

Making decisions with data: Are we environmentally friendly?



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Statistical literacy is a vital component of numeracy. Students need to learn to critically evaluate and interpret statistical information if they are to become informed citizens. This article examines a Year 5 unit of work that uses the data collection and analysis cycle within a sustainability context.

Preparing our students to be statistically literate in today's world is paramount. If students are to make informed decisions in life, both now and in the future, they need to understand and reason critically with data (Watson, 2006). The goal of critical statistical literacy reflects a combination of two of the general capabilities in the *Australian Curriculum* (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2013), namely, critical and creative thinking and numeracy, as reflected in the element of interpreting statistical information.

In this article we describe a unit of work completed by four Year 5 classes in an Australian capital city school. The unit introduced students to a four-step procedure for undertaking statistical investigations, where they developed an understanding of the foundational concept of variation and the relationship of samples to populations. An appreciation of uncertainty in making decisions with data was also a key learning component. The availability of the Australian Bureau of Statistics (ABS) *CensusAtSchool* website meant that students could move beyond their classes and collect random samples from a pseudo-population of Year 5 students, observe variation, and make decisions.

Alignment with the Australian Curriculum: Mathematics for Year 5

The unit of work addresses the statistics and probability section of the *Australian Curriculum: Mathematics* for Year 5, specifically, the two descriptors under data representation and interpretation: (a) Pose questions and collect

categorical or numerical data by observation or survey (ACMSP118) and (b) Describe and interpret different data sets in context (ACMSP120). The unit also provides the opportunity to enhance the proficiencies in the *Australian Curriculum: Mathematics*, such as understanding the terms, 'sample', 'population', 'random'; problem solving where a strategy is devised for analysing data to answer a question, and reasoning involving generalising from data; and analysis to a conclusion. Furthermore, all of the organising elements of the general capability of critical and creative thinking are also reflected in the unit, specifically, inquiring involving identifying, exploring and organising information and ideas; generating ideas, possibilities and actions; reflecting on thinking and processes; and analysing, synthesising and evaluating reasoning and procedures.

Activity 1: A movie or a book?

The unit commenced with a whole-class discussion activity introducing the students to the four-step procedure for undertaking investigations in statistics (Franklin, Kader, Mewborn, Moreno, Peck, & Scheaffer, 2007):

- Posing a question
- Collecting data
- Analysing data
- Making decisions acknowledging uncertainty

An imaginary scenario was then presented:

Imagine that your cousin gave you a \$20 gift voucher for your birthday. The voucher was for a book store but can be swapped for

a movie ticket instead. You have to decide whether you will spend the \$20 at the book store OR at the movies.

Beginning with their own classes, the students were asked:

First, for everyone in our class right now, which do you think would be more popular, buying books or going to the movies?

Students gave various reasons for their predictions with some students expressing the important notion of uncertainty in drawing a conclusion such as, “It depends on what movies are on.” Following the group discussion, the students indicated their preferences by raising their hands; the teacher collected and recorded the data on the whiteboard. The students were then asked what they could conclude from the class data and how certain they were that it was true.

In one class movies were only slightly more popular. As their initial prediction was a movie preference, the class concluded that, “Our hypothesis was correct.” It was agreed that their finding was true for their class at the present point in time. The students were then asked to consider a larger sample, namely, all Year 5 students in their school:

- What might we infer or conclude for all Year 5s in our school by using the data from our own class?
- Would we be certain of our conclusion here? Why/why not?

Following a sharing of views some students expressed concern at drawing broader generalisations, suggesting that they had an emerging understanding of the core concepts of sample and population and the relationship between the two. This understanding is evident in responses such as, “Because it’s like jumping to the conclusion, so say, say our class thinks it’s [movie preference] popular, that concludes that ... we’re all Year 5s okay, we’re all the same, [and] other Year 5s will obviously like it too.” These doubts about generalising from their class sample led to a discussion on the lack of certainty involved.

The final step was generalising to a broader population, namely, all Year 5s across Australia. The question was posed:

Would our one class here in (our city) be good for making a prediction about all Year 5 students in Australia? Why/why not?

The students discussed potential variation of opinions of students in other parts of the country, covering the key ideas of sample, random, population, and generalising. They concluded that they would be uncertain about making decisions for all Australian Year 5 students. These understandings provided the introduction to the main activity.

Activity 2: Are we environmentally friendly?

The second activity, the main investigation, lasted about three hours in total and was set within a sustainability context. This context was in line with one of three cross-curriculum priorities in the *Australian Curriculum: Mathematics*. The activity commenced with a fictitious newspaper article (Figure 1). Using such a context was intended to create the questioning behaviour expected of statistically literate adults.

Building on the understandings developed in Activity 1, the students were asked:

- What do you think of the Down-to-Earth Watchers’ claims that children are not environmentally friendly after all?
- Is it true? Why or why not?
- What claims did Mr Plant make about all children in Australia?

The majority of students quickly offered explanations such as, it is “not exactly true cause he only, he only surveyed, only some people like a class ... some people from the class might have been away, or, ... only one class doesn’t actually mean the whole world.” Other responses further indicated students’ appreciation of the sample-population relationship and the difficulties in extrapolating from a sample to a larger population. Students explained that Mr Plant “only surveyed one class in Tasmania and he didn’t survey like the whole people, like classes in Australia and so ... he’s jumping to conclusions by one little class.”

Testing Mr Plant’s claims

Having experienced Activity 1, the students were keen to investigate their own class. The question posed was, “Do you think our class is environmentally friendly?”

In predicting the possible outcomes, students were sometimes divided in their opinions such as, “Yes, we are environmentally friendly,” which

Friday 17 May 2013

Forestdale Times

Children not environmentally friendly after all

“Australian school children are not as environmentally friendly as we thought,” said Mr Plant from the Down-to-Earth Watchers Group. “We surveyed a class of Year 5 students in Tasmania and we were shocked with the results.

The survey found that children do not do enough in their home to conserve the environment. Many students admitted to having long baths, tossing soft-drink

cans in with the food rubbish, or worse, just leaving them on benches in parks. No efforts were made to conserve electricity either with most moving from room to room leaving lights, TVs and iPods on.

“Children need to take more care of the environment. They simply don’t care at all”, Mr Plant said.

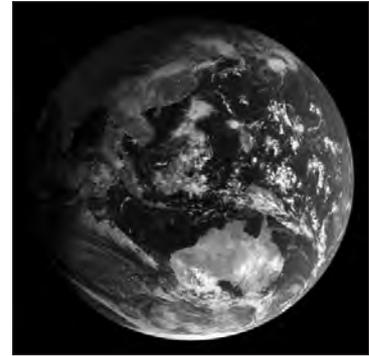


Figure 1. Stimulus— fictitious newspaper article.

was countered with responses such as “Um, I am not exactly sure ’cause we haven’t got like, we only know about ourselves; I don’t know like for example if Ruben is environmentally friendly.”

Students were then introduced to the ABS *CensusAtSchool* website, which gathered data on students throughout Australia. It was decided that the ABS questions in Table 1 could help refine the overall question of being environmentally friendly. Students were interested to see how their class would answer the questions. If they were undecided on one or more questions, they were to “answer for what you do most of the time.”

Making decisions while acknowledging uncertainty

The class tallied the number of ‘yes’ votes of all students for each item and expressed these as percentages, which were listed on the board. The students had been exposed to the basic notion of percent in our previous activities and had calculated percentages using a calculator. The present activity enabled the students to apply their

emerging part-whole understanding of percentage, where they considered the issue of “What results will convince us that we are environmentally friendly?” This led to a discussion of criteria to meet for each of the questions. Working in pairs, students decided on their own criteria for drawing a conclusion, namely, the percentage of ‘yes’ answers they deemed necessary for the certainty of their conclusions. In the following response from one student, percentages and the associated criteria for their application are indicated, together with the degree of certainty of the conclusion drawn:

Energy is more expensive than water, so to be environmentally friendly water has to be at 50% while energy needs to be at 75%. The actions that need to be at half are: shorter showers and turning off the tap. The actions that need to be at 75% are: recycling, water tanks and turning off appliances. We are not environment[al]ly friendly because some of the answers do not match our criteria. I am fairly certain my conclusions are right, because my criteria says that energy questions are more important and those questions are not fulfilled.

Table 1. Five-item survey completed by each student.

Am I environmentally friendly?	Yes	No
Our household has a water tank.		
I take shorter showers (4 minutes maximum).		
I turn the tap off while brushing my teeth.		
I turn off appliances (e.g., TV, computer, gaming consoles) at the power point.		
My household recycles rubbish.		

The class was not unanimous in deciding whether the class was environmentally friendly because the pairs' criteria were slightly different. This situation was different from elsewhere in mathematics where students expect a unique 'correct' answer (Watson & Nathan, 2010).

Progressing from sample to population

Students then progressed from their class sample to making a decision based on their criteria for all Year 5 classes in their school and then for all Year 5 classes in Australia. Four main understandings were consolidated in the remainder of the activity:

- distinguishing between sample and population;
- appreciating the variation that occurs in different random samples;
- making evidence-based decisions, generalising from random samples to the population; and
- recognising greater certainty of decisions as more samples are collected.

These foundational ideas were developed in the next component of the investigation, namely, exploring random samples from the ABS *CensusAtSchool* website.

Exploring random samples

The aim was that students would come to appreciate how decisions could be made with more certainty if random samples from a broader population were considered, and that every Year 5 student in the population had the same/equal chance of being in the sample. Because the environmental survey items had come from the ABS *CensusAtSchool* data set, random samples could be collected from a 'population' of 1300 Year 5 Australian students.

To select random samples from the *CensusAtSchool* data set, students were re-introduced to the sampler feature (Figure 2) in the *TinkerPlots*

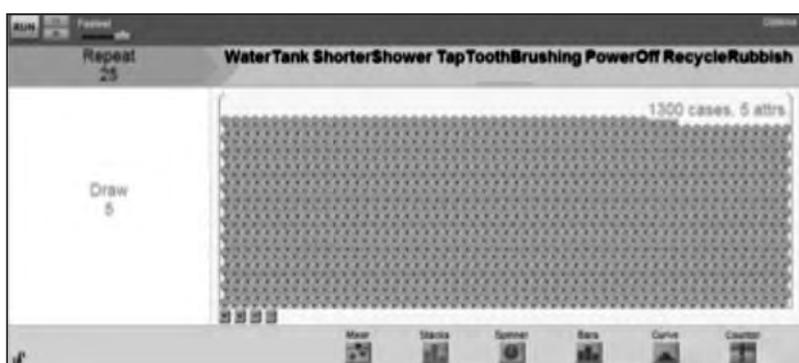


Figure 2. Data in TinkerPlots sampler for random selection.

software (Konold & Miller, 2011), which they had used in a previous activity to simulate tossing coins (English & Watson, 2016). Students explored one, then multiple, random samples of the same size as their class. Beginning with one random sample, students used their initial criteria to decide if their random sample of Year 5 students in Australia was environmentally friendly. Students were asked, "How certain are you of your conclusion?" By comparing the outcomes of their random sample with those of others in the class, students could see the variation that occurred and hence the difficulty in drawing inferences about the ABS population of Year 5 students. To increase the certainty with which conclusions might be drawn, students ran a total of 9 random samples. They recorded their outcomes in a table, an example of which appears in Figure 3.

	Water Tank	Shorter Shower	Tap Tooth Brushing	Power Off	Recycle
My random sample	35%	73%	85%	58%	81%
Random Sample 2	27%	62%	81%	69%	77%
Random Sample 3	46%	54%	85%	65%	81%
Random Sample 4	46%	69%	96%	50%	81%
Random Sample 5	50%	77%	88%	69%	73%
Random Sample 6	50%	62%	85%	58%	81%
Random Sample 7	35%	69%	96%	62%	73%
Random Sample 8	42%	65%	85%	69%	77%
Random Sample 9	31%	73%	92%	65%	77%

Figure 3. A table of results for nine random samples.

Using the outcomes from their nine random samples, students recorded their predictions for the population percentage for each survey item they were considering. Figure 4 displays an example of one student's predictions for the ABS population recorded in the first row. The actual values from the ABS data are in the second line of the table.

Students' reasons for why they chose their predicted percentages ranged in sophistication,

beginning with simple responses such as, “I chose these percentage [sic] because it’s suitable and I think these percentages is [sic] friendly.”

	WaterTank	Shower	Teeth	PowerOff	Recycle
My prediction	35%	62%	85%	64%	77%
Our population	40%	65%	90%	57%	82%

Figure 4. Predictions and actual values for the ABS population.

More advanced responses made use of the mean or mode such as, “Because they are the numbers most of the school [samples] use and are the numbers in the middle of each column” (in Figure 3). It is worth noting that the students had not yet been formally introduced to the mode, median, or mean.

The final discussion included how students felt generally about a decision based on the percentages from the ABS population and whether Mr. Plant’s claim in the article was accurate. Students agreed they did not know what data Mr. Plant had used to make his claim and certainly his one class in Tasmania was not representative of Australia. They were not willing to believe his conclusion but admitted they could not use the data from their class either. Using the ABS data, they were more certain about concluding that Australian students are environmentally friendly. After suggestions that some people might not have water tanks because they live where there is no rain or in an apartment building where it is not possible to have one, they agreed that the percentages in Figure 4 (with only water tank below 50%) supported an answer of ‘yes.’

Concluding points

In this article we have described two activities, the second of which featured the use of ABS data and *TinkerPlots*. The software not only enriched and extended students’ learning, but also was essential for generating multiple random samples that could not be done manually.

The unit of work allowed students to set their own criteria for being environmentally friendly, which introduced a high degree of variability in student responses. Answers of both “yes, friendly” and “no, not friendly” were acceptable provided that their chosen criteria were applied rigorously. Later in the unit, however, another order of

variation was introduced when each pair of students collected a different random sample from the ABS ‘population’. The members of the class were now not applying their different criteria to the same sample (the class data) but to different samples.

At the end of the unit, students did demonstrate the core understandings we were trying to achieve, including distinguishing between sample and population, appreciating the variation that occurs in different random samples, making evidence-based decisions, generalising from random samples to the population, and recognising that decisions can be made with greater certainty as more samples are collected. For students to deal meaningfully with these statistical ideas in the later grades, we consider it imperative that such foundations be established in the primary school.

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