Using technology to support statistical reasoning: Birds, eggs and times to hatch

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This article by Elizabeth Reeve and Kim Beswick illustrates how primary children may engage with the Statistics and Probability content contained in the Australian Curriculum. Technology has opened up many possibilities for young children to engage with statistics. In the process the children learned a great deal more than just mathematics.

The Statistics and Probability strand of the *Australian Curriculum: Mathematics* (Australian Curriculum, Assessment and Reporting Authority, 2012) includes the content descriptions shown in Table 1 for Data representation and interpretation in the middle primary school years.

Table 1. Selected content descriptors for Statistics and Probability in the Australian Curriculum.

Year 3	Identify questions or issues for categorical variables. Identify data sources and plan methods of data collection and recording
	Collect data, organise into categories and create displays using lists, tables, picture graphs and simple column graphs, with and without the use of digital technologies
Year 4	Construct suitable data displays, with and without the use of digital technologies, from given or collected data. Include tables, column graphs and picture graphs where one picture can represent many data values
Year 5	Pose questions and collect categorical or numerical data by observation or survey
	Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies
	Describe and interpret different data sets in context

The content and ordering of the content descriptions implies at least three things. Namely:

- that children should work with data that they have collected for themselves,
- working with and understanding categorical data is easier than working with and understanding numerical data, and
- that the kinds of data representations that are appropriate are independent of whether or not digital technologies are used.

The investigation described in this paper provides an example of how, in accordance with the first of these implications, working with familiar data can help children to access important ideas in Statistics and Probability. It also challenges the second and third implications. We suggest that if the data and context are familiar, the use of technology can facilitate a shift in the focus of an investigation from producing prescribed data displays to interpreting displays that can be readily created and manipulated. This, in turn allows more sophisticated ideas to be accessed, and both categorical and numerical data to be worked with in a meaningful way.

The paper describes an investigation initiated and conducted outside the classroom by a Year 3 student (Lizzy) who was 9 years old. Her mother (Kim) provided support as needed. *TinkerPlots Dynamic Data Exploration* software (Konold & Miller, 2005) was used to create scatter plots to show relationships between pairs of variables. *TinkerPlots* is designed to be used by students throughout the middle primary school and early secondary years. It allows students to work intuitively with data and to create data displays that help them to interrogate data and tell stories from it. Although the content descriptor, "Identify everyday questions and issues involving at least one numerical and at least one categorical variable, and collect data directly from secondary sources" appears at Year 9, and "Use scatter plots to investigate and comment on relationships between two numerical variables" appears at Year 10, we demonstrate that with the help of technology and with a focus on intuitive understanding rather than statistical calculation, much younger children can access this content. Lizzy was able to make sense of the scatter plots made in this investigation because they were created to answer questions that arose directly from it.

The investigation

The description that follows is organised into six stages that could be useful in planning other investigations. These stages were:

1. Noticing, and forming an hypothesis about a relationship
2. Specifying the variables in the question
3. Changing/refining the focus
4. Describing and testing relationships
5. Considering an outlier
6. Reflecting on the learning.

The quotations included are from email exchanges between the authors.

1. Noticing, and forming an hypothesis about a relationship

The authors live on a small rural property with a number of ducks (some are shown in Figure 1) and chickens, both of which provide eggs for the family. The investigation was sparked when Lizzy noticed that duck eggs are bigger than chicken eggs and ducks are also bigger than chickens. This prompted her to ask, "I wonder if bigger birds have bigger eggs and if the smaller birds have smaller eggs?" Lizzy thought that they might and decided to check by using the Internet to find the sizes of both emus and sparrows and their eggs.

Figure 1. A group of ducks and ducklings.

2. Specifying the variables in the question

It quickly became apparent that before she could find the sizes of the birds, we had to decide what size meant: it could mean mass, length or height. After some discussion, we decided to use mass because that would tell us about the size of the bird, whatever shape it was, and so it would be possible to compare the sizes of differently shaped birds. It proved difficult to find both pieces of data for sparrows, so Lizzy looked up robins instead and also swans. These were familiar birds with differing sizes. No duck eggs were available to be weighed on the day these data were collected, so ducks were not included either. Entering the data on data cards (one for each bird) in TinkerPlots was easy to understand, and making the scatter plots simply involved dragging and dropping variables onto the axes of a plot. An example of a data card (from later in the investigation) is shown in Figure 2 and the initial scatter plot is shown in Figure 3.

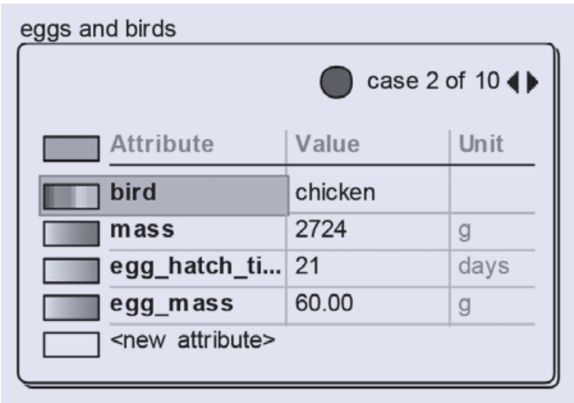

Figure 2. Data card for chickens.

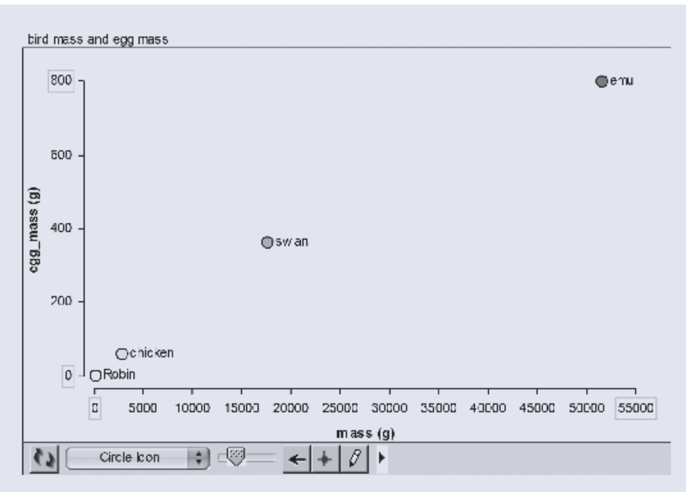

Figure 3. Scatter plot of bird mass and egg mass.

3. Changing/refining the focus

The investigation was conducted in the spring; there were lots of ducklings in the yard and cygnets on the river, so Lizzy turned her attention to the time it takes different eggs to hatch and wondered whether this might also be related to the mass of the bird. The Internet again provided data that were added to those already collected. In the process, spread over about 10 days, Lizzy discovered many interesting facts. She wrote:

> It takes about 50 days to hatch an emu egg.
>
> The male usually picks out where he wants the female to lay her eggs. She will lay 1 egg every 3 days and when she has got 6–8 eggs in the nest the male will brood. The male sits on the egg not the female.
>
> A sparrow egg takes 3–16 days to hatch.
>
> Here's something interesting, it takes 32–40 days for a swan egg to hatch but it depends on the breed of the swan.
>
> Baby swans are called cygnets.

We made two kinds of plots: one showing egg mass and hatching time and the other showing bird mass and egg hatching time. Different versions were made as data for more birds were added. Later versions are shown in Figures 4 and 5.

4. Describing and testing relationships

When Kim asked, "Can you describe the pattern?", Lizzy replied, "As the birds get heavier the egg takes longer. But did we get the right gender?" Lizzy understood the relationship that the scatter plots showed, but a new factor that we had not considered had also occurred to her. We speculated about whether male and female birds of the same kind actually have different masses and thought that the mass of the female would probably be the most relevant, although emus could be an interesting case (the male broods). Unfortunately we could not find data that would allow us to pursue this line of inquiry.

In order to test further our hypothesis about the relationship between bird mass and hatching time, Lizzy found data on more birds and these were added to the data set.

She wrote:

> I have found out how long an egret egg takes to hatch and a crane's.
>
> A whooping crane takes 29 to 31 days to hatch its eggs.
>
> I found out about the great egret. The great egret is the tallest, largest white egret that can be seen in the Sungei Buloh Nature Park. It lays about 1–6 eggs and they hatch at different times about 25 days later.
>
> But then I found out that our theory is completely right because a finch is smaller than a sparrow. The finch eggs take about 2 weeks to hatch.
>
> I then found out a lot more birds so here they are…
>
> > Gray headed king fisher — This bird is just a small bird. Most king fishers are bigger. The gray headed king fisher breeds at the end of its first year. Its eggs take about 20–30 days to hatch.
> >
> > Robin — It takes 12–14 days for them to hatch but that's from when the last egg is laid. When the chicks come out they have to stay in the nest for 9–16 days!"

When ranges for the hatching times were found, we discussed the need to have a single value to be entered in TinkerPlots and what a reasonable number might be. We agreed that the midpoint of the range was an appropriate number.

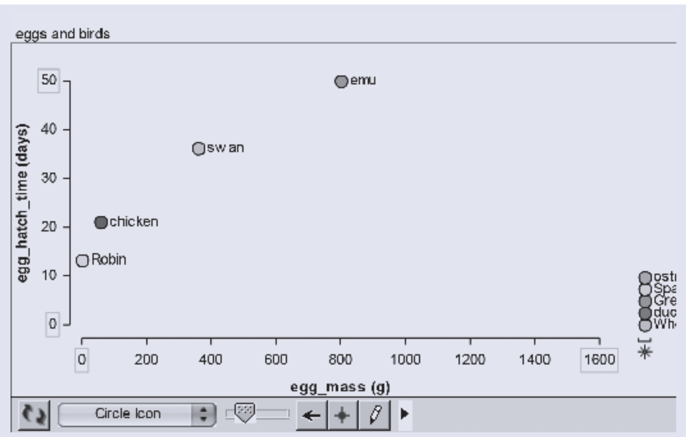

Figure 4. Scatter plot of hatching time against egg mass.

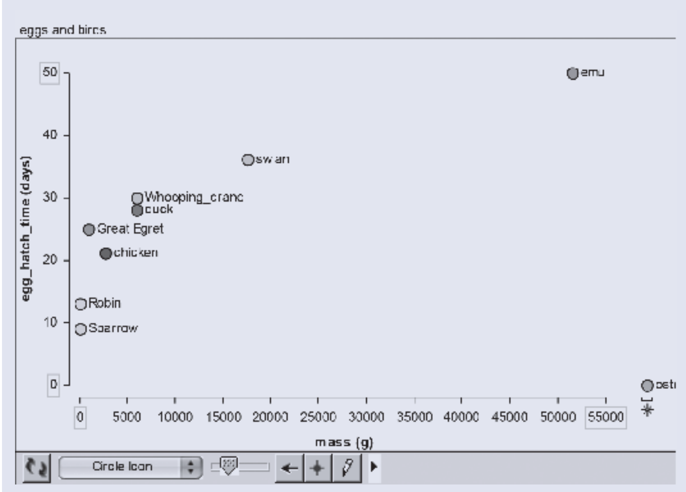

Figure 5. Scatter plot of hatching time against bird mass.

5. Considering an outlier

When the investigation seemed to have about run its course, Kim suggested that Lizzy look up data for the Kiwi. When these data were added, the scatter plot shown in Figure 6 was obtained. This led to a discussion of exceptions, or outliers. Outliers are not mentioned in the content descriptors of the Australian Curriculum: Mathematics until Year 8 but, in the context of familiar data and representations of it, its meaning was obvious. In addition, TinkerPlots has a feature that allows a particular data point to be hidden and so the effect on a plot of an outlier can be readily explored by alternately hiding and un-hiding the relevant data point.

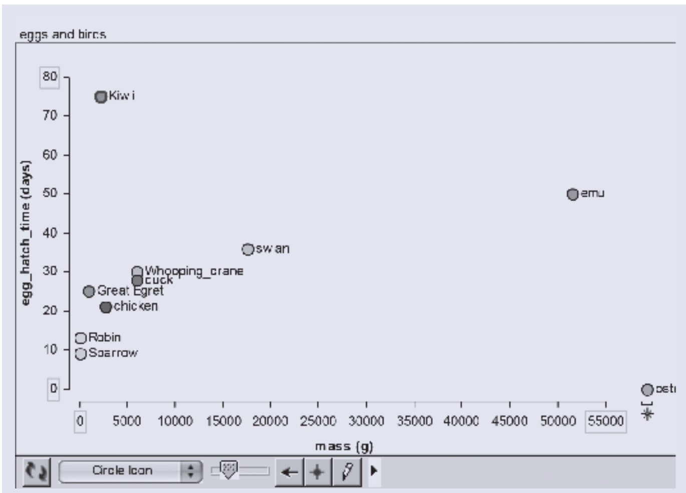

Figure 6. Scatter plot of hatching time against bird mass with the Kiwi.

6. Reflecting on the learning

In preparation for writing this paper, Lizzy looked back over the email trail and summarised the investigation as follows:

> We found out that an emu egg takes about 50 days to hatch. The male usually picks out a place where he wants the female to lay her eggs. She will lay 1 egg every 3 days and when she has 6–8 eggs in her nest the male will brood. We also found out that the female does not sit on her nest the male does. A sparrow egg will take a shorter amount of time. A sparrow's eggs will hatch in about 3–16 days. We also found some interesting facts about swans. We found out that it takes 32–40 days for a swan egg to hatch depending on the breed. We also found out that baby swans are called cygnets. We found out that the heavier birds' eggs take longer to hatch. The birds' egg hatching times go according to their sizes: sparrow (3–16 days), chicken (21), duck (28), swan (32–40) and emu (50 days). A Whooping Crane takes 29–31 days to hatch their eggs. We found that the Great Egret will lay 1–6 eggs and in about 25 days time they will hatch. We proved our theory finding out that a finch is smaller than a sparrow and their eggs take only 2 weeks to hatch. A Gray headed King Fisher's eggs take about 20–30 days to hatch. Whereas a Robin only 12–14 days for their eggs to hatch and she found out that after they have hatched the chicks have to stay in the nest for the next 9–16 days!

Conclusion

Using TinkerPlots in this investigation allowed Lizzy to explore relationships between pairs of numerical variables in an intuitive and meaningful way. Describing the relationship between variables was as natural as reporting other facts about birds and their breeding habits. Although this investigation was carried out at home, it could have been pursued in a classroom context. The key features that we believe made the ideas accessible were that the ideas arose from Lizzy's experiences, she was allowed to pursue questions that interested her, and the technology removed the tedium of constructing data displays, allowing her to focus on their meaning.

References

Australian Curriculum Assessment and Reporting Authority. (2012). *The Australian curriculum: Mathematics*. Retrieved from http://www.australiancurriculum.edu.au/Mathematics/Curriculum/F-10

Konold, C. & Miller, C. D. (2005). *Tinkerplots: Dynamic data exploration* [software]. Emeryville, CA: Key Curriculum Press.