

STRONG STRUCTURES

Teacher Guide

Term 2, 2023



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OVERVIEW



Strong Structures is an education program for years 3-7 that introduces the concept of structures and what makes them strong.

The program comprises a new, interactive and curriculum-aligned Challenge Course in the Makers Empire 3D design app. Through purpose-made video content, students learn about the different types and designs of strong structures and the science behind them. They explore how engineers and architects use scientific and mathematical knowledge to design strong structures. Students respond to the video content through in-app quizzes and design tutorials. The Challenge Course concludes with a Design Thinking Project which asks students to design a strong structure to help solve a problem of everyday life.

The Natural Disasters Challenge Course aligns with UN Sustainable Development Goal - #11 Sustainable Cities and Communities.

SCHEDULE

Before week 1

Download and read the Teacher Guide.
Watch 4 short webinars and set up ready to begin.

Week 1

Introduce students to Makers Empire 3D and complete in-app Basic Training tutorials, if not completed previously. If students are familiar with Makers Empire 3D software, they can refresh their skills by revisiting the Training Lab. The Video Room contains step-by-step videos narrated by student designers that can provide inspiration for students.

Weeks 2-6

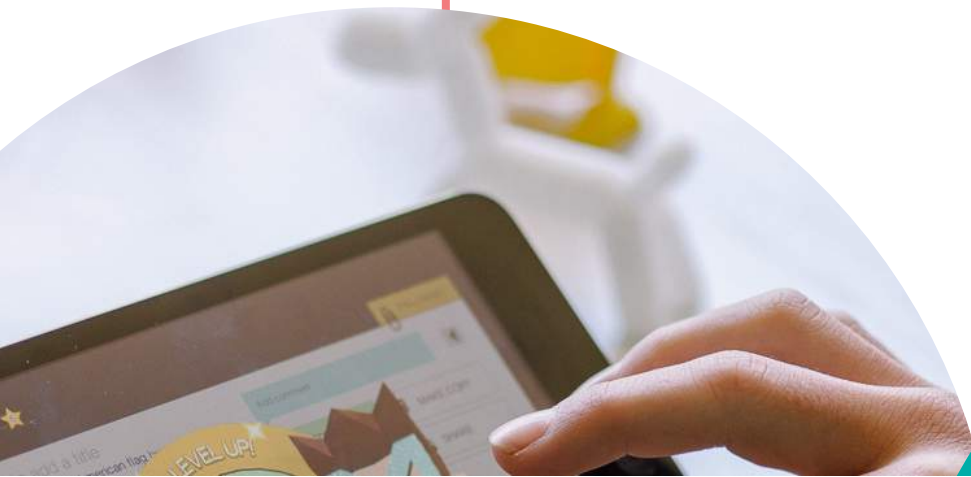
Teachers facilitate learning processes, with students using Makers Empire 3D to complete the in-app Strong Structures Challenge Course. Teachers attend optional Online Support Sessions on Tuesday 9 May.

Week 7-9

Teachers support student in their design thinking project, employing design thinking methodologies that engage students in empathising, defining, ideating, prototyping and testing their design solutions.

Week 10

Students reflect and share, communicating the key features of their design solution. Teachers complete an online survey. The survey invites schools to select 3 top student designs for inclusion in an Online Gallery created by Makers Empire.



COMPONENTS

Challenge Course Components

- 1 Video #1 - What makes a structure strong?
- 2 Quiz #1 - What makes a structure strong?
- 3 Pro-Training Design Tutorial #1 - Build a House: Learn the different parts that make a simple house
- 4 Video #2 - The science behind strong structures
- 5 Quiz #2 - The science behind strong structures
- 6 Pro-Training Design Tutorial #2 - Build a Beam Bridge: Strong materials, strong design
- 7 Video #3 - Which shape is the strongest for building?
- 8 Quiz #3 - Which shape is the strongest for building?
- 9 Pro-Training Design Tutorial #3 - Triangles and Trusses: A bridge built to last
- 10 Video #4 - Building strong structures
- 11 Quiz #4 - Building strong structures
- 12 Pro-Training Design Tutorial #4 - Heavy Lifting: A crane to carry the load
- 13 Video #5 - How Engineers and Architects solve the problems of everyday life
- 14 Quiz #5 - How Engineers and Architects solve the problems of everyday life
- 15 Design Thinking Project - Design a strong structure that solves an everyday problem
- 16 Reflect and Share - Students sharing their thinking and communicating key features of their design solution

CURRICULUM LINKS



Learning Objectives:

- Students will explore ways that scientific understanding is used by engineers and architects when they design strong structures.
- Students will learn about the important roles that materials and shapes play in the design of strong structures.
- Students will explore how and why engineers develop new innovations to solve problems when designing strong structures in challenging environments.
- Students will develop an awareness about the different types and designs of strong structures.
- Students will identify ways that strong structures help to solve problems in everyday life.
- Students will apply problem-solving and design thinking methodologies to design a strong structure aimed at solving a problem of everyday life.

Australian Curriculum Content Descriptions

Science

- Students investigate how scientific knowledge is used by engineers and architects to identify problems, consider responses and make decisions when designing and building strong structures. (ACSHE100 - v8.4, AC9S3H02, AC9S4H02, AC9S5H02, AC9S6H02 - v9)
- Students explain how new evidence or different perspectives can lead to changes in scientific knowledge which impact on the use of materials and designs of strong structures. (AC9S7H01 - v.9)
- Students examine the properties of natural and made materials including stone, wood, metal and concrete and consider how these properties influence their use in strong structures. (ACSSU074 - v8.4, AC9S4U04 - v9)
- Students recognise that forces can be exerted by one object on another through direct contact and that this influences the design of strong structures. (ACSSU076 - v8.4, AC9S4U03 - v9)
- Students investigate and represent balanced and unbalanced forces and explore how they act on the design features of strong structures including gravitational force, acting on objects. (AC9S7U04 -v9)

Science Elaborations

- Exploring Aboriginal and Torres Strait Islander knowledge, technologies and contributions to structural engineering including tools, machines and architecture.

CURRICULUM LINKS



Technologies

- Students investigate how forces and the properties of materials affect the function and behaviour of strong structures. (ACTDEK011 - v8.4, AC9TDE4K02 - v9)
- Students analyse how force, motion and energy are used to manipulate engineered, strong structures. (AC9TDE8K03 - v9)
- Students investigate and explain how the characteristics, properties and suitability of materials, systems and components can be used and combined in developing design solutions related to strong structures. (ACTDEK013, ACTDEK023 - v8.4) (ACTDE6K05, 9TDE8K06 - v9)
- Students recognise the role of people in design and technologies occupations and explore factors, including sustainability that impact on the design of strong structures when meeting community needs. (ACTDEK010, ACTDEK019 - v8.4) (AC9TDE4K01, AC9TDE6K01, AC9TDE8K01 - v9)
- Students consider the impact of natural disasters on the design of constructed environments such as the structural design of buildings and other strong structures. (ACTDEK010, ACTDEK019 - v8.4) (AC9TDE4K01, AC9TDE6K01 - v9)
- Students critique needs and opportunities when designing a strong structure to solve an everyday problem including the development of design briefs and selection of appropriate materials, tools and systems. (ACTDEP014, ACTDEP024 - v8.4) (AC9TDE4P01, AC9TDE6P01, AC9TDE8P01- v9)
- Students generate, iterate and communicate design ideas to address an everyday problem by designing a strong structure. (ACTDEP015, ACTDEP025 - v8.4) (AC9TDE4P02, AC9TDE6P02, AC9TDE8P02- v9)
- Students design accurate, innovative 3D models to scale using Makers Empire 3D modelling software. (ACTDEP016, ACTDEP026 - v8.4) (AC9TDE4P03, AC9TDE6P03, AC9TDE8P03- v9)
- Students create prototypes of their design ideas and develop tests to assess the suitability of their designed solutions. (ACTDEP016, ACTDEP026 -v8.4) (AC9TDE4P03, AC9TDE6P03, AC9TDE8P03 - v9)
- Students evaluate their designs against design brief criteria and respond to feedback from peers and teachers. (ACTDEP017, ACTDEP027 - v8.4) (AC9TDE4P04, AC9TDE6P04, AC9TDE8P04 - v9)
- Students work collaboratively to develop project plans and design solutions that meet timelines and design briefs. (ACTDEP018, ACTDEP028 v8.4) (AC9TDE4P05, AC9TDE6P05, AC9TDE8P05 -v9)

CURRICULUM LINKS



Mathematics

- Students recognise and perform transformations of shapes including rotations, translations, dilations and reflections using Makers Empire 3D software. (AC9M4P03, AC9M5P03, AC9M6P03, AC9M7P03 -v9)

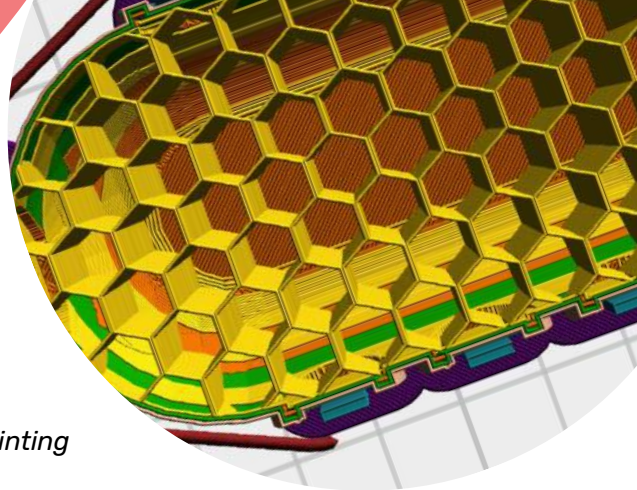
General Capabilities

The learning experiences are closely aligned with:

- Critical and Creative Thinking
- Numeracy: Measurement and Geometry
- Personal and Social Capability
- Ethical Understanding
- Intercultural Understanding



MORE TO EXPLORE



Honeycomb structure in 3D printing

Embedding the Challenge Course within a broader program of online and offline experiences, can enhance students' opportunities for design thinking. These More to Explore strategies can assist students to take time for deep engagement - reflecting, collaborating, thinking critically, ethically and creatively, researching and questioning ideas, reasoning, problem solving and extending their application of design tools.

Below are suggested strategies, some shared by teachers already incorporating design thinking, Makers Empire tools and Challenge Courses into their learning programs. Adopt, adapt or use these strategies as a springboard to innovate and design your own learning strategies that best meet your needs and context.

More to Explore | Design Thinking

Empathise

Learn about your audience | Gain deep and meaningful insights into the knowledge and experiences of others to better understand the problem

- Brainstorm what students already know about strong structures and invite them to share personal stories about strong structures in their everyday life. Consider the strong structures they might use in a day.
- As a class, watch video 1 and discuss the features of strong structures.
- Walk the school or local community to notice strong structures and collect data about shapes, materials and design features that make them strong. Notice both natural and human-made structures.
- Visit a bridge in your local community or view a range of bridges online and observe features such as beams, trusses, arches and suspensions. Discuss what makes the bridge strong. Identify the shapes used and the forces acting on the bridge. Videos 2-5 can assist learning and discussion.
- As Australia's first builders and architects, research First Nations knowledge about structures, building and engineering.
- If your school have a 3D printer, observe the preview of a 3D printed object in your school's 3D slicing software. Notice and discuss the infill pattern of hexagons, providing cost effective, lightweight strength to the printed model.



Honeycomb structure in nature

MORE TO EXPLORE



Define

Decide how you can best help your audience and where you can you make the biggest difference. Invest time in clarifying the problem to help achieve a more successful solution

- As a class or as individuals, students interview a community member who contributes to the planning or building of strong structures in their local community. Discuss how their knowledge of STEM assists them in their role.
- As a class discuss and develop 'How might we...?' questions to determine how best to solve the challenge.
- To increase intellectual challenge for students, consider including design constraints as part of the design brief (e.g. that the structure must include triangles, or that the structure must be able to hold the weight of a heavy book). Constraints and parameters can also enhance creative and innovative thinking.

Ideate

Be creative and think of as many solutions as you can

- Use a range of ideating strategies such as mind mapping, storyboarding, brainstorming and sketching, to encourage students to generate many possible solutions to think beyond the obvious and address the challenge.
- Access online digital collaboration tools such as Padlet and Lucidspark, to assist students to collaborate on brainstorming and mind mapping ideas.
- Structuring the ideation process, such as adding time limits and quantity goals, can promote a free flow of ideas. For example, 'Aim for 100 ideas in 10 minutes.'

Prototype

Make something that explains your best ideas to other people. Rough is okay!

- Engage students in a process to rank and select an idea to prototype first. They may consider variables such as the most original idea, the idea they think will have most success or the idea they think will benefit more end users.
- Students create prototype models of strong structures to assist with the development of their in-app design. Students can explore the different ways they might manipulate materials to strengthen and reinforce the structure including twisting, braiding, layering and changing shape and thickness. Design challenges may include:
 - Design a structure using only paper that will hold the weight of a heavy book.
 - Using everyday materials (such as toothpicks, playdough and jelly lollies), build a bridge to hold the weight of a heavy object.

MORE TO EXPLORE



- As a class, discuss the importance of investing time in their design to ensure it meets their design criteria. Highlight the 'effort score' with students as one tool that can assist you as their teacher, to measure effort and design skills. The effort score is a complex algorithm designed by Makers Empire that incorporates a combination of time, editing and complexity within a student design. <https://help.makersempire.com/en/articles/3367438-what-is-the-effort-score>
- Students add notes (written or audio) to their prototype within the app to help explain their design choices. <https://help.makersempire.com/en/articles/5699829-how-do-i-use-notes-on-a-design>
- Students create a video of their prototype to pitch it to others and explain its design features

Test

Show your prototypes to your audience to see if they work, or if you can make them better!

- Invite students to use the 'notes' tool to reflect on how well their design achieved its purpose, how effectively it met the design criteria and how they might change their design in further iterations to better meet the design criteria.
- Students seek critical feedback from peers and teachers.
- Students work with a partner to reflect on the design process and communicate their thinking. Reflective questions could include: What did my first iteration teach me? How did I improve my design? What skills did I learn? What did I find hard and how did I overcome any challenges? What might I do differently next time? What am I left wondering about? How might I learn more?
- Students visit the Gallery tab in the app and search for their friend's design to open the design and add comments. Your school's privacy setting can be managed from the Teacher Dashboard. <https://help.makersempire.com/en/articles/867135-what-are-my-options-re-student-privacy-and-sensitive-content>
- View time and effort put into student designs via the Teacher Dashboard. Provide feedback and pose design challenges to nudge thinking.
- Provide tokens to students to acknowledge effort and increase motivation <https://help.makersempire.com/en/articles/759997-how-can-i-unlock-shapes-or-give-tokens-to-my-students>

Repeat

Your first idea probably won't be perfect. That's okay - keep trying

- Invite students to research prototypes in the everyday world that began their life as prototype failures, from bubble wrap to pacemakers, and discuss the importance of failure as a part of a growth and innovation mindset. <https://www.makersempire.com/4-failures-why-prototyping-matters/>

MORE TO EXPLORE



More to Explore | Online Design Tools

- Students explore the pro-training design tutorials with a partner and take turns to teach their partner new skills and seek support on areas where they are stuck.
- Students revisit the Training Lab's Video Room to be inspired by the curated and narrated designs shared by others student designers.
- Students revisit the Training Lab to refine their design skills in the Pro-Training Tutorial Room, using the filter tabs to target areas of need such as rotating or grouping shapes.
- Students create their own Pro-Training Tutorials using the 'notes' feature to add instructions and teach someone a new skill.
- Students teach a new design skill to the class, highlighting where they got stuck and how they overcame challenges.
- Students incorporate the audio capability of the 'notes' feature to add dialogue, narration or sound effects to their designs.
- Students share their prototype failures (such as 3D printed models, models constructed with natural materials, in-app designs, drawings) to the class and share how they used testing and feedback to improve their design solution.
- Students use the augmented reality capability to visualise and test their 3D designs in authentic, place-based contexts, which can assist them to present and pitch their design solution to others.



ADDITIONAL RESOURCES

With recommended year levels



Strong Structures

- Ritchie, S, 2011, ***Look at That Building! A First Book of Structures***, Kids Can Press, Years 3-4
- Agrawal, R & Hickey, K, 2021, ***How Was That Built? The Stories Behind Awesome Structures***, Bloomsbury Publishing PLC, Years 4-7
- Dillon, P & Biesty, S, 2014, ***The Story of Buildings: From the Pyramids to the Sydney Opera House and Beyond***, Candlewick Press, Years 4-7
- Shand, J & Bassani, S, 2018, ***How Do Bridges Not Fall Down?: A Book about Architecture & Engineering***, Flowerpot Press, Years 3-7
- Carol A. Johmann & Elizabeth Rieth, 1999, ***Bridges: Amazing Structures to Design, Build & Test***, Williamson Pub, Years 3-7
- Graham, I, 2012, ***Megastructures: tallest, longest, biggest, deepest***, Firefly Books Years 6-7
- ABC Education, ***For the Juniors, First the Base, then the Frame***, Years 3-4
<https://www.abc.net.au/education/for-the-juniors-first-the-base-then-the-frame/13849550>
- ABC Education, ***Catalyst, Science, The Physics of a Slinky Drop***, Years 3-8
<https://www.abc.net.au/education/catalyst-the-physics-of-a-slinky-drop/13920394>
- ABC Education, ***For the Juniors: Tall Buildings that won't Fall***, Years 3-4
<https://www.abc.net.au/education/for-the-juniors-tall-buildings-that-wont-fall/13849520>
- ABC Education, ***Elliot and the Surfing Scientist: Shrinking and Expanding Metals***, Years 5-8
<https://www.abc.net.au/education/elliot-and-the-surfing-scientist-shrinking-and-expanding-metals/13887188>
- Design Squad Global, ***Strong Structures with Triangles***, Years 3-7
<https://www.youtube.com/watch?v=mBHJtWbsiaA>
- SciShow Kids, ***What Makes Bridges So Strong?*** Years 3-4
<https://www.youtube.com/watch?v=oVOnRPefcno>
- ***How Stuff Works, How Bridges Work***, Lamb, R, Morrissey, M & Kiger, P, 2000, Years 5-7
<https://science.howstuffworks.com/engineering/civil/bridge1.htm>
- Reel Truth Science, ***Engineering Connections: Earthquake Proof Bridge with Richard Hammond***, 49.58min documentary, Years 4-7
https://www.youtube.com/watch?v=dQf_vE7tOlw&t=2542s
- Reel Truth Science, ***Engineering Connections: Burj Al Arab Hotel with Richard Hammond***, 49.58min documentary, Years 4-7
<https://www.youtube.com/watch?v=1jFMroHSi0Y>

Design Thinking

- Beaty, A & Roberts, D, 2013, ***Rosie Revere, Engineer***, Years 3-7
- FableVision, 2011, ***Above and Beyond*** Years 3-7
<https://www.youtube.com/watch?v=7KMM387HNQk>

Makers Empire Online Resources

- Visit the Makers Empire Free Resources to find posters, guides and printables that may assist students with their learning.
<https://www.makersempire.com/free-resources/>

WEEKLY EMAILS

You will receive a weekly email from Makers Empire to support your involvement in the Managed Project. These emails will outline helpful information aligned to the schedule, a tip of the week and suggestions for enhancing learning and engagement.



ONLINE SUPPORT SESSION

An Online Support Session will be offered to support your involvement with the Managed Project:
Focus: Design Thinking, sharing, questions

Tuesday 9 May

4:00PM - 4:30PM

<https://us02web.zoom.us/j/4875989195>

Sessions will be facilitated consecutively to coincide with the 4:00-4:30PM timeslot in your time zone.

Additional zoom calls can be facilitated as the need arises. Contact us at **info@makersempire.com** to book a date and time.





NEED HELP?

Contact us:

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