Using mathematics to drive future-focused financial capability

Carly Sawatzki

Deakin University, Vic.
<carly.sawatzki@deakin.edu.au>

Jill Brown

Deakin University, Vic.
<jill.brown@deakin.edu.au>

Simone Zmood

Deakin University, Vic.
<simone.zmood@deakin.edu.au>

The authors offer a learning sequence where students learn to mathematise, problem-solve and reason in financial contexts. As part of their mathematical modelling students are also asked to consider their values around fast fashion.

The proposed revisions to the *Australian Curriculum: Mathematics* highlight the importance of learning to mathematise, problem-solve and reason in real world contexts, including financial contexts. Through the Economics + Maths = Financial Capability research project, we have been imagining fresh ideas for connecting the *Australian Curriculum's Mathematics and Humanities and Social Sciences* (HaSS) learning areas. In our work with teachers, we explore the idea of developing among students a future-focused financial capability: that is, the disposition to consider the impact of personal spending choices on community and environment, and more ethical, sustainable possibilities. In this article, we present two mathematical modelling tasks with a focus on fast fashion, textile waste, and purchasing behaviour—important financial contexts that might be productively explored through mathematical modelling.

A rationale for mathematical modelling tasks in financial contexts

The Alice Springs (Mparntwe) Education Declaration (Education Council, 2019) specifies that the purpose of the Australian education system is to help all young Australians to become successful learners, confident and creative individuals, and active and informed citizens. These goals underpin the design of the *Australian Curriculum,* which specifies that curriculum documentation "can be used flexibly by schools, according to jurisdictional and system policies and schedules, to develop programs that meet the educational needs of their students" (ACARA, 2021c, para. 2). Further, schools are encouraged to implement the *Australian Curriculum* "in ways that value teachers' professional knowledge, reflect local contexts and take into account individual students' family, cultural and community backgrounds" (ACARA, 2021c, para. 2).

At the school level, this occurs through a focus on both disciplinary knowledge, skills and understanding (learning areas), and general capabilities (ACARA, 2021a). In mathematics, teachers work to "develop the numeracy capabilities that all students need in their personal, work and civic life, and provide the fundamentals on which mathematical specialties and professional applications of mathematics are built" (ACARA, 2021b, para. 1). The mathematics rationale statement notes that the curriculum "encourages teachers to help students become self-motivated, confident learners through inquiry and active participation in challenging and engaging experiences" (ACARA, 2021b, para. 4).

Mathematical modelling is one pedagogical approach to achieving the intended design of this curriculum. To understand what is meant by mathematical modelling we can consider two worlds: the real-world, reality; and the mathematical world, mathematics. mathematical modelling is described by Stillman Galbraith, Brown, and Edwards (2007) as occurring when we begin in the real world, that is "reality → mathematics [and ask] 'Where can I find some mathematics to help me with this problem?'" (p. 689) (See also Brown, 2017).

In the version of the *Australian Curriculum: Mathematics* made available for consultation (ACARA, 2021d), mathematical modelling, alongside investigations, and the making and testing of conjectures are more explicitly included as essential aspects of doing and learning mathematics. Clearly, engagement in mathematical modelling by students provides opportunities for inquiry and active participation, increases their appreciation and knowledge of the world in which we live, and enhances their motivation to learn mathematics.

Critical aspects of our world include problems and decisions that affect personal, community, and planetary well-being. In relation to safety, Brown (2021) shows how mathematical modelling can be used to understand why babies and small children should not be left unattended in 'hot' cars. In relation to risk, Fletcher (2009) unpacks the mathematics involved in a television game show which has strong parallels to various types of gambling and gaming. In relation to finance, Sawatzki, Zmood and Brown (2020) focus on the real cost of buying now and paying later as they explore new payment options.

Money, and economics and finance more generally, plays a central role in many real-world problems that students will confront today and tomorrow. In the project discussed here, we have ensured that the selection of real-world contexts is close to young people and allows for meaningful exploration of financial trends, issues, and problems.

An example of a context: The climate crisis and fast fashion

Globally, the impact of accelerated climate warming is being felt via extreme weather such as fire, flood, and drought. The negative consequences of these phenomena for people, agriculture, and wildlife are significant. The United Nations Intergovernmental Panel on Climate Change (IPCC) has reported that it is "unequivocal that human influence has warmed the atmosphere, ocean and land," (IPCC, 2021, p. 5) and even under the most ambitious emission reduction scenarios, the world is likely to reach the dangerous tipping point of 1.5 degrees or more above pre-industrial levels by 2040. Although there are several major changes that can be made within sectors generating large emissions, success ultimately relies on changing the values that drive consumption behaviour.

The fashion industry is a good example to explore with students. Globally, textile production is responsible for 8% of annual greenhouse gas (GHG) emissions and this is expected to grow to 26% by 2050 (Australasian Circular Textile Association, 2020). Fashion industry marketing intends to get people to follow rapidly changing trends. Social media platforms like Instagram and TikTok, and the celebrities and fashion influencers that post there, encourage young people to purchase clothing that is cheap, quickly becomes obsolete, and is replaced more often. This results in more clothing being purchased overall and more clothing being discarded (Park & Martinez, 2020). Since 2000, global clothing production has doubled and the average number of wears per garment has decreased by over a third (Ellen MacArthur Foundation, 2017). Each Australian acquires an average of 27 kilograms of new clothing and discards around 23 kilograms of clothing to landfill annually (Australian Government, 2021).

Economists distinguish between linear and circular economic models. Capitalist economies are linear in that businesses take resources and turn them into products that are destined to become waste. By contrast, a circular economy seeks to transform our throwaway economy into one where waste is eliminated, resources are circulated, and nature is regenerated. Transitioning to a circular economy means shifting consumer values and behaviour. Socially and environmentally conscious not-for-profit organisations, designers, and consumers are leading a counter-movement against fast fashion towards a circular economy (i.e., zero waste) that values reducing, recycling, and upcycling clothing (Park & Martinez, 2020).

As educators, we have an important role to play too. Teaching about linear and circular economic models helps students to consider the impact of the choices they make, and how these choices will impact the environment, the community, and the economy. Mathematising the machinations of the fashion industry can enhance students' understanding of important economic and mathematical concepts, including the circular economy, demand, supply, and pricing. Important considerations can be discussed, such as: discretionary spending; the quality and longevity of clothing; ways to reduce consumption; and ways to recycle and upcycle clothing.

Interpreting the opportunities to challenge Year 7 students

The two tasks presented below connect the *Australian Curriculum's Mathematics and Humanities and Social Sciences* (HaSS) learning areas and are intended to challenge Year 7 students. We encourage you to approach these as a sequence of lessons, allowing time for students to think mathematically and deeply.

In Year 7, students learn to:

- Calculate volumes of rectangular prisms (Mathematics, ACMMG160)

- Express one quantity as a fraction of another, with and without the use of digital technologies (Mathematics, ACMNA155)
- Recognise and solve problems involving simple ratios (Mathematics, ACMNA173)
- Investigate and calculate 'best buys', with and without digital technologies (Mathematics, ACMNA174)
- Consider the ways consumers and producers interact and respond to each other in the market (Economics & Business, ACHEK017).
- Gather relevant data and information from a range of digital, online and print sources (Economics & Business, ACHES022)
- Generate a range of alternatives in response to an observed economic or business issue or event, and evaluate the potential costs and benefits of each alternative (Economics & Business, ACHES024).

In the *Australian Curriculum: Mathematics*, the proficiencies describe the actions through which students engage in learning and doing mathematics. The overall and Year 7 proficiency statements are presented in Table 1. We include both sets to illustrate that the proficiencies are not simply entwined with mathematical content and concepts. There are both "big picture" and specific mathematical practices that teachers might emphasise, and support students to develop, by paying explicit attention to the proficiencies in their own right. We note that the proficiencies intend to promote flexible ways of thinking and acting mathematically in the real world. We leave it to the reader to see how many of these actions would be undertaken by students as they solve the two tasks, preferably in collaboration and discussion with other students.

Table 1. The mathematical proficiencies

Proficiency	Overall proficiency statements	Year 7 includes
Understanding	Students build a robust knowledge of adaptable and transferable mathematical concepts. They make connections between related concepts and progressively apply the familiar to develop new ideas. They develop an understanding of the relationship between the 'why' and the 'how' of mathematics. Students build understanding when they connect related ideas, when they represent concepts in different ways, when they identify commonalities and differences between aspects of content, when they describe their thinking mathematically, and when they interpret mathematical information.	Students describe patterns in uses of indices with whole numbers, recognising equivalences between fractions, decimals, percentages and ratios. They plot points on the Cartesian plane, identifying angles formed by a transversal crossing a pair of lines, and connect the laws and properties of numbers to algebraic terms and expressions.
Fluency	Students develop skills in choosing appropriate procedures; carrying out procedures flexibly, accurately, efficiently and appropriately; and recalling factual knowledge and concepts readily. Students are fluent when they calculate answers efficiently, when they recognise robust ways of answering questions, when they choose appropriate methods and approximations, when they recall definitions and regularly use facts, and when they can manipulate expressions and equations to find solutions.	Students calculate accurately with integers, representing fractions and decimals in various ways. They investigate best buys, find measures of central tendency, and calculate areas of shapes and volumes of prisms.
Reasoning	Students develop an increasingly sophisticated capacity for logical thought and actions, such as analysing, proving, evaluating, explaining, inferring, justifying and generalising. Students are reasoning mathematically when they explain their thinking, when they deduce and justify strategies used and conclusions reached, when they adapt the known to the unknown, when they transfer learning from one context to another, when they prove that something is true or false, and when they compare and contrast related ideas and explain their choices.	Students formulate and solve authentic problems using numbers and measurements. They work with transformations and identify symmetry, calculate angles, and interpret sets of data collected through chance experiments.
Problem-solving	Students develop the ability to make choices, interpret, formulate, model and investigate problem situations, and communicate solutions effectively. Students formulate and solve problems when they use mathematics to represent unfamiliar or meaningful situations, when they design investigations and plan their approaches, when they apply their existing strategies to seek solutions, and when they verify that their answers are reasonable.	Students apply the number laws to calculations. They apply known geometric facts to draw conclusions about shapes, and apply an understanding of ratio when interpreting data displays.

Task 1: Textile waste and landfill

Share this quick video with students—https://youtube/-MUqsWrrb8A—then ask them to consider the following task:

> The Save the World company has employed you to prepare a marketing campaign to encourage people to reduce textile waste.
>
> First, they want you to create an initial model to estimate the amount of textile waste generated in Australia through clothing sent to landfill. You need to explain your model in everyday language, so the Directors of Save the World understand it. Be sure to have a model that allows for changes in the amount of garments bought yearly, the proportion of this total sent to landfill, and any other variables you identify as important.
>
> The Save the World company also wants you to devise a way to visualise the amount of textile waste sent to landfill in a way that can help Australians comprehend the enormity of the issue and perhaps consider changing their purchasing behaviour. If possible, expand your initial model from the Australian to the global situation.
>
> You can use the information provided, source data from elsewhere, or a combination of these. Be sure to indicate the source of any additional information in your report to Save the World.

Sample solution

For a first simple model, we make two assumptions:

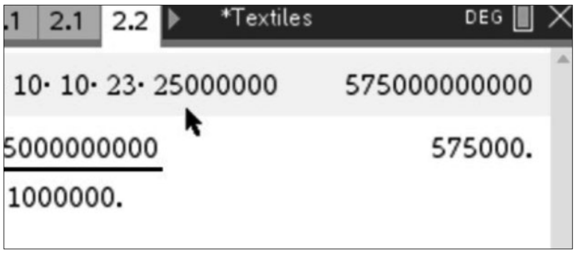
1. The volume of 1 kg is approximately the same as the volume of 1 litre of water, a 10 cm by 10 cm by 10 cm cube.
2. Data are for the whole Australian population, but 25 million people can be used as a rough estimate.

Initial model for volume of waste (cubic centimetres):

= volume of 1 kg of waste × amount of waste per person [kg] × number of people
= 10×10×10×23×25 000 000 = 575 000 000 000 cubic centimetres.

To convert to cubic metres, we need to divide by 1 000 000...

= 575 000 000 000 ÷1 000 000
= 575 000 cubic metres



Alternative model (same assumptions)

Each 1 kg takes up 10 cm by 10 cm by 10 cm, so 1000 kg fills 1 cubic metre.

Total volume of waste (cubic metres) = waste per person [kg] × number of people ÷ 1 000

For initial values this gives...

Total volume of waste = 23 × 25 000 000 ÷ 1 000
= 575 000 cubic metres (as previously)

Visualise these representations:

- Imagine a path of waste 1 metre wide and 10 cm deep. How long would the path be?
- How many classrooms would the waste fill?
- How many sporting stadiums (imagine the Melbourne Cricket Ground [MCG]) would the waste fill?
- What other visual ideas might students imagine and suggest?

How long is the path?

575 000 ÷ width ÷ depth =
575 000 ÷ 1 ÷ 0.1 = 5 750 000 m = 5750 km long

How many classrooms?

A recent media article reported that the average Australian classroom is 81 cubic metres (see Andamon, Woo & Rajagopalan, 2021).

Number of classrooms
= total waste ÷ average volume per classroom
= 575 000 ÷ 81
= 7098 ≈ 7100 classrooms

We leave it to the reader to complete the calculation for the sporting stadium.

Importantly, based on their initial model, which of these visual images do students believe will be most powerful and meaningful to the target audience of the advertising campaign? Encourage students to explain their thinking. Next, ask students to revisit their initial model and reconsider the assumptions.

Task 2: Buying clothing: What do I value most, price, or planet?

Ask students to consider the following task:

> Choose three items of clothing that you would like to buy (e.g., a pair of jeans and two tees). Use the internet to find the cost of comparable items from different stores or brands. Estimate how many times you might wear this item. Now calculate the cost per wear, depending on where you choose to buy. Illustrate the results using a chart or table. For each item, write a sentence about the quality of the item and how long you predict it will last in terms of both wear and tear, and fashion trends.
>
> Following this, work in small groups to share and compare your findings, and discuss the following questions:
>
> 1. How and why did the cost per wear vary between different items of clothing?
> 2. List three guidelines that your family could use to decide how and when to buy clothing.

Sample solution

Our initial model assumes five wears per month and estimates lifespan based on previous experience.

Cost per wear = cost ÷ (wears per month × lifespan in months)

We compiled Table 3 below for easy comparison. We might revisit the model and reconsider our assumptions (wears per month and estimated lifespan). Any adjustments will inevitably affect the cost per wear. For example, students might consider the reasonableness of a 10-year lifespan for Nudie Jeans, as one's size is likely to fluctuate over that period. To see the impact of varying our assumptions, a spreadsheet or other digital technology should be used. Students could consider, for example, if increasing (or decreasing) the mean wears per garment impacts on their decision as to which jeans to purchase.

Concluding remarks

These tasks create opportunities for students to develop mathematical knowledge, skills, and proficiencies while discussing their personal values, including their feelings about keeping up with fashion trends and protecting the environment. Since personal values underpin financial behaviour, these conversations help students to clarify their motivations, develop an awareness of the impact of their spending, and consider opportunities for financial activism. Mathematical modelling generates opportunities for powerful and rewarding learning. As teachers, the key is to let go so that students do the cognitive lifting (it's okay if they overlook important details and make mistakes). It is important that students appreciate the focus is on the real-world and not a particular mathematics idea or strategy. These are important foundations for future-focused financial decision-making.

Additional classroom resources

ABC's Your Planet
https://www.abc.net.au/your-planet/

ABC's War on Waste
https://iview.abc.net.au/show/war-on-waste/series/1

ABC's Fight for Planet: Our Climate Challenge
https://www.abc.net.au/education/collections/fight-for-planet-a-our-climate-change-challenge/

Table 3. Comparing the cost per wear for a pair of jeans from different fashion retailers

Retailer	KMart	Cotton On	Country Road	Nudie Jeans
Cost	$20	$34.99 (on sale)	$99.95	$229
Value proposition	Affordable	Affordable	Quality	Sustainably made Free repairs forever
Assumed wears per month	5	5	5	5
Expanded lifespan	12 months	12 months	24 months	10 years (120 months)
Cost per wear	33 c	58 c	83 c	38 c

References

Andamon, M. M., Woo, J., & Rajagopalan, P. (2021, February 17). *Australian children are learning in classrooms with very poor air quality.* Retrieved from https://theconversation.com/australian-children-are-learning-in-classrooms-with-very-poor-air-quality-154950

Australasian Circular Textile Association. (2020). *A circular economy for the textile and apparel sector: Position paper.* Retrieved from https://acta.global/wp-content/uploads/2020/05/ACTA_PositionPaper2020_FINAL.pdf

Australian Curriculum, Assessment and Reporting Authority [ACARA]. (2021a). *Australian Curriculum: Learning Areas.* Retrieved from https://www.australiancurriculum.edu.au/f-10-curriculum/learning-areas/

Australian Curriculum, Assessment and Reporting Authority [ACARA]. (2021b). *Australian Curriculum: Mathematics, Rationale*. Retrieved from https://www.australiancurriculum.edu.au/f-10-curriculum/mathematics/rationale/

Australian Curriculum, Assessment and Reporting Authority [ACARA]. (2021c). *Implementation of the Australian Curriculum.* Retrieved from https://www.australiancurriculum.edu.au/f-10-curriculum/implementation-of-the-australian-curriculum/

Australian Curriculum, Assessment and Reporting Authority [ACARA]. (2021d). *Mathematics Consultation Curriculum: All Elements F–10.* Retrieved from https://www.australiancurriculum.edu.au/media/7044/mathematics_all_elements_f-10.pdf

Australian Government, Department of Agriculture, Water and the Environment. (2021). *Clothing textiles waste round table and exhibition.* Retrieved from https://www.environment.gov.au/protection/waste/product-stewardship/textile-waste-roundtable

Brown, J. (2017). Editorial: What is mathematical modelling? *Australian Senior Mathematics Journal, 31*(1), 3–5.

Brown, J. P. (2021). Understanding the real-world: Sweaty Jo. *Mathematics Teacher: Learning and Teaching PK–12, 114*(7), 528-535.

Education Council. (2019). *Alice Springs (Mparntwe) education declaration.* Retrieved from https://www.dese.gov.au/download/4816/alice-springs-mparntwe-education-declaration/7180/alice-springs-mparntwe-education-declaration.pdf

Ellen MacArthur Foundation. (2017). *A new textiles economy: Redesigning fashion's future.* Retrieved from https://emf.thirdlight.com/link/2axvc7eob8zx-za4ule/@/preview/1?o

Fletcher, M. (2009). The Con Test. *Australian Senior Mathematics Journal, 23*(1), 17–19.

Intergovernmental Panel on Climate Change [IPCC]. (2021). *Climate Change 2021: The Physical Science Basis. Summary for Policymakers.* Retrieved from https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

Park, H., & Martinez, C. M. J. (2020). *Secondhand clothing sales are booming—and may help solve the sustainability crisis in the fashion industry.* Retrieved from https://theconversation.com/secondhand-clothing-sales-are-booming-and-may-help-solve-the-sustainability-crisis-in-the-fashion-industry-148403

Stillman, G., Galbraith, P., Brown, J., & Edwards, I. (2007). A framework for success in implementing mathematical modelling in the secondary classroom. In J. Watson & K. Beswick (Eds.), *Mathematics: Essential research, essential practice (Proceedings of the 30th Mathematics Education Research Group of Australasia conference*, Hobart, Vol. 2, pp. 688–707). Adelaide: MERGA.

Sawatzki, C., Zmood, S., & Brown, J. (2020). Doing the maths on buy now pay later services. *Vinculum 57*(4), 20–21.

Acknowledgements

The authors have received funding from the Ecstra Foundation for the Economics + Maths = Financial Capability research project. This project has received Deakin University ethics approval (Reference Number: HAE-21-043). We are working in partnership with The Australian Association of Mathematics Teachers (AAMT), Business Educators Australasia (BEA), The Victorian Commercial Teachers Association (VCTA), and The Mathematical Association of Victoria (MAV).