
Investigation-specific reproducibles are included with the relevant investigation. Generic reproducibles and assessment rubrics are also included. Many of the reproducibles can be used as an assessment task.

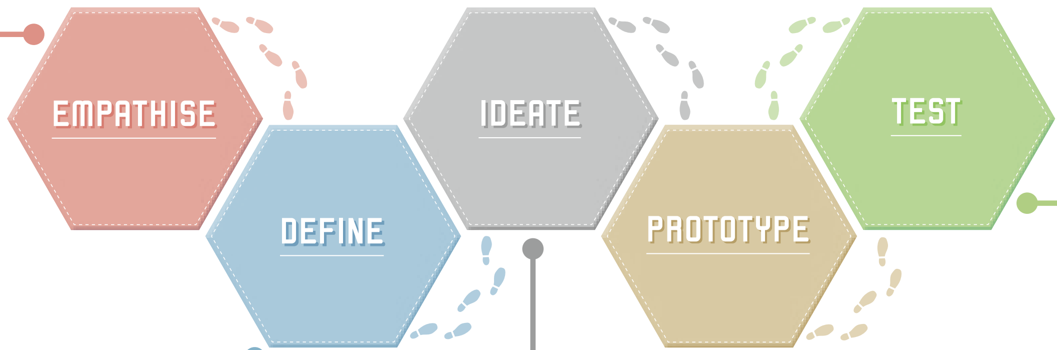
Digital Resources
Includes PDFs of the cards and Teacher Resource Book, templates so that educators can create their own STEM projects, learning journal templates and a glossary booklet. The PDFs of reproducibles, templates and graphic organisers can be filled in electronically by students, or can be printed out and then filled in.

THE DESIGN THINKING PROCESS

For each STEM investigation, students must first explore the key scientific concepts relating to the investigation before completing the challenge using a design thinking process. There are many variations of the design thinking process; the version used in *STEM Investigations* was made famous by Stanford University Design School. This process guides students through the different stages necessary to produce an end product or process relating to the original challenge.

The five stages are:

- EMPATHISE with and learn other points of view
- DEFINE the issue
- IDEATE / create possible solutions
- PROTOTYPE
- TEST their designs.



During this stage, students focus on finding out different points of view. They look for patterns and trends in the information they initially find out.

The main focus of this stage is reframing the challenge. The initial challenge is usually quite open, so at this stage students learn how to define what needs to be done. This includes noting insights that have been generated.

The Ideate stage is all about generating lots of ideas. Students need to be flexible in their thinking and be able to move beyond obvious ideas. At this stage, ideas are not judged, just generated and gathered.

At this stage students are asked to create a physical prototype of a solution. It is the stage where students need to get their ideas out of their heads and present them in a way that engages other students and helps them to understand the ideas. When students create, it helps them to think and solve problems and disagreements. Students can role-play, make storyboards or use sticky notes; the most important feature is that viewers can interact with whatever is produced.

At this stage students test their prototype to see if it meets the requirements of the audience or users, Students also check to see if their prototype meets the criteria set at the start of the design process. They are given the opportunity to cycle through the Prototype and Test stages again.

STEM INVESTIGATIONS AUTHORS

Charlotte Forwood holds a PhD (exploring student understanding of Science vocabulary) and a Master of Teaching. She has more than 20 years' experience teaching Upper Primary and Secondary students. She has recently been involved in a pilot STEM program, *High Possibility Classrooms*. As well as teaching and writing authoritative teaching and learning resources, Charlotte also presents at national and international conferences. Charlotte is currently the Director of Learning Design and Development at Camberwell Girls Grammar School.

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