A taste of Asia with statistics and technology

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Josh Reid and Colin Carmichael describe how some Year 6 children have developed their understanding of mathematics by studying Asian countries. The statistical analyses undertaken by these children appears to have strengthened their understanding of statistical concepts and at the same time provided them with tools for understanding complex socio-cultural relationships.

Introduction

Can and should statistics learning outcomes be met in non-mathematical contexts? Despite its placement in the mathematics curriculum, statistics is regarded as a "methodological discipline rather than a core substantive area" (Moore & Cobb, 2000, p. 620). Children need opportunities to apply statistical methodology in authentic contexts, with such contexts readily available in non-mathematical disciplines such as the social sciences (Watson & Neal, 2012). Arguably the social sciences provide a naturalistic setting for learning and understanding statistical concepts, which in turn, provide children with tools to better understand relationships in the social-sciences.

The teaching of statistics in the social sciences also meets the cross-curricular requirements of the *Australian Curriculum: Mathematics* (Australian Curriculum Assessment and Reporting Authority [ACARA], 2013) with one of its aims including that children be able to see connections between mathematics and other disciplines. The Australian Curriculum also identifies numeracy as one of seven core capabilities that need to be taught across the curriculum. In as much as statistical literacy is an element of numeracy, the teaching of statistics in the social sciences promotes the "cross-disciplinary" approach to numeracy that is advocated by the curriculum writers.

With this rationale in mind, the authors developed and implemented a cross-disciplinary unit of study for a class of Year 6 children in NSW that sought to develop links between the *Australian Curriculum: Mathematics* (ACARA, 2013) and its social science counterpart (ACARA, 2014). The authors were also mindful of the role of technology as a general capability in the Australian Curriculum and the focus on Asia as a cross-curriculum priority. In this paper the unit *A Taste of Asia* is described and the mathematical learning of children as they undertook this unit is discussed.

Background

Children in this study were in a Year 6 class attending an independent primary school situated in rural NSW. The group comprised 10 males and 17 females, who were aged between 11 and 12 years old. In the year preceding this study the lead author had designed a unit on Asia focussed on exploring how a culture changes through its interactions with other cultures. A major component of the unit had been children researching key facts on an Asian country of their choice, and making comparisons between this country and Australia. In the current study, the unit was modified so that children were also asked to research and collect key statistics on their chosen Asian country.

Once the unit commenced, children were allocated five weeks (consisting of one 45 minute computer lesson per week plus a minimum of an hour a week) to research an Asian country of their choice. The computer lesson focused on the development of children's statistical concepts, and in particular provided them with opportunities to explore the features of *TinkerPlots* (Konold & Miller, 2012), an interactive statistical software package. Much of this was based on activities associated with the resource book *Digging into Australian data* (Watson et al., 2010). During their social-science lessons, the children were asked to research key statistical facts related to their chosen Asian country (see Table 1) and in doing so work towards Geography outcomes such as "ACHGK032: research the population size and density of a selection of countries around the world" (ACARA, 2014, p. 46). As is seen in the table, some variables such as "birth rate per 1000 people" were complex for children of this age, but were included intentionally to provide the children with an opportunity to explore bivariate (two variable) relationships. These data were subsequently compiled by the teacher into the *Taste of Asia* dataset that contained 22 countries in the Asia region, in addition to Australia.

for promoting children's understanding of both mathematics and social-science. Country population figures, for example, were expressed by the children in thousands, millions or units. This motivated class discussion The compilation of these statistics into a meaningful dataset was not without its problems and provided valuable teaching opportunities related to large numbers. In addition to this, comparisons of climate data allowed children to be aware of the need to disaggregate some of these and consider, for example, specific capital city temperatures rather than country averages. The use of statistics such as life-expectancy also generated some discussion and provided children with tools for a deeper understanding of international socio-cultural comparisons.

Children's interactions with A Taste of Asia

Once the *Taste of Asia* data-set was compiled, students were asked to pose questions related to these Asian countries. To help meet Australian Curriculum statistics outcomes (e.g., ACMSP147 "Interpret and compare a range of data displays"), the class teacher (lead author) imposed the following guidelines for the questions: some of the questions require two variables to be compared, and there must be an opportunity for the person to explain their answer/s.

Table 1. Key variables in the Taste of Asia dataset

Key variable	Details
Population	Expressed in whole numbers
Land Size	Area of country in square kilometers
Male life expectancy	Average life expectancy in years
Female life expectancy	Average life expectancy in years
Average income	GDP of country in $AUS, divided by population
Birth rate	Number of births per 1000 people
Main religion	Most common religion in the country
Language	Official language of the country
Olympic medals	Number of Olympic medals won in 2012 games
Average temperature	Average high temperature in the capital city (°C)
Average rainfall	Average rainfall for capital city (mm)

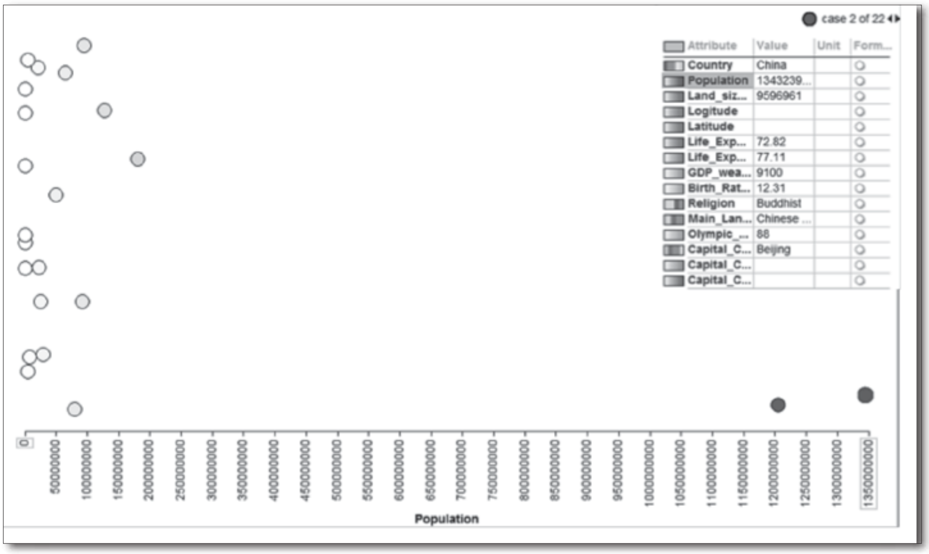

Figure 1. Student plot for country with highest population

After the students had created their set of questions, they swapped with a peer who proceeded to complete the task using TinkerPlots. These questions were, in the main, quite descriptive and included:

- "Which country has the highest population?"
- "Which country with a main religion of Christianity won the most Olympic medals?"

In order to answer these questions, students interrogated the data-set using TinkerPlots, but only in a fact-finding way. Whereas the questions could have been answered from a tabular representation of these data, the students preferred to use plots (perhaps because of the novelty). Figure 1, for example, shows a student's solution for the first question: the countries were sorted by population and the country with the highest was then identified.

The questions posed by the children limited the interpretations that could be made with these data. With this in mind, the class teacher (lead author) imposed additional questions for the children. In the next section the following question is considered: Do countries with low life expectancy generally have high birth rates? Why would this be?

Children's bivariate analysis of Taste of Asia data

Prior to their analysis of these data, children had been provided with some guidance regarding the analysis of data. Rather than introduce formal statistical terms, the lead author allowed children to use their own language when describing graphical features. Though bivariate analyses at this level are normally restricted to side-by-side column graphs (ACARA, 2013, p. 49), the lead author used the opportunities in the lesson to develop children's understanding of scatter-plots.

More specifically the children were directed to plot a continuous variable against itself (see Figure 2), and then describe the specific pattern obtained. They responded by saying each axis went up at the same rate, this was described as a "clear relationship". This notion was subsequently used as the basis for bivariate comparisons, in that children could use this clear relationship as a comparative benchmark.

During this explanation, the concept of outliers was also discussed (see Figure 3, which shows Australia as a circled outlier near the bottom of the plot). The students described these points with unusually small or large values as "glitches" that don't follow the relationship that others do.

In regards to the relationship between life expectancy and birth rate, 11 of the children completed the question; the others did not get to it in the allocated time. Of these, six were able to construct a scatterplot similar to that shown in Figure 4, though some had grouped variables into intervals on one or both axes.

These children explained the relationship between life expectancy and birth rate, with the following comments showing that they were prompted to consider causative mechanisms in a complex socio-cultural relationship:

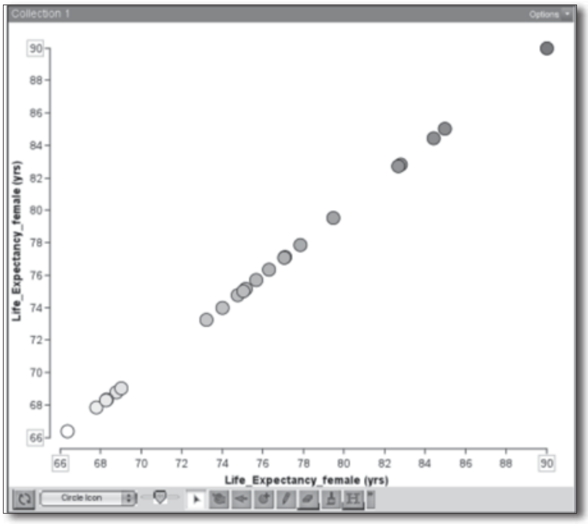

Figure 2. Scatterplot of continuous variable against itself (a clear relationship)

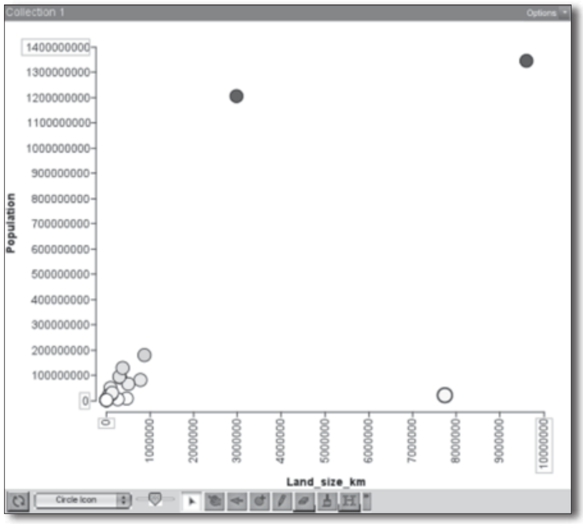

Figure 3. Plot showing concept of outlier

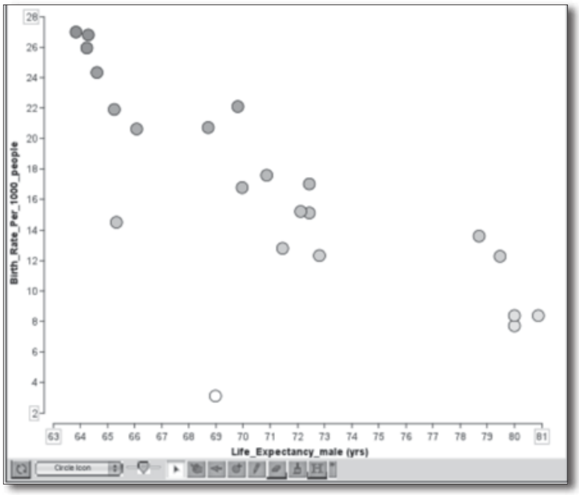

Figure 4. Plot of life-expectancy against birth rate

> "Yes because the higher the population, the less food people get, the less money people get, people die sooner."

> "Yes because they probably have a high population so they wouldn't have as much food to share around."

> "Yes they do. They might try for children more than others because the children might not live as long."

These responses support findings that children in the primary years can (and perhaps should) be able to access quite complex statistical concepts (e.g., Watson, 2008). Not all, however, were successful with this task, with one student having difficulty interpreting the plot and focusing on individual points rather than relationships in general. This student commented as follows: "No, because the countries with the low life expectancy have lower birth rates because of the bad environment and conditions for birth."

Conclusion

In this paper we have reported how the novel inclusion of a statistical component into a social science unit enabled children to deepen their understanding of both social science and statistical concepts. The use of authentic data during mathematics lessons provided relevance for the children whilst opening up opportunities to strengthen their knowledge of number. Some of the children were able to explore quite complex statistical relationships in an authentic context, which prompted them to consider possible explanations for these relationships.

Best of all, the software used in the unit provided a number of affordances. Its relative novelty motivated the children to explore these Asian countries in a more thorough way than would have been possible without the software. Its ease of use also permitted children to explore questions of their own, even when they were not directed to (see student quote below). This, perhaps, is the key to their future learning and understanding of statistics.

> .. even though I don't think we were really supposed to, some of us during (err) we looked up our questions... so if we thought, hey I think there might be a (err) some connection between just say Malaysia's land size

> and Malaysia's number of people or something ... and then look at another country's compared to it, and see if they had the same number.

Whereas authors such as Watson and Neal (2012) have identified potential links between mathematics and social science curricula, this study has demonstrated social science related outcomes can be successfully integrated with Mathematics instruction. The implications of this study for teachers are very positive. The opportunities to address multiple learning outcomes across different key learning areas can and should be done where possible. Doing so alleviates the time constraints all teachers work under, but also creates multiple opportunities for student (and teacher) learning.

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Quantitative reasoning in problem solving


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In this article, Ajay Ramful and Siew Yin Ho explain the meaning of quantitative reasoning, describing how it is used in the to solve mathematical problems. They also describe a diagrammatic approach to represent relationships among quantities and provide examples of problems and their solutions.

We open this article with the following snapshot problem and an excerpt from a Grade 6 student's interview.

Paper Dolls Problem

Lili spent 4 days making paper dolls for her friends. Each day she managed to make 2 paper dolls more than the day before. She made a total of 24 paper dolls. How many paper dolls did she make on the last day? (modified from SEAB, ©2013)

Initially, the Grade 6 student subtracted 8 (2 paper dolls x 4 days) from 24. Then she crossed out the calculation and subtracted 6 from 24.

I: And the 6 you obtained by?
S: Three days of adding two more each day.
I: Three days, adding two. And then you got 18.
S: Yes.
I: So, does the 18 represent anything?
S: How many dollars she would make if she did not make 2 more (paper dolls) than the day before.
I: You were saying you want to divide. Right?
S: Umm (nodding).
I: Are you still thinking about what you want to divide?
S: Yes (hesitating); That does not work.
I: What does not work?
S: 18 divided by 4.
(I: Interviewer; S: student)

The lack of divisibility led her to abort this path and started to use a guess-and-check procedure. Ten minutes had already elapsed and we decided to end the interview as she mentioned "I am quite confused now."

What was the missing element in the student's solution? What elements of the problem made it challenging for the student? What form of reasoning does such a task require?

In a previous study (Ramful & Ho, 2014), we explained how the same Grade 6 student was constrained in reasoning with quantitative relations and consequently had to resort to numerical reasoning. In this complementary article, we focus on helping students represent and reason with quantitative relationships.

Background

The solution to a mathematical problem requires not only understanding the statement of the problem, making a plan or applying particular