Introduction to Modelling
Lesson 4: Improved Theme Park Model

Australian Curriculum: Mathematics (Years 8 and 9)

ACMNA208: Solve problems involving direct proportion. Explore the relationship between graphs and equations corresponding to simple rate problems. (Year 9)

- identifying direct proportion in real-life contexts

ACMNA 192: Simplify algebraic expressions involving the four operations. (Year 8)

Lesson abstract

Students plan a new ride to maximise flow of people through the ride whilst maintaining excitement. They investigate how aspects of the design of a ride affect the potential queuing time. They use this in combination with consideration of patterns of people joining lines to gain understanding of the net effect of the numbers of those leaving the line to go on the ride and those joining at the other end. They can improve their models of queuing time by including additional factors.

Mathematical purpose (for students)

Mathematical modelling starts with simple models that are improved.

Mathematical purpose (for teachers)

Students gain understanding of the balance of queuing inputs and outputs, and of flow in general. The queue will grow or shrink depending on the rate at which people are joining it, compared to the capacity of the ride to take people. The mathematics of flow is now central, involving proportional reasoning and rate concepts. Estimation in common metric units is involved, with optional algebra. By developing a more sophisticated model of theme park queues, students understand the improvement cycling in the modelling process. After evaluating a model, the mathematical modelling process often starts again, refining the assumptions and including more factors.

Lesson Length 45 minutes approximately (+optional 10 minutes)

Vocabulary Encountered

Lesson Materials

- Slide show: ST7_Intro_To_ Modelling_4a.pptx
- Spreadsheet software (optional)
- Video (optional) http://www.youtube.com/watch?v=a3YDlhy2UmE

We value your feedback after these lessons via https://www.surveymonkey.com/r/J8GPD7Z

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Lesson structure

- Introducing the challenge (Teacher introduction - 10 minutes)
- Discussing how to tackle the challenge (Collaborative small-group work - 15 minutes)
- Sharing ideas (Whole-class discussion -10 minutes)
- Extending the model (Collaborative small-group work - 10 minutes)
- *Optional:* Extending the challenge (10 minutes)

Introducing the Challenge: Planning a New Ride

This lesson introduces the improvement process in modelling, extending the challenge of Lesson 2 by looking in more depth at key aspects of the design of a ride that affect the time spent in line. Students will need to build on their work from lesson 2.

Show and read the slide Planning a new ride.
Theme park ride design tries to maximise flow whilst also ensuring riders experience a thrill and want to ride again!

The emphasis in this lesson is about how a ride can be designed to take a lot of people in a short time (i.e. high flow rate).

You may want to show some video of various theme park rides, such as the YouTube video http://www.youtube.com/watch?v=a3YDlhy2UmE

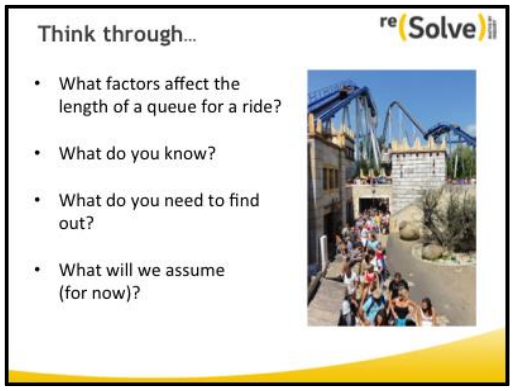
These two videos (each approximately 12 minutes) are informative for teachers, although not specifically about queueing.

John Wardley on Designing Roller Coasters
https://www.youtube.com/watch?v=vIxBuqD3C0o
https://www.youtube.com/watch?v=dVjgcrkTa2M

Ask the groups to work together to consider what sort of ride they might suggest that would improve flow rates, that is how quickly people have their rides. Show students the slide Different types of ride. This shows that many theme park rides might be considered as updated forms of the simple playground ride types: the slide, swing and roundabout.

Students may have researched some data for at least one type of ride. Encourage students to share their data with each other. (If they have no data they may have to make some estimates).

Tell students they should be prepared to share their findings on features that lead to higher flow rates with the whole group.



You may want to show the slide Think through... for this challenge

- What factors OF THE RIDE affect the length of a queue for a ride?
- What do you know?
- What do you need to find out?
- What will you assume (for now)?

Encourage students to consider how the different types of ride (swing, slide and roundabout) and the different ways they transport passengers might affect the flow rate. For example, getting people on and off a roundabout-

type ride might take a considerable amount of time and then the ride would have to take even more time. This might compare rather poorly with a slide-type roller coaster where the time on the ride is often brief. Typically roller coasters that involve a (near) vertical drop are very brief (e.g. one minute): but the experience is exhilarating. It may also be possible to be loading one of two trains on the track as the other makes its way around the circuit. Of course, there needs to be some careful thought to safety issues so that only one train is on the 'slide' at any one time. This is impossible for the other types of ride.

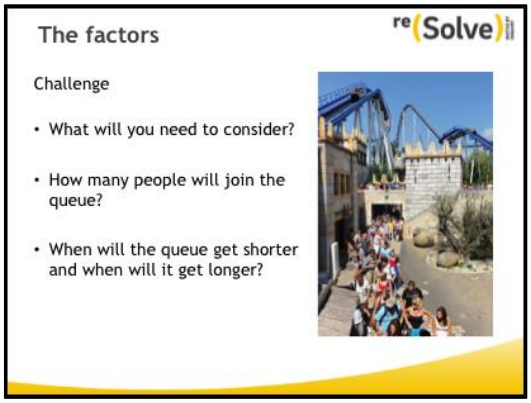
A helpful article is found at: http://www.themeparkinsider.com/flume/201304/3441/

Enabling prompts

For those groups that are not making progress,

the slide The factors will help them focus on a specific issue.

- How many people are on the ride at any time? Can this be increased safely?
- How long does the ride take? Can this time be reduced whilst still keeping the ride thrilling?
- Which type of ride, slide, swing or roundabout is likely to have the fastest flow rate?



Reflections

Checkpoint on understanding the problem

The aim is to now ensure that, through class discussion, that all groups have gained an adequate understanding of the problem and how it might be tackled.

Draw on your observations of how students have been working so far to try to elicit from them some of the suggestions given in the slide Things to think about…

Carefully select some students to present so that you get a range of different thinking.

Discuss with students how they might find the flow rate for their improved ride by finding, for each of the variables they have chosen to include, some reasonable values –through either researching using the web or practical work.

Checkpoint on helpful ride characteristics

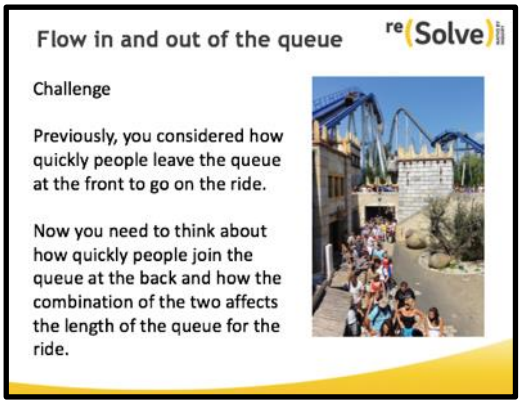
Spend some time in whole-class discussion considering some examples that illustrate how queues can be affected by ride design. Display these to the whole-class.

Highlight how high volume rides are good for shortening queuing times. So trains with large numbers of passengers are good. Rides such as 'swing boats' can also be good as they can hold substantial numbers of passengers. It is also good to be able to have a quick change over of passengers, so wheel rides that start off horizontal are helpful as every 'capsule' can be unloaded and loaded at the same time (contrast this with wheel rides that are vertical throughout – unloading and loading takes considerably more time).

Extending Your Model: How Long is the Queue?

Show the slide Flow in and out of the queue

Extend students' thinking about flow by considering how people both join the queue and leave as they go on the ride. The aim is structured thinking about the variables and their relationships.



The aim here is again to show how the improvement process can extend the model to make it more useful or powerful.

Ask students to make a model, simplifying the situation and exploring the effect of their modelling assumptions.

Show the slide Think through ...

Students may need to consider the front and the back of the queue separately before putting them together to see whether the queue will get longer or shorter.

Students may find using a spreadsheet is helpful to develop tables and graphs. Otherwise, students can draw their own tables showing how many people in the queue at the end of each cycle of the ride.

A cycle is taken to be the total time from the start of a ride through to the next time it sets off again, thus taking account of unloading and loading passengers.

Bring the class together to collect and explore ideas from different groups.

Then ask all groups to reflect on what they learnt from each other and how they might use this to improve their advice to the theme park manager.

Extending the challenge (optional)

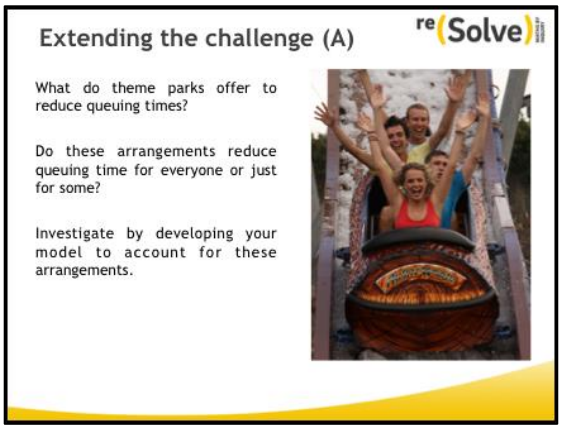
Extending the challenge A

Show the slide Extending the challenge A

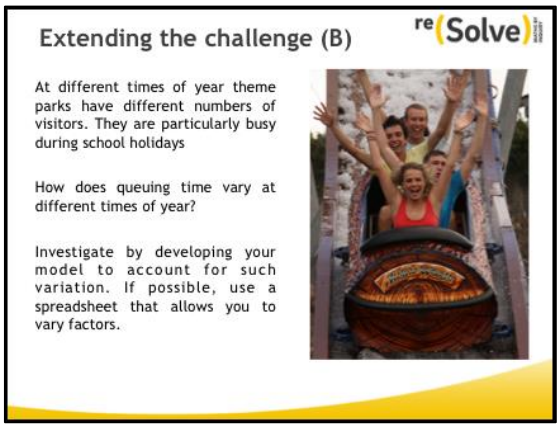
Students could make a model to find the impact on queueing times of:

- selling a certain number of pre-booked times on the rides,
- having a special 'single riders only' queue,
- having a special 'families only' queue.

You might introduce some students to the idea of simulating the random aspects of queuing, using dice and/or random number generators.



Extending the challenge B

Show slide Extending the challenge B

Students modify their models to take into account the different numbers of visitors to the theme park at different times of the year.