**Levels 9/10 digital technologies Activity**

## Digital data in the future

### Introduction to Numeracy in Digital Technologies

In Digital Technologies, numeracy capabilities are required for students to address the outcomes. Numeracy links 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 algorithms are needed 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 engage with, and analyse, large data sets, as well as 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

The Digital Technologies sub-strand Data and Information pertains to how computers process, store, and transmit information. In particular, 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 capabilities as well as mathematical knowledge to understand both qualitative and quantitative data. Students 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 involves students making sense of data using a range of strategies, including abstraction and finding patterns (Victorian Curriculum and Assessment Authority, n.d.). 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 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, as well as when and how they might be best used.
* led to explore the concept of computational thinking: Students 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*. The teacher 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: Digital Data in the Future

In this lesson, students will explore how data have been digitally stored in recent years and how they might be stored in the future. Students will compare digital and analogue data storage methods, and will develop an argued case for the storage of a time capsule for their year level.

### Prerequisite/Corequisite Knowledge: Digital Technologies

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

* Access the Internet and conduct independent research
* Verify sources of information on the Internet
* Understand the basics of data storage, including the technological concepts of hyperscale data servers, binary numbers, bits and bytes, big data storage, deletion, obsolescence, and security.

### 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 8.

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

* Familiarity with large numbers
* Indirect knowledge of the binary system (e.g., based on yes/no chance experiments), as well as of other number systems that are not base-10 (e.g., dozens, 24-hour day)
* Knowledge of measurement of units of time
* Knowledge of the concept of capacity
* Knowledge of, and ability to interpret, percentages
* Ability to gather and record data/information in tables, with and without technology.

## Lesson Description

In this scenario, the students are making plans to develop a time capsule for their year level. The students have decided to create journal entries to reflect a day-in-the-life of a student in 2021 (or 2022 and beyond, depending upon when lesson is taught). Each class will make one day-in-the-life submission and they can choose how they would like to share it.

In this lesson, the students will work in groups of four to decide how they would like their class to present their submission. Each group will present their argued case to the rest of the class. The students should be given approximately 90 minutes to complete this lesson.

1. Students will form groups of four and will be given a different digital method of presenting their day-in-the-life submission (video, PowerPoint, digital poster, PDF document, animation, or audio file).
2. Each group will be asked to explain why their digital presentation idea is the best option and will asked to use the following terms in their response: hyperscale data servers, binary numbers, bits and bytes, big data storage, and security
	* This is a useful starting point for understanding binary numbers in relation to digital data storage: <http://androidgrl.github.io/2019/01/01/binary/>
3. Having researched these terms, the groups will develop a short ‘argued case’ for their presentation. They will have 3 minutes each to present. In the argued case, the groups should answer the following questions:
	* Why are binary numbers important to storing digital data?
	* What is big data and how do we measure it?
	* How much storage capacity would a typical presentation like yours usually require?
	* Where would it best be stored and why? (e.g., cloud storage, offline storage)
4. As a class, the teacher will lead the groups to add their responses to these questions to a shared spreadsheet and support the students to come to a final decision for the time capsule project.
5. To conclude the lesson, the teacher will lead the students through a reflection on data storage methods, engaging with large numbers, and conceptualising the amount of data that we store each day. The teachers will use this quotation as the basis for the discussion:

‘To meet the ever-growing demand for digital data storage, around 100 new hyperscale data centres are built every two years. My recent study examined these trends and concluded that, at a 50% annual growth rate, around 150 years from now the number of digital bits would reach an impossible value, exceeding the number of all atoms on Earth. About 110 years from now, the power required to sustain this digital production will exceed the total planetary power consumption today’ (Vopson, 2021, Data Storage section, para. 4).

## 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
 | Evaluate critically how well student-developed solutions and existing information systems and policies take account of future risks and sustainability and provide opportunities for innovation [(VCDTCD054)](https://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCDTCD054). | Investigating actions, devices and events that are potential risks to information systems, for example losing portable storage devices containing important files, deliberately infecting systems through malware, and power surges. |

## 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
 | Students will explore digital data storage solutions that are used every day, including cloud computing. Students will garner an understanding of how the binary numbers are used to turn digital data into stored data. |
| **Application of Mathematical Knowledge*** Problem Solving
* Estimation
* Concepts
* Skills
 | Students will use their mathematical skills (e.g., measurement, place value) to understand how binary numbers are used in digital data storage. |
| **Use of Tools*** Physical
* Representational
* Digital
 | Students will explore a digital presentation tool. In researching this tool, students will develop skills in using, accessing, and choosing digital tools that meet their needs. |
| **Promotion of Positive Dispositions*** Confidence
* Flexibility
* Initiative
* Risk
 | Students will work in groups with a directed focus to enable them to confidently create an argued case for their presentation method (e.g., video, PowerPoint, animation, audio). As students investigate the key terms highlighted in this activity, they will need to demonstrate flexibility in their understanding of binary numbers and storage capacity. |
| **Critical Orientation*** Interpreting Mathematical Results
* Making Evidence-Based Judgements
 | In this lesson, students will interpret mathematical results by comparing the required storage capacity of each group’s presentation and make informed judgements about which presentation option is most viable for the time capsule. |

## References

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