re(Solve) MATHS BY INQUIRY

SPECIAL TOPIC 6

Mathematics and Algorithmic Thinking

Overview

This topic will introduce students to the possibilities of computer-based mathematics, showing how it complements, extends, and enriches traditional mathematical methods, and demonstrating the methods with which mathematicians work in the real world. The topic is made up of 3 different subject areas under a common heading: "How algorithmic thinking helps us decipher a complex world":

- Understanding data through visualisation (9+)
- Understanding behaviour through simulation (10+)
- Understanding pattern formation through generative geometry (8+)

The first subject area focuses on how algorithms can be used to extract knowledge from real world data. The other two subject areas focus on understanding phenomena in the real world by investigating the processes that drive them, written as algorithms and brought to life by simulations.

Each subject area will be covered by two units, an Application unit and a Behind-the-scenes unit.

Application units:

- Introduce students to the subject without requiring coding.
- Contain computer-based as well as "unplugged" activities.
- Do not require progression to the corresponding Behind-the-scenes unit.

Behind-the-scenes units:

- Unpack parts of the computation introduced in the Application unit.
- Focus on the mathematics but assume prior exposure to basic coding.
- Require some knowledge of the subject area from the Application units before coding. Advice will be provided on which tasks to cover from the Application unit.

The pedagogical emphasis of all materials will be the mathematical aspects and not the coding. The explorations included will range from bite-sized investigations where students are guided step by step, to open-ended explorations where students design their own projects. Software has been selected to be free, easy to install (or used in browser), easy to learn and uncomplicated to use.

Core development team

Professor Bernd Meyer, Eugene Roizman, Toan Kien Huynh.

Australian Curriculum: Mathematics

The approach is fully consistent with the Australian Curriculum: Digital Technologies and the Australian Curriculum: Mathematics. Curriculum links will be expressly indicated in each lesson plan.

Special requirements

Students will need computers (individual or pairs) and the teacher may want to use data projection. Trial schools will require a local Python installation (Anaconda distribution, freely available), Chrome browser, Excel, and other unit-specific software (described in the following tables). Detailed installation instruction will be provided with each unit.

Seashell and corresponding simulated pattern: Hans Meinhardt, MPI for Developmental Biology, Tübingen. Creative commons: http://rstb.royalsocietypublishing.org/content/370/1666/2014

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Trialling Requirements

We are asking teachers to choose at least one unit to trial with their class. Unit content and availability is up to date at time of writing but may change to a small extent.

Program time required

Each unit is planned to last for approximately 3 weeks, with additional optional open-ended tasks supplied. The combination of an application unit and the corresponding coding unit will require 4 - 5 weeks. These times represent minimum requirements: most modules can be used for significantly longer explorations if desired.

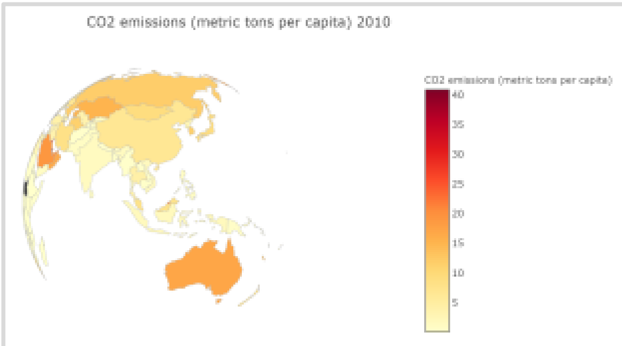
Materials can be accessed from the Members section of the reSolve website http://www.resolve.edu.au. Email mbi@science.org.au to trial.

Feedback to help us improve the lessons can be provided by:

- Completing the short online survey (a link is provided on the lesson plans) AND
- Completing the Detailed Feedback questions provided for each lesson, and emailing to us AND/OR
- Making comments on the lesson plan or on student work, then scanning and emailing to us OR
- Phoning us if preferred to give your detailed responses verbally.

Some of our best feedback is obtained when another teacher observes the lesson. If you are able, have a colleague observe and provide additional feedback, or if you wish, contact us and we may be able to arrange for an external observer.

For information about Special Topics, contact Director of Special Topics Kaye.Stacey@science.org.au or Lucy.Bates@science.org.au.To find out more about reSolve Mathematics by Inquiry, visit http://resolve.edu.au or contact mbi@science.org.au.



Rotating world map created from 2010 World Bank Data

Term 4 2017 (available approximately 14th October 2017)			
Unit	Year	Summary	Software Used
Understanding Data through Visualisation - Application Unit	9+	Computer-based data visualisation and analysis can help us discover meaning that is hiding in a data set. In this unit students will start with raw data and apply different visualisation/analysis methods until the data has "given up its secrets". Activities will generally use meaningful real-world data collections such as World Bank Open Data, or data collected by students. Standard visualisations (e.g. line plots, box plots, scatter plots, histograms) will be used, as well as new visualisation methods (e.g. the rotating map illustrated above) and advanced methods that form the basis of “big data” processing.	Chrome, Python (Anaconda dist.), Excel
Understanding Data through Visualisation - Behind the Scenes Unit	9+	This unit will be accessible with beginner’s level coding skills, as students work with examples from the application unit and vary them creatively. Exercises will let students explore data manipulation and generate interactive and creative visualisations. More advanced students can explore clustering of high-dimensional data.	Chrome, Python (Anaconda dist.), Excel

Term 1 2018 (available approximately 7th February 2018)

Unit	Year	Summary	Software Used
Understanding Behaviour through Simulation - Application Unit	10+	With curriculum links to Statistics and Probability, this unit explores how complex behaviours can be understood through simulation in ways that no other method allows. Simulations as “super-charged thought experiments” can reveal counter-intuitive effects that would be difficult to discover through abstract reasoning (e.g. the Monty Hall problem). Concepts of game theory are discussed to demonstrate how mathematical and computational techniques interact and complement each other.	Chrome, Python (Anaconda dist.), Excel, Plot.ly, Cellular, Wolfram CDF Player
Understanding Behaviour through Simulation - Behind the Scenes Unit	10+	Students will develop their own simplified versions of some of the simulations (e.g. Monty-Hall, Schelling, Optimal Stopping, Snowdrift) that have been used in the Application unit. There will be a choice of these with different degrees of complexity and teachers will pick one or several depending on the level of pre-existing coding knowledge and time available. Some coding tasks will be accessible at entry level via block-based programming and spreadsheets, while others will require some competence in coding with a textual programming language at beginner’s level.	Chrome, Python (Anaconda dist.), Excel, Plot.ly, Cellular, Wolfram CDF Player

Term 2 2018 (available approximately 29th March 2018)

Unit	Year	Summary	Software Used
Understanding Pattern Formation through Generative Geometry - Application Unit	8+	Generative geometry investigates form through the algorithms that construct shapes rather than the final patterns that are produced. It is used in novel approaches to computational art as much as in understanding forms in nature. This unit explores how patterns in nature (e.g. growth patterns in plants) can be understood through simple pattern generation mechanisms. It leads from simple numerical series that form the basis of naturally occurring patterns (such as the Fibonacci series) to increasingly complex mechanisms of generative geometry (such as Turing Patterns: the seashells on page 1 are shown next to a pattern simulated using cellular automata). While this unit is based on techniques similar to those used in many materials for generative arts, the distinguishing factor is that it focuses on pattern generation in the real world. However, strong links may be made with art and graphic design.	Chrome, Python (Anaconda dist.), Excel, Scribble, Wolfram CDF Player
Understanding Pattern Formation through Generative Geometry - Behind the Scenes Unit	8+	Accessible at a very beginner’s level of coding, in this unit students will implement examples from the Application unit and vary these creatively. Examples include simple fractals, diffusion patterns, branching patterns and cellular automata. At least one of these will be accessible via spreadsheets alone.	Chrome, Python (Anaconda dist.), Excel, Scribble, Wolfram CDF Player