Using statistics to explore cross-curricular and social issues opportunities

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The area of statistics is one in which teachers may be encouraged to make important links to other curriculum areas and social issues. Statistical literacy is a key component of being numerate and living as an informed citizen. The teaching of statistics provides an opportunity to inform and educate students about social issues and moral behaviour, as well as reinforcing the links between mathematics and other areas of study. The *Australian Curriculum: Mathematics* (ACM) (ACARA, 2013b) states "Mathematics is composed of multiple but interrelated and interdependent concepts and systems which students apply beyond the mathematics classroom" (p. 1). In no other area is this so pronounced as in the Statistics and Probability Strand.

When designing a fourth year pre-service teacher unit on teaching Statistics and Probability, while still covering all of the big ideas of statistics and probability, it was decided to make the cross-curricular and social issues a focus of the unit. In this way it was hoped to model an approach that the students could use in their future classrooms. Many of the tasks used were derived from *Maths300* (Williams & Lovitt, 2010) and *Digging Into Australian Data With TinkerPlots* (Watson et al., 2011). Both of these resources made use of software that enabled probability simulations and used dynamic data analysis tools which allowed the reinforcement of the fundamental connections between statistics and probability while encouraging informal statistical inference (Flavel, 2013; Konold & Kazak, 2008; Konold & Miller, 2004). A selection of the tasks used within the unit, which translate directly into a secondary school classroom, are described in this article.

Using historical data

Watson et al. (2011) devote several sections of *Digging Into Australian Data With TinkerPlots* to exploring historical and popular culture (sport) data which would link in well with the Years 9 and 10 *Australian Curriculum: History* (ACARA, 2013c). There are investigations on Australian Prime Ministers, the Melbourne Cup, the First Fleet, Australian sports and Australian explorers. One of the students' favourites was using the *TinkerPlots* software (Konold & Miller, 2004) to analyse Melbourne Cup data to determine what attributes the typical Melbourne Cup winner possessed.

The students determined that a typical winner was a bay (42%) stallion (42%) either 4 or 5 years old (29% each). They found that the median weight carried by the winners was 51.5 kg but the middle half, as determined by the hat plot, carried between 48 and 54.9 kg. Similarly, the median starting price was 9 to 1,

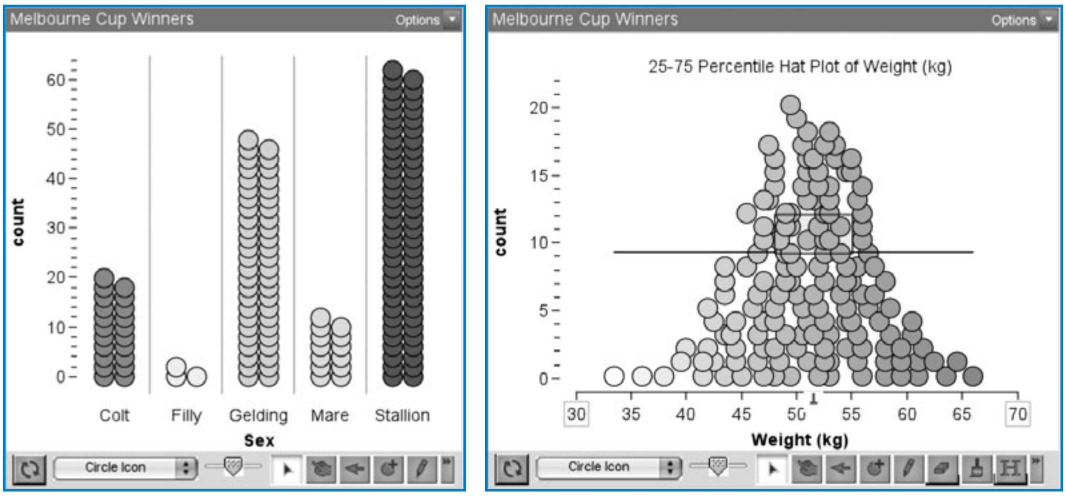

Figure 1. Examples of graphs used to determine what is typical for a Melbourne Cup winner.

but the middle half of the winners started at between 5 to 1 and 15 to 1. This generated significant discussion amongst the students, as a judgement had to be made about which values were more representative of the typical winner.

When the students were asked to find a former Melbourne Cup winner which best fitted the typical profile, different groups of students proposed different horses. The mathematical discussions which ensued as the groups endeavoured to justify their selections to each other were very rich and demonstrated both understanding and reasoning, two of the Mathematical Proficiency Strands of the ACM. This task directly links to the Year 10 History Curriculum (ACARA, 2013c) by relating to Australia's contribution to international popular culture (sport). Other statistics and probability tasks that could link to this curriculum descriptor as well as Health and Physical Education courses are Dice Footy (lesson 161), Dice Cricket (lesson 175), Sporting Finals AFL (lesson 149) and Sporting Finals (lesson 179) from maths300 as well as Goodwill Cyclists (lesson 5.2), Basketball Data (lessons 5.3 & 5.4) and Which Football Code? (lesson 5.5) from Watson et al. (2011).

Radioactive waste

The Year 10 Australian History Curriculum (ACARA, 2013c) draws attention to significant events that have contributed to an awareness of environmental issues, specifically mentioning the nuclear accident at Chernobyl and the Jabiluka mine controversy. The recent nuclear disaster at Fukushima would fit within this descriptor and link with the cross-curricular priority of Asia and Australia's engagement with Asia. The lesson *Radioactivity* from maths300 addresses the issue of generation of radioactive waste. Understanding radioactive waste involves the scientific concept of a half-life and exponential decay functions. All radioactive material is described in terms of its half-life.

This lesson begins with a stimulus activity about nuclear accidents. During this discussion the teacher is able to explain about radioactive decay. Information about this may be sourced from Kids World (2011). Scientists do not know what triggers any particular atom to decay, but they do know over time what fraction of rays have decayed. The random nature of the atoms decaying allows the link to probability to be made.

A role play simulation is set up. Each student plays the part of an atom with a 1 in 6 chance of decaying. All students roll their individual dice and the teacher rolls a large die which is the 'death die'. All students who roll the same number as the teacher, fire off their poisonous rays and sit down. Class data is collected of the number of remaining atoms at the end of each year. When approximately half of the atoms have decayed there is a deliberate pause by the teacher and the students

Year	Atoms
0	20
1	17
2	13
3	10
…	…
6	5
…	…
9	2
…	…
12	1
…	…
15	0

Figure 2. Example of data collection with a half-life of approximately three years.

are asked to predict how long it will be before all of the atoms have decayed. The role play is continued with more class data being collected and the concept of half-life is explored (see Figure 2).

A real example of half-life can be introduced to reinforce the concept. For example, the main contaminating material released during the Chernobyl disaster in the Ukraine and Fukoshima was Caesium-137 which has a half-life of 30 years. A computer simulation from maths300 (Flavel, 2013) provides another mathematical model and allows students to investigate different sample sizes, different probabilities and the shape of the distribution to form conclusions (see Figure 3).

Links could also be made with half-life of plastic bags in the environment (Sustainability), half-life of medicines, or other nuclear disasters. An important link can be made with Aboriginal and Torres Strait Islander histories and cultures by introducing the British nuclear tests at Maralinga. One of the contaminants released at Maralinga was Plutonium-239 which has a half-life of 24 100 years. Importantly this lesson also addresses the General Capability of Ethical Understanding.

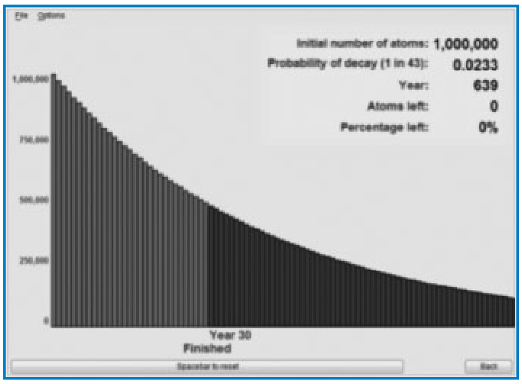

Figure 3. An example of a half-life of 30 years.

Weather

Many mathematics textbooks try to establish the cross-curricular uses of graphs such as those of temperature and rainfall. The texts tend to ask closed questions to see whether students are able to read accurate data from the graphical representation. A far richer and open task is to provide students with several graphs and ask them to match the graphs with the cities from which they are taken. To do this well, students need to draw on mathematical knowledge as well as information about northern and southern hemispheres, proximity to the equator, how far the cities are from the coast and many other geographical considerations, without losing the requirement to accurately read the data. This is an ideal activity to promote cross-curricular links and there is much mathematical and geographical discussion as students working in groups endeavour to match the graphs and cities. The *Maths300* software (Flavel, 2013) allows worksheets to be tailored to include cities of choice and it is a simple process to add cities to the data base (see Figure 4). This is an important aspect as it allows a personalisation of the data for students. They can add cities they have been to, cities about which they are studying, places where their relatives live or places they would like to visit.

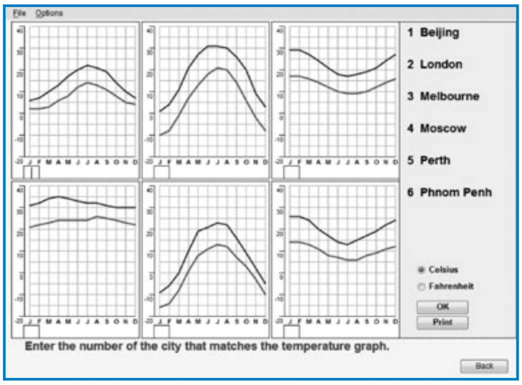

Figure 4. Temperature graphs example.

Watson et al. (2011) also investigate weather data for Australia's capital cities collected from 1956 to 2008. The data file supplied includes total rainfall for the month, the highest daily maximum and the lowest daily minimum temperatures for the month as well as the average maximum and minimum temperatures for the month. As the data set is very large, filters may be used to make the data more manageable. In order to do this students are forced to be much more discerning about the data selected for use, an important skill with so much data available. (In

Figures 5 and 6, the average maximum and minimum temperatures for Melbourne, Brisbane and Darwin (ordered from left to right) are shown for each month of the year.) Although the data for the average maximum temperatures appears quite ordered and predictable, the data for the average minimum temperatures perhaps shows some surprises, which is always a good reason to investigate the data (Watson et al., 2011). Students could pose a question about this data, form a hypothesis, investigate by using different analysis tools and communicate their conclusions.

There are many different investigations possible with this data set making cross-curricular links to History, Geography, Science and Environmental Science.

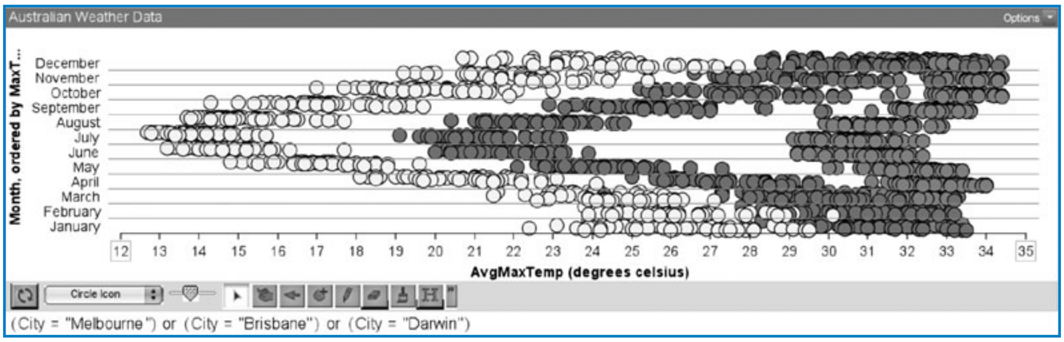

Figure 5. Average maximum temperatures for Melbourne, Brisbane and Darwin.

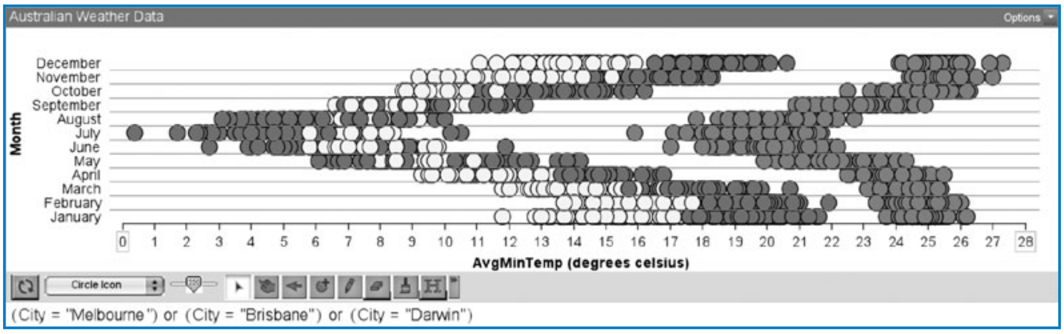

Figure 6. Average minimum temperatures for Melbourne, Brisbane and Darwin.

Fair games

As well as addressing many aspects of the Statistics and Probability curriculum, the investigation of what constitutes a 'fair' game allows the integration of most of the General Capabilities of the Australian Curriculum (ACARA, 2013a) such as Literacy, Numeracy, Information and Communication Technologies, Critical and Creative Thinking, Personal and Social Capability, and Ethical Understanding (and could be broadened to include Intercultural Understanding). This aspect of Statistics and Probability provides an opportunity to inform and educate students about social issues and moral behaviour while connecting mathematics to the real world in a meaningful way for students.

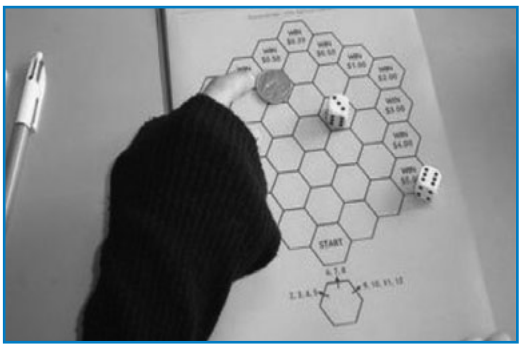

Figure 7. Playing Win at the Fair.

The *Maths300* lesson *Win at the Fair* investigates the psychology of fairground games and how they lure customers by appearing to be easier to win than they are. However, this particular version of the game actually loses money for the operator because the prizes, for the $1 outlay, are too generous. Students only have to play a few games to suspect this may be the case (see Figure 7). The lesson requires students to collect and analyse data to confirm their suspicions (see Figure 8), and raises the question: How can the board be redesigned so that the operator makes a fair profit (see Figure 9)?

One of the major strengths of this lesson is providing students with the opportunity to re-design the game to make a fair profit and test their boards with multiple trials. This involves students thinking carefully about the delicate balance between the probability of winning the game and the notion of a 'fair profit'. The students have ownership of the lesson once they are asked to create new rules for the game and this provides an opportunity for them to demonstrate their higher-order thinking, problem solving and reasoning skills.

The lesson can be used to address the social issue behind gambling and how operators of 'games' such as poker machines pre-organise the payouts to produce the results they want. Consequently, although the players sometimes believe they are playing a game of chance, they have no long-term chance whatsoever. Once again, links to the General Capabilities of Ethical Understanding and Personal and Social Capability (ACARA, 2013a) may be made. Another lesson that introduces and addresses social issues is the Maths of Lotto (lesson 180) in maths300.

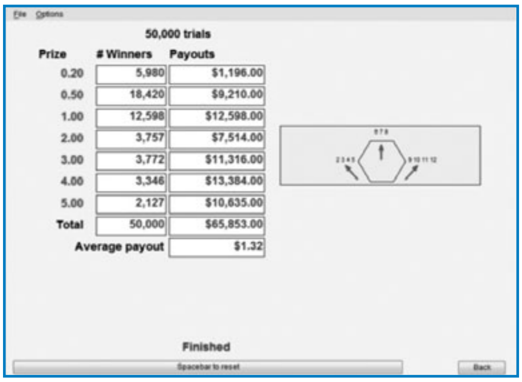

Figure 8. Data collection showing a loss.

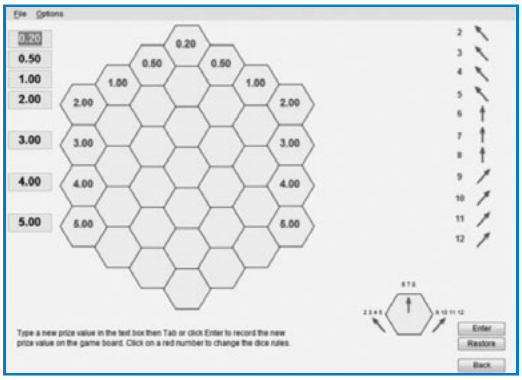

Figure 9. Design a new board.

Conclusion

The collection of tasks described in this article demonstrates the ease with which Statistics and Probability tasks may be integrated across the curriculum in a meaningful manner. There are many such mathematically rich, investigative tasks available, that tick many of the Australian Curriculum boxes about covering statistical and probabilistic content, embedding the Mathematical Proficiencies and addressing the General Capabilities and Cross-Curriculum Priorities (ACARA, 2013a).

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