# Levels 7/8 Digital technologies Activity

## Finding the shortest path

### Introduction to Numeracy in Digital Technologies

In Digital Technologies, both numeracy and mathematical skills are required for students to address the outcomes. These numeracy and mathematical skills are evident in all three of the Digital Technologies sub-strands:

* Digital Systems
* Data and Information
* Creating Digital Solutions

As computers are, at their core, mathematical machines, the importance of mathematics skills in their use is not surprising. To compute, means to calculate, and this term refers to the very first functionality of computers. Today’s technology can be used to do far more than solve equations, but it still relies on algorithms to run programs and carry out every task. From opening an app on a mobile phone to creating a website, algorithms underpin every computer task that people undertake. It is clear then, that students should develop an understanding of how computers, and by extension algorithms, work.

Beyond the mathematical underpinnings of the computer itself, many actions that users complete on a daily basis require additional, sophisticated numeracy skills. Students in years 7 and 8 are asked to engage with, and analyse, large data sets, complex algorithms and programs. Learners also use numeracy skills to create diagrams and visual representations of complex ideas, and model how technology systems interact with each other in the digital technologies curriculum.

**Digital Systems**

Exploring how digital systems work means that students are led to explore how technologies are connected to create a functional system that achieves a goal. An example might be the way that email is transmitted from one computer to another computer. In understanding how devices, hardware, and software interact, students use diagrams and symbolic representations to make sense of complex hierarchies and interactions. Making, interpreting, and analysing diagrams are key numeracy skills necessary for learning in Digital Technologies.

**Data and Information**

Digital Technologies sub-strand Data and Information focuses on how computers process, store, and transmit information. Students are asked to “develop... strategies and techniques for capturing accurate and usable qualitative and quantitative data of different formats” (Australian Curriculum Assessment and Reporting Authority, n.d.). The numeracy skills for this sub-strand include understanding data in real-world contexts and being able to design ways to collect and manage data. As students use technology to visualise data. They are engaging numeracy skills as well as mathematical knowledge to understand both qualitative and quantitative data. They then use this knowledge to make informed decisions about using technology to represent and interpret what the data might mean.

### Creating Digital Solutions

In this sub-strand, students develop digital solutions to increasingly complex problems. Students analyse problems connected to current events such as a mass beaching of whales or tracking the growth of Greta Thunberg’s School Strike for Climate. Teachers may then, for example, support students to design a digital tracking solution that might be useful for students their own age. This activity would require students to demonstrate their numeracy abilities through their “capacity to use mathematical knowledge in a range of contexts” (Li et al., 2014, p. 84). Students would take risks with mathematical concepts such as analysing data in different ways or developing algorithms and iteratively improving them over time. More recently, the work of three Victorian students during the Covid-19 pandemic has demonstrated the impact of a digital solution through their [CovidBaseAU Twitter account](https://twitter.com/covidbaseau), which has gained more than 53 000 international followers. These teenagers designed and created daily visualisations that provide up to date Covid-19 statistics in accessible and unique ways. Their use of technology has enabled them to create an effective digital solution to the problem of complex statistics and engaging with multiple stakeholders.

Strong numeracy skills, underpinned by well-developed mathematical understandings, are inextricably linked to the Digital Technologies curriculum in Australia.

### Developing Numeracy Understanding in Digital Technologies

To support students’ numeracy development in Digital Technologies, it is important to provide a range of learning experiences for students to demonstrate their understanding of numeracy and to employ their numeracy skills. Computational thinking is a unique type of thinking skill that focuses on students making sense of data using a range of strategies including abstraction and findings patterns (Victorian Curriculum and Assessment Authority, 2021). One of these strategies is algorithmic thinking.

Algorithmic thinking is a technology skill that has implications for both numeracy and technologies learners (Blannin & Symons, 2019). Similar to the mathematical concept of an algorithm, algorithmic thinking in digital technologies means developing a set of step-by-step instructions for a computer to follow to achieve a desired outcome (Bayetto, 2011). These algorithms can be combined to create a computer program. Papert (1980) identified that learning to code a computer with algorithms can help develop students’ mathematical thinking from an early age. In designing computer algorithms, students can explore the mathematical concepts of algorithms and, “… sketch half-understood ideas, and assemble on the screen a semi-concrete image of the mathematical structures he or she is building intellectually” (Noss & Hoyles, 1996, p. 55). An exploration of computer coding can enhance a learner’s ability to understand mathematical concepts that may otherwise be out of conceptual reach (Papert, 1980).

When students are able to develop numeracy skills such as algorithmic thinking and to use digital technologies to create computer programs, they have the opportunity to “develop a critical orientation to the way they use mathematics to engage with and work in the world”. (Geiger et al., 2015, p. 1133).

In particular, students’ numeracy skills are developed through digital technologies when students are:

* exposed to a range of data representations. The teacher should dedicate time to explore the relative benefits and challenges of different types of data and when and how they might be best used.
* led to explore the concept of computational thinking. They should be supported to identify patterns, decompose problems, and create logical steps to solve problems. These skills can then lead to increased abilities with algorithmic thinking.
* supported to explain key mathematical terminology. There may be terms with which students are unfamiliar. The teacher should seek to normalise the use of terms such as algorithm, abstraction, structured data, and decomposition. Teachers should consider engaging students in the development of a glossary of key terms for use in the classroom.
* provided access to increasingly complex algorithms through object-oriented and text-based coding languages. By investigating existing algorithms and unpacking their functionality, students can be supported to develop a deeper understanding of algorithms and algorithmic thinking.
* shown representations of data that encourage identification of complex patterns and are given the opportunity to interrogate large data sets to ensure its validity.
* supported to investigate how data are stored and compressed, using their understanding of binary and base-ten number systems to make informed decisions.

## Lesson Plan: Finding the Shortest Path

In this lesson, the students’ task is to design the shortest route between capital cities across Australia. The scenario is that the students have been chosen as representatives of their school. As the chosen representatives, they will be taking a country-wide tour to share their ideas for the future of education in each capital city. There are limited funds for travel, and students will have one car and one driver. Each group of three students will choose a start and end point for their tour and will plan their route using Google Maps, namely the functionality to create their own maps called ‘My Maps.’

There are multiple options for visiting each state and territory, including ferries and trains that accept passenger cars. Students will be asked to calculate the route that made best use of their limited funds for accommodations, fuel, travel expenses and food. The concluding discussion at the end of this lesson will engage students in the ideas of using algorithms to automate this process. What steps might the computer need to take to plan this tour for you?

### Prerequisite/Corequisite Knowledge: Digital Technologies

Students need to have and/or develop the ability to:

* Access and use Google Earth
* Measure distance and maintain running totals of distances
* Plan and communicate ideas for solving complex problems
* Examine components of a system and the ways that they interconnect.

### Background Mathematical Skills and Understandings

Teachers of Digital Technologies are not expected to teach the mathematical knowledge and skills that students will draw upon when engaging with this activity. The students will have learnt and should be adept with the required mathematical knowledge and skills to complete the activity. According to the Victorian Curriculum: Mathematics, the required mathematical knowledge and skills should have been developed in earlier years of schooling, that is, by the end of Level 6.

For this activity, the background mathematical skills and knowledge are:

* Ability to locate landmarks on maps
* Knowledge of, and ability to interpret legends and scales on maps
* Familiarity with the notion of enlargements
* Ability to create (simple) maps to show position and pathways
* Knowledge of units of time and metric units of length
* Ability to use scaled instruments to measure and compare lengths
* Ability to add lengths (distances) to obtain a total
* Ability to create displays of data using a table and to interpret the data therein
* Ability to use algorithms that involve a short sequence of steps and decisions to solve problems. However, students may not be familiar with the term *algorithm*.

## Lesson Description

1. Introduce the idea that the students have been invited to take part in a national tour of Australia’s capital cities. There will be groups of three students travelling together with a driver in one car. They have limited funds for food and petrol ($6000), so they need to find the shortest, most efficient route for each group of three students that takes them on a trip that visits each city. If students require further support, an online spreadsheet can be used to scaffold their learning and tracking of costs and distances.
2. Ask students to explore Google Maps and identify the capital cities in each state and territory. Next, lead students to create their own map, to which they will add their tour stops and details. To do this, students will need to follow the instructions at https://www.google.com.au/maps/about/mymaps/.
3. Once each group has created their own map, lead a brief (5-minute) discussion about the functionality of Google Maps. What does this mapping software offer? Answers might include:
   * the automatic measurement of distance
   * the ability to trace distance along roads and measure their distance
   * the ability to zoom in and out to see locations clearly
   * the functionality to create a shareable map that can be used on mobile devices and sent to friends and family
   * geographic and traffic information, including estimated real-time travel times
4. Discuss how the software achieves these by using algorithms. These are step-by-step instructions that the computer follows, in sequence, to get an answer. For example, when a user zooms in on a map, an algorithm is enacted.
5. Next, ask the students to begin planning their tour. At the end of a designated period, students need to calculate their total travel distance in kilometers by using the ‘ruler’ tool in Google Maps: ‘My Maps’. In the My Maps function, the ruler gives the ability to create personal maps that can be modified and compared to find the most appropriate route.
6. Collate each group’s data into a shared table. There will be discrepancies between the total distances, which can be discussed.
7. Lead a final discussion about the different approaches taken by each group. Some will have begun their tour from their hometown, whereas others may have begun from the nation’s capital. Others may have travelled North to South or East to West, or perhaps in a more chaotic pattern. What has this meant to the total kilometers travelled? How might a computer do this more efficiently?

Set up the next lesson by explaining that students will be looking at how a computer program decides on the best route between two points and uses an algorithm to achieve this. Before then, review this great example (<https://www.kidscodecs.com/dijkstras-algorithm/>) of how a Global Positioning System works.

## Table 1: Links to the Victorian Curriculum – Digital Technologies

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| Strand and Sub-Strand  (if applicable) | Content Description (Code) | Elaboration(s) |
| * Creating Digital Solutions | Define and decompose real-world problems taking into account functional requirements and economic, environmental, social, technical and usability constraints (VCDTCD040) | Identifying that problems can be decomposed into sub elements, for example creating a decision tree to represent the breakdown and relationships of sub elements to the main problem or identifying the elements of game design such as characters, movements, collisions and scoring |

## Table 2: Links to the 21st Century Numeracy Model (Goos et al., 2014)

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| Aspect of the Model | How This Aspect is Addressed by the Lesson |
| **Attention to Real-Life Contexts**   * Citizenship * Work * Personal and Social Life | This lesson is connected to the context of Australia as a large country that is navigable through a network of roads and railways. The route that students will design can be used to demonstrate the purpose of an algorithm in designing a route for travel. |
| **Application of Mathematical Knowledge**   * Problem Solving * Estimation * Concepts * Skills | Students will solve problems of location and distance in this lesson. In designing a touring route around Australia, students will estimate the shortest routes and test their theories using My Maps. They will refine their estimates and rethink their approaches as they remap their routes. Students will be guided to engage with concepts of scale and distance when, for example, they plan a route from Hobart to Melbourne and engage with the digital representation of Bass Strait and the changes in scale as they zoom in and out. |
| **Use of Tools**   * Physical * Representational * Digital | The use of Google Maps in this lesson is a digital representation of the physical land mass of Australia. |
| **Promotion of Positive Dispositions**   * Confidence * Flexibility * Initiative * Risk | This lesson is purposefully designed as an open, problem-based learning task. As such, there are many solutions, which enables learners to find success in numerous ways. There are opportunities to develop confidence in understanding measurement, scale, addition of, basic computation, and to take risks in trialling various options and testing ideas. |
| **Critical Orientation**   * Interpreting Mathematical Results * Making Evidence-Based Judgements | In comparing results, students will be led to compare the routes planned by their peers and will explore how different strategies led to different outcomes. The total number of kilometres travelled will lead to discussions about the appropriateness of the routes that were designed. In turn, this leads students to interpret results and make informed judgements based on evidence. |

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