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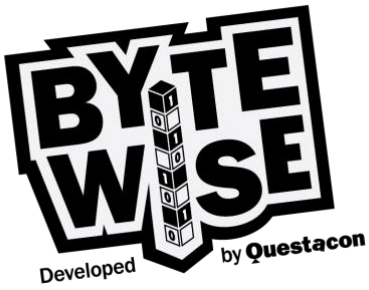

Byte Wise Exhibition Notes

Overview

The Questacon travelling exhibition *Byte Wise* is targeted at visitors aged 10 to 15 years but is also accessible to the broader public.

There are 24 exhibits in the *Byte Wise* suite. These interactive exhibits explore principles from mathematics and computational thinking.

This document lists the *Byte Wise* exhibits and their details, including: descriptions; key themes and subject areas; and links to the Australian national **Mathematics** and **Digital Technologies** curriculums.

Support Questions

Use the following questions to strengthen the educational experience of students, and to help connect exhibit concepts to their everyday lives.

- Have you ever had to turn something off and on to fix it? Why did that help?
- Why are some dice-roll results more likely than others?
- How many different ways can the pips on two dice add to seven?
- How many ways can the pips on two dice add to three?
- How and why do computers use binary to encode information?
- How do you write a basic set of instructions for a computer?
- Can you make a computer that doesn’t use electricity?
- How are decision-making components designed in a mechanical computer?
- Can you beat a computer at a simple game like noughts-and-crosses?

Amazing Rooms

Figure 1: Amazing Rooms exhibit

Trace a path through a house only using each door once.

How it works

Starting outside the house use the rope to trace a path through the house that goes through every door once.

Things to Try or ask around the exhibit

- Can you trace a path that ends inside the house?
- Can you trace a path that ends outside the house?

Background

In mathematics there are paths you can define called Euler paths and Euler Circuits. Euler paths don't need to begin and end at the same point while Euler circuits do. Because the house has an odd number of doors only a Euler Path is possible to trace with the rope.

Finding the science in your world

Euler path rules can be used to solve problems like reconstructing ancient DNA sequences and building electrical circuits.

Themes

Mathematics: Topology, position, pathways, logic reasoning.

Subject Areas

Mathematics – Geometry and location.

Devious Dice

Figure 2: Devious Dice exhibit

Explore the random nature of a single dice roll, and the predictable nature of many dice rolls.

How it Works

Roll the dice and place tokens in the columns based on the outcome of the roll.

Things to Try or Ask Around the Exhibit

- What shape do the columns of tokens form?
- What does this tell you about the likelihood of certain results?
- How does it change if you roll different numbers of dice?

Background

The distributions of tokens these dice rolls produce, including the common 'normal distribution,' are found in many natural processes.

Finding the Science in Your World

Understanding the expected distribution of a set of data can help detect external influences on a system, and even detect fraud.

Themes

Mathematics: randomness, statistics, probability

Subject Areas

Mathematics – Statistics and Probability

Flip Out

Figure 3: Flip Out exhibit

Explore number representation in the binary counting system.

How it Works

Flip the blocks provided to see numbers represented using both binary and decimal counting systems.

Things to Try or Ask Around the Exhibit

- How high can you count with the blocks provided?
- How many ways are there of representing each number in binary?
- If you added another block to the left, how many dots would be on it to continue the pattern?

Background

Binary is a base two counting system, meaning it only requires two digits: 0 and 1. The two faces of the blocks in this exhibit stand in for these two states.

Finding the Science in Your World

Computers use a binary counting system because it is simple to produce a system that switches between and reads only two states.

Themes

Mathematics: number and place value, decimal, binary, base numbers

Subject Areas

Mathematics – Number and place value.

Get Over It

Figure 4: Get Over It exhibit

Not all puzzles have solutions!

How it Works

Starting on any part of the land, try to plot a path that crosses each bridge only once.

Things to Try or Ask Around the Exhibit

- Is the challenge with fixed bridges possible? How do you know?
- What if you change the number of bridges?

Background

Some problems do not have solutions, and it's important to be able to know when this is the case.

This puzzle, based on an actual historical situation in the city of Königsberg, has been proven to be unsolvable with certain numbers of bridges.

Finding the Science in Your World

This problem, and others like it, led to huge advances in the fields of topology, networking and combinatorics.

Themes

Science: pose questions

Subject Areas

Mathematics: graph theory, patterns

Science – Pose and ponder questions

Hexominoes

Figure 5: Hexominoes exhibit

Explore polyominoes by creating larger copies of each shape.

How it works

By combining the four shapes in different ways larger versions of each shape can be created.

Things to Try or ask around the exhibit

- How much bigger is each created shape than its smaller version?

Background

Polyominoes are shapes made up of collections of squares joined in different ways.

Finding the science in your world

Dominoes are the most well-known polyominoes and are made up of two squares. The game *Tetris* uses tetrominoes – shapes made up of four connected squares.

Themes

Mathematics: two-dimensional shapes, puzzle, topology, geometry

Subject Areas

Mathematics – Measurement and Geometry.

Hidden Images

Figure 6: Hidden Images exhibit

Use pixels to represent pictures and shapes.

How it Works

Create patterns and shapes using a board of colour-flipping tiles - a simple 'digital' display.

Things to Try or Ask Around the Exhibit

- What shapes and pictures can you make?
- How complex an image can you make with this board?
- What if you had a larger one?

Background

These squares are examples of *pixels*, which are used to create images on digital displays.

Finding the Science in Your World

Pixels are used in many displays, from mobile phone and television screens, up to enormous digital cinema projectors.

Themes

Digital Technologies: programming, encoding, image representation

Subject Areas

Digital Technologies – Knowledge and understanding

Hyperbolic Curves

Figure 7: Hyperbolic Curves exhibit

Straight lines can be used to approximate curves.

How it Works

Turn a wheel to pull straight strings in different directions.

Things to Try or Ask Around the Exhibit

- The strings remain straight, but can you see shapes that appear to have curved edges emerge?
- How can you make this illusion more convincing?

Background

Curved surfaces can be formed from straight lines - in this case from the *negative space* around the lines.

This shape is called a **hyperboloid**.

Finding the Science in Your World

Building such as Centrepoint Tower in Sydney use hyperboloids as structural elements, forming the high-tension cables to form a hyperboloid.

Computers use square pixels to draw curved elements on digital displays in a similar way.

Themes

Mathematics: geometry, shapes, three-dimensional shapes, two-dimensional shapes, mod

Subject Areas

Mathematics – Measurement and geometry.

Interference Patterns

Figure 8: Interference Patterns exhibit

Overlay the cards to create unexpected patterns.

How it Works

When similar patterns are laid over each other, other shapes start to become visible. These are called moiré patterns.

Things to Try or Ask Around the Exhibit

- Try moving the cards at different speeds and in different ways. Do you see the moiré patterns change?
- Do the patterns move differently when you move the cards left-to-right, as opposed to up-and-down?

Background

Moiré patterns arise because of differences between two superposed patterns, and while they can be visually impressive they are not always desirable.

Finding the Science in Your World

Moiré patterns appear when looking through multiple fly screens, viewing particular patterned clothing on televisions, and are used to prevent photocopying of certain protected documents.

Themes

Mathematics: two-dimensional shapes, patterns, symmetry

Subject Areas

Mathematics – Measurement and Geometry.

Knight’s Tour, Tourist’s Drive

Figure 9: Knight's Tour, Tourist's Drive exhibit

Using network maps the same problem can be shown in two different ways.

How it works

Take the knight piece on a tour of the board. If that is too difficult there is an easier tourist drive to complete.

Things to Try or ask around the exhibit

- Can you use the numbers on the Tourist’s Drive to complete the Knight’s Tour?

Background

The Tourist’s Drive is a network map of the Knight’s Tour. It is just a different way of showing the connections between each move.

Finding the science in your world

Network mapping is used to visualise very big and complicated networks, such as the internet.

Themes

Digital technologies: algorithms, programming, steps and decisions, problem solving.

Mathematics: comparisons, networks, simple maps, position, pathways, logic reasoning, puzzle.

Subject Areas

Digital technologies – Processes and production skills

Mathematics – Geometry, location and transformations.

Maths on the Map

Figure 10: Maths on the Map exhibit

How many colours do you need on a map?

How it Works

Place tiles to create coloured regions on a map. Can you place the tiles such that no two areas of the same colour touch?

Things to Try or Ask Around the Exhibit

- How many colours do you need to complete this challenge?
- Do you need more colours if the map gets more complicated?

Background

This type of map-colouring problem is a famous solved problem in mathematics. The related *four colour theorem* was the first major theorem to be proven using a computer.

Finding the Science in Your World

Problems like this one occur in a surprising number of places, from colouring actual maps to deciding where to place mobile phone towers.

Themes

Mathematics: geometry, tessellation, two-dimensional shapes, patterns,

Subject Areas

Mathematics – Measurement and Geometry.

Mirror Mirror

Figure 11: Mirror Mirror exhibit

How many different shapes can you make using a single shape and a mirror?

How it works

Using the shape and mirror provided try to create as many new shapes as possible.

Things to Try or ask around the exhibit

- Are some shapes impossible to make with just a mirror?

Background

The ability to imagine how a shape changes when looked at through a mirror is called spatial reasoning.

Finding the science in your world

We use spatial reasoning to navigate our way around the world without tripping over things.

Themes

Mathematics: geometry, tessellation, two-dimensional shapes, patterns,

Subject Areas

Mathematics – Measurement and Geometry.

Multimaze

Can you navigate a maze that changes every time you use it?

How it Works

Turn dials to change the pathways you can take through the maze!

Things to Try or Ask Around the Exhibit

- Is there one strategy that will always work, or will you have to change your plan every time?
- Can you find configurations that make the maze easier or harder?
- Try creating a challenge for a friend to solve!

Background

When someone uses a computer they change its internal state; this can make troubleshooting hard for future users! This is why turning a device off and on again can fix many problems.

Finding the Science in Your World

Programmers have to find ways to write programs that will work given any initial state of a computer or ensure the computer will be in a configuration that allows their programs to run.

Themes

Digital Technologies: decisions, problem solving, user input.

Subject Areas

Digital Technologies – Processes and production skills.

Placing Pipes

Figure 12: Placing Pipes exhibit

Explore algorithmic thinking by finding the most efficient way to place sections of pipe.

How it works

Place the sections of pipe in the channels so that there is as little wasted space as possible.

Things to Try or ask around the exhibit

- Is there more than one way to place the pipes in the channels?
- What is the most efficient way to place the pipes?
- Can you find the least efficient way to place the pipes?

Background

Algorithmic Thinking is a highly ordered form of thinking that we use in order to find solutions by following logical steps.

Finding the science in your world

Finding the most efficient way to cut and place materials with the fewest possible cuts helps to reduce the amount of waste left over.

Themes

Mathematics: volume, length, height, width, three-dimensional shapes, comparisons

Digital Technologies: sorting, steps and decisions, problem solving

Subject Areas

Mathematics - Measurement and Geometry

Digital Technologies – Processes and production skills

Pythagoras Wheel

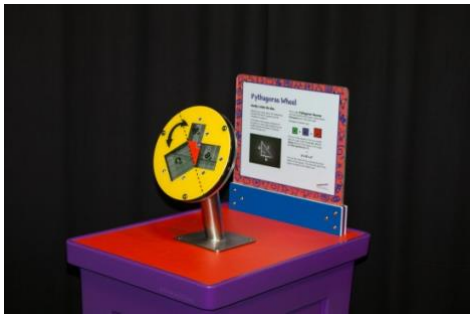

Figure 13: Pythagoras Wheel exhibit

Pythagoras' theorem describes the relationship between the sides of right angle triangles.

How it Works

Rotate a wheel to allow fluid to flow between squares made from the sides of a right-angle triangle.

Things to Try or Ask Around the Exhibit

- What is the relationship between these squares?
- Is this true for every right-angle triangle?

Background

Pythagoras was the first person to prove this theorem over 2500 years ago. He proved it using a geometric proof similar to the method demonstrated here.

Finding the Science in Your World

Engineers and designers need to know the relationships between shapes when designing structures; Pythagoras' theorem is a powerful method in their toolbox.

Themes

Mathematics: geometry, Pythagoras’ theorem.

Subject Areas

Mathematics – Measurement and Geometry.

Noughts-and-Crosses

Figure 14: Noughts and Crosses exhibit

Some games can be played perfectly even by simple computers; noughts-and-crosses is one of them.

How it Works

Play against the “computer” in a game of noughts-and-crosses!

Things to Try or Ask Around the Exhibit

- Try different strategies! Is there any way you can win?
- What is the computer's strategy?

Background

Conditional logic, the kind of logic used in this program, forms the foundation for many more complicated algorithms.

Finding the Science in Your World

Conditional statements are used to tell computers how to do a huge number of things, from when to capitalise a letter to which route a GPS should take.

Themes

Digital Technologies: problems, decisions.

Subject Areas

Digital Technologies – Processes and production skills.

Shifting Shapes

Figure 15: Shifting Shapes exhibit

Discover how shapes combine in a hands-on geometric puzzle.

How it Works

Complete the tangrams provided using pieces of various shapes and sizes, then try your hand at reconstructing a dissected pyramid.

Things to Try or Ask Around the Exhibit

Is there more than one way to complete each puzzle? Can you prove it?

Background

Studying puzzles like these helped mathematicians make significant discoveries in areas like geometry.

Finding the Science in Your World

When stacking objects for transportation it's important to know how objects fit together and what shapes they create!

Themes

Mathematics: two-dimensional shapes, three-dimensional shapes, puzzle, topology, geometry.

Subject Areas

Mathematics – Measurement and Geometry.

Snakes

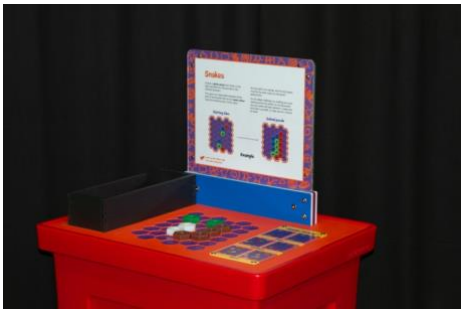

Figure 16: Snakes exhibit

Think outside the box to solve this unconventional maze problem!

How it Works

Use the coloured tiles to create paths between start and end points without any paths overlapping.

Things to Try or Ask Around the Exhibit

- Try designing your own version of this puzzle. Be warned that not all puzzles you can create will have solutions!
- What makes a puzzle like this easy or difficult?

Background

Maze-type puzzles like this one encourage lateral thinking and visual problem solving skills, and explore geometric configurations and tessellating shapes.

Finding the Science in Your World

This is sometimes called the "Plumber's Problem." When designing buildings care has to be taken to not let certain pipes and cables overlap!

Themes

Mathematics: simple maps, position, pathways, logic reasoning

Subject Areas

Mathematics – Measurement

Geometry – Geometric reasoning.

Sorting Mat

Figure 17: Sorting Mat exhibit

Sort human-shaped tokens on this bench-top exhibit, or try a large, carpet version that sorts real people!

How it Works

Use a simple sorting method to order objects and people by height.

Things to Try or Ask Around the Exhibit

- How quickly does this sorting method find the shortest or tallest objects?
- Is there a limit on how many objects could be sorted at once like this?

Background

It is important for computers to be able to sort lists efficiently. This exhibit investigates one way of sorting objects, but there are many others, each with their own advantages and disadvantages.

Finding the Science in Your World

Any time a computer places objects from a list into an order it uses a sorting algorithm. Internet search engines are successful when they are able to quickly sort huge numbers of results (e.g. sorting a list of websites by how closely they match your search terms).

Themes

Digital technologies: sorting, algorithms, classifications, patterns.

Subject Areas

Digital Technologies – Knowledge and understanding

Mathematics – Measurement and Geometry.

Squares and Cubes

Figure 18: Squares and Cubes exhibit

Stack blocks to make large structures and explore different aspects of that object's size.

How it Works

Investigate how the volume of a structure changes with its other dimensions by stacking cubes.

Things to Try or Ask Around the Exhibit

- Does volume or side length change more quickly as you place more blocks?
- Can you determine what the relationship between volume, area and width is by building larger and larger cubes?

Background

Different aspects of an object's size grow at different rates depending on their dimensionality.

Finding the Science in Your World

Engineers need to know this relationship when designing large structures, as volume and surface area determine different structural properties of materials.

Themes

Mathematics: volume, length, height, width, perimeter, surface area, three-dimensional shapes, cube, comparisons

Subject Areas

Mathematics - Measurement and Geometry.

The Why of Pi

Figure 19: The Why of Pi exhibit

Explore the famous physical and mathematical constant π in this hands-on exhibit.

How it Works

Rotate a wheel along a line to find the length of the wheel's circumference and discover the origins of π.

Things to Try or Ask Around the Exhibit

- How many times does the wheel fit along the line?
- Is it a whole number?
- Does the size of the wheel matter?

Background

π is the ratio between a circle's circumference and its diameter, so the number of times you can fit the wheel inside the line is exactly π.

Finding the Science in Your World

π is studied and used widely in physics and mathematics, due both to its applications in real systems and interesting properties as a number.

Themes

Mathematics: patterns, circle, measurement, fractions, rounding, irrational numbers, π, relationships, rational numbers.

Subject Areas

Mathematics – Number and algebra.

Travel Troubles

Figure 20: Travel Troubles exhibit

Use lateral thinking to solve classic stacking and algorithmic problems.

How it Works

1. Move a stack of discs from one peg to another in the right order while obeying a set of rules!
2. Find a way of transporting a fox, goose and sack of corn safely across a river.

Things to Try or Ask Around the Exhibit

- Can you devise a set of instructions that will always work?
- How many moves do you need to complete the puzzles?
- How would your method change if there were more objects in the puzzles?

Background

Both these problems can be solved using iterative algorithms, which form the foundation for many in computer programs.

Finding the Science in Your World

Modern computers can solve a huge variety of problems using algorithms like those needed to solve these puzzles.

Themes

Digital technologies: algorithms, programming, steps and decisions, problem solving.

Subject Areas

Digital technologies – Processes and production skills.

Travelling Salesman

Figure 21: Travelling Salesman exhibit

The travelling salesman is a classic maths problem that still interests scholars around the world.

How it Works

Travel from city to city, paying tolls based on what roads you take.

Things to Try or Ask Around the Exhibit

- What is the cheapest route you can find?
- How do you know if you've found the cheapest route?
- Try using different maps; are some harder than others?

Background

For some problems it can be relatively easy to find a *good* solution, but may be very hard to find the *best* solution. The travelling salesman is a classic example of such a problem.

Finding the Science in Your World

Navigation software solves a version of the travelling salesman problem in many situations, from planning trips to designing delivery routes (substituting the tolls in the version presented here for 'distance' or 'travel time' perhaps in the real world).

Themes

Digital technologies: solve simple problems.

Mathematics: counting, comparisons, addition, map reading.

Subject Areas

Digital Technologies – Knowledge and understanding.

Mathematics – Geometry location and transformations.

What Sort Are You?

Figure 22: What Sort Are You? exhibit

Sorting algorithms are employed by computers to determine how to order lists.

How it Works

Use various sorting algorithms to sort objects by weight!

Things to Try or Ask Around the Exhibit

- Can you come up with your own sorting methods?
- What are the advantages and disadvantages of each method?

Background

There are many ways computers can sort lists of objects, each with its own strengths and weaknesses.

Finding the Science in Your World

Any time a computer orders a list of objects it uses a sorting algorithm. Internet search engines are successful when they are able to quickly sort huge numbers of results (e.g. sorting a list of websites by how closely they match your search terms).

Themes

Digital technologies: algorithms, programming, comparisons, ordering.

Subject Areas

Digital Technologies – Knowledge and understanding.

3UP 4UP

Figure 23: 3UP 4UP exhibit

Explore finite states to identify impossible problems.

How it works

Follow the rules to flip the blocks so that only one colour is on each side.

Things to Try or ask around the exhibit

- Can you get all three blocks red by flipping two at a time?
- How many flips does it take to make all the blocks blue?

Background

This exhibit demonstrates finite states that are either incredibly easy or impossible to accomplish.

Finding the science in your world

Logical problem solving can help you identify if a problem is impossible before you attempt it, saving time and effort.

Themes

Digital technologies: algorithms, programming, steps and decisions, problem solving.

Subject Areas

Digital technologies – Processes and production skills.

Australian Curriculum Links

Byte Wise exhibits link to the Australian National Curriculum across all years, particularly in Mathematics and Digital Technologies. Core links indicate content that is directly covered within the exhibition, while optional links indicate content that depends on how exhibits are facilitated or presented.

Foundation – Year 2 core links

- Data Representation and Interpretation (ACMSP263)
    - Represent data with objects and drawings where one object or drawing represents one data value. Describe the displays
- Digital Technologies Processes and Production Skills (ACTDIP004)
    - Follow, describe and represent a sequence of steps and decisions (algorithms) needed to solve simple problems
- Digital Technologies Knowledge and Understanding (ACTDIK002)
    - Recognise and explore patterns in data and represent data as pictures, symbols and diagrams

Foundation core links

- Number Place and Value (ACMNA289)
    - Compare, order and make correspondences between collections, initially to 20, and explain reasoning
- Patterns and Algebra (ACMNA005)
    - Sort and classify familiar objects and explain the basis for these classifications. Copy, continue and create patterns with objects and drawings

Year 1 core links

- Using Units of Measurement (ACMMG019)
    - Measure and compare the lengths and capacities of pairs of objects using uniform informal units

Year 1 optional links

- Data Representation and Interpretation (ACMSP262)
    - Choose simple questions and gather responses and make simple inferences

Year 2 core links

- Using Units of Measurement (ACMMG037)
- Compare and order several shapes and objects based on length, area, volume and capacity using appropriate uniform informal units
- Using Units of Measurement (ACMMG038)
- Compare masses of objects using balance scales

Year 2 optional links

- Shape (ACMMG043)
    - Describe the features of three-dimensional objects
- Number and Place Value (ACMNA028)
    - Group, partition and rearrange collections up to 1000 in hundreds, tens and ones to facilitate more efficient counting

Year 3 optional links

- Using Units of Measurement (ACMMG061)
    - Measure, order and compare objects using familiar metric units of length, mass and capacity
- Chance (ACMSP067)
    - Conduct chance experiments, identify and describe possible outcomes and recognise variation in results

Years 3-4 core links

- Digital Technologies Processes and Production Skills (ACTDIP010)
    - Define simple problems, and describe and follow a sequence of steps and decisions (algorithms) needed to solve them

Year 3-4 optional links

- Digital Technologies Processes and Production Skills (ACTDIP011)
    - Implement simple digital solutions as visual programs with algorithms involving branching (decisions) and user input

Year 4 optional link

- Using Units of Measurement (ACMMG084)
    - Use scaled instruments to measure and compare lengths, masses, capacities and temperatures
- Shape (ACMMG087)
    - Compare and describe two dimensional shapes that result from combining and splitting common shapes, with and without the use of digital technologies

Year 5-6 core links

- Digital Technologies Knowledge and Understanding (ACTDIK015)
    - Examine how whole numbers are used to represent all data in digital systems

Year 6 core links

- Shape (ACMMG140)
- Construct simple prisms and pyramids

Year 7-8 optional links

- Digital Technologies Knowledge and Understanding (ACTDIK024)
    - Investigate how digital systems represent text, image and audio data in binary

Year 8 core links

- Real Numbers (ACMNA186)
- Investigate the concept of irrational numbers, including π

Year 8 optional links

- Using Units of Measurement (ACMMG197)
    - Investigate the relationship between features of circles such as circumference, area, radius and diameter. Use formulas to solve problems involving circumference and area

Year 9 core links

- Pythagoras and Trigonometry (ACMMG222)
- Investigate Pythagoras' Theorem and its application to solving simple problems involving right angled triangles

Year 10 optional links

- Using Units of Measurement (ACMMG242)
    - Solve problems involving surface area and volume for a range of prisms, cylinders and composite solids
- (ACARA website): Year 10 Chance (ACMSP246)
    - Describe the results of two- and three-step chance experiments, both with and without replacements, assign probabilities to outcomes and determine probabilities of events. Investigate the concept of independence.