THE ROLE OF CONTEXT IN YOUNG CHILDREN'S INTERPRETATION OF A DATA TABLE

VIRGINIA KINNEAR
Deakin University
v.kinnear@deakin.edu.au

ABSTRACT

This paper describes the role of data and task context in young children's interpretation of and reasoning about data tables. A design-based descriptive study was conducted with fourteen 5-year-old children in their first year of formal schooling. A picture storybook provided the data context for a data modelling activity that focused on interpreting and analysing a data table. The children spontaneously read zero as a data value of interest and explained their interpretation of data using knowledge gleaned from the context of the storybook. Presenting the data pictorially and numerically using the structure of a table supported children's successful reading and interpretation of the data. The structure and representation of the table facilitated development of statistical reasoning that was unexpected of children as young as 5 years.

Keywords: *Statistics education research; Data context; Case-data tables; Young children; Pictorial representation*

1. INTRODUCTION

Young children's capacity to engage meaningfully with statistical learning continues to be affirmed in research (Leavy & Hourigan, 2018; Lehrer & English, 2018; Makar, 2018; Suh et al., 2021; Watson, 2018). Taking into account the short history of statistics in the school curriculum (Watson, 2018), statistics education research for children in the early years remains thin and educational opportunities for learning statistics are neglected or superficial (Downton et al., 2020). Disciplinary distinctions between mathematics and statistics matter in the design and focus of stochastic learning experiences for young children. Wild et al. (2018) note that "for educational purposes, statistics needs to be defined by the ends it pursues" (p. 7). In research with young children, statistics' core disciplinary purposes need to be distinguished, if statistics education is to build upwards, rather than the current trend of statistical content trickling down into school level curriculum (Zieffler et al., 2018, p. 57). Statistics' heart is data, drawn from the problem context (Moore, 2006) that brings with it variation; a "slippery concept" (Shaughnessy, 2007, p. 972). A key outcome for statistics learning is for children to not only use statistical representations such as graphs and tables to read data, but also to analyse that information in order to interpret and draw conclusions from it, and develop "good graph sense" (Shaughnessy, 2007, p. 991). The role of context is central to providing meaning for the data (numerical or otherwise), and in engaging children in stochastic experiences that develop disciplinary specific knowledge and ways of thinking (Kinnear, 2013; Leavy & Hourigan, 2018; Lehrer & Schauble, 2002, 2004; Watson, 2018).

Recent research attention on young children's statistical reasoning and learning has begun to translate research questions into studies about children's engagement with data representations, such as data tables and graphs. However, we still know very little about how to support young children to read, interpret and construct graphs and data tables as representational structures in statistics (Guimarães et al., 2021; Makar, 2018; Mulligan, 2015; Oslington et al., 2020) and the impact of context on children's engagement with data (English, 2012; Leavy & Hourigan, 2018; Makar, 2016). Some studies support the effective use of picture storybooks to provide meaningful contexts to represent data and to develop mathematical thinking (van den Heuvel-Panhuizen et al., 2016; van den Heuvel-Panhuizen & van den Boogaard, 2008). New questions, however, need to be raised concerning the interrelationships between

Statistics Education Research Journal, 22(2), Article 3. https://doi.org/10.52041/serj.v22i2.445

story context and interpreting data. This paper describes a design-based study of a cohort of fourteeen 5-year-old children in their first ten weeks of formal schooling in a metropolitan city in Victoria, Australia[1]. The study used data modelling activities that were initiated and contextualised by picture storybooks. This paper describes the children's spontaneous responses to a data table and their reasoning about the modelling problem context to explain that data.

Three research questions guided the study.

1. What knowledge and reasoning skills do young children bring to problem-solving in data modelling activities?
2. How do young children's use a storybook context to notice and interpret data presented as a table?
3. How do children interpret the meaning of zero and a missing quantity in a data table?

1.1. DATA CONTEXT AND INFERENTIAL REASONING

Data context generates the need for a statistical inquiry (Pfannkuch, 2011). The context for data seeds the problem, is the source of the data that will be handled to solve the problem and is also the source of knowledge for interpreting the data, and so functions as both the linchpin and framing structure in data analysis (Cobb & Moore, 1997; Garfield & Ben-Zvi, 2007). Young children need to come to see that the data context is inextricably linked to resolving the initiating problem when analysing data. For example, some investigations have focused on meaningful contexts for children where they collect data and interpret how the temperature changes from month to month (Oslington et al., 2020) or when they reason about how their plants grow (Lehrer & Schauble, 2004).

Inference is central to statistics and when connected to familiar experiences which provide young children with access to ways of thinking statistically (Makar, 2016). Inferential reasoning is a process that both relies on, and draws from, data to make judgements (be they decisions, predictions or generalisations) and therefore focuses attention on the role and influence of the data context on statistical reasoning. In data analysis, inferential reasoning extends description and interpretation, to making inferences beyond the data (Ben-Zvi et al., 2009), engaging in ideas about variation, and therefore uncertainty and prediction (Makar, 2016). Several key conceptions of variation found in research include noticing, acknowledging, describing and explaining sources of variation (Biehler et al., 2018). Schaeffer (2006) points out that the principal differences between mathematical and statistical reasoning is most apparent in inferential statistical analysis when reasoning is based on data that does not necessarily have an explainable cause.

The contexts of data explorations are central to inferential reasoning, where data needs to be moved from being simply read, to being used for sense making (Friel et al., 2001; Wild & Pfannkuch, 1999). Familiarity with the context of a problem is known to influence data analysis and interpretation (Gal, 2005; Watson, 2018) and so knowledge of the context influences how children determine the relevance of data in problem-solving (Leavy & Hourigan, 2016; Pfannkuch & Wild, 2004). Children's explanations about data can reveal the context knowledge they relied on, and internal processes and sense-making used in reasoning (Gil & Ben-Zvi, 2011).

The relationship between context and data has been described by Wild and Pfannkuch (1998) as involving interplay or shuffling between the data and context spheres, between "finding something out" and "ascertain(ing) meaning of what we have seen" (p. 336). In the course of a statistical investigation however, context can create a contradiction, as it has the capacity to both motivate and mislead when data and context knowledge are inconsistent or insufficient in the face of data (Biehler et al., 2018; Makar et al., 2011). Context therefore has the potential to make a statistical problem more accessible, but also to constrain it (Langrall et al., 2011). The interconnectedness between the data and data context impacts children's engagement with the statistical problem and the knowledge they bring to finding a solution (Kinnear, 2013; Leavy & Hourigan, 2018).

Context it seems, is the working hub of statistics (Pfannkuch et al., 2018). It has a role in statistical reasoning that should be embraced, not ignored (Makar et al., 2011) as it is a means of opening up and scaffolding young children's access to statistical ideas (Makar, 2018). Data modelling provides a starting point for engaging statistical reasoning as a developmental process (Lehrer & Schauble, 2005)

[1] This paper reports secondary analysis of data drawn from a doctoral thesis study by the author.

as it reflects the structural components identified in statistical investigation at the elementary level (Leavy, 2008). The principles of data modelling design use realistic contexts to authenticate and frame the problem (Lehrer & Schauble, 2002, 2004). These principles are attributed to their success in promoting statistical reasoning, including informal inferential reasoning, particularly when utilising picture books to contextualise a modelling problem (Kinnear, 2013; Leavy & Hourigan, 2019).

1.2. LEARNING TO READ DATA REPRESENTATIONS

The design of visual displays and other representations of data influences how information is processed and understood (Boels et al., 2019). Research that has examined the use of data tables in statistical practice is scant (Guimarães et al., 2021; Konold et al., 2017), as is research on the influence of the data context on the way young children reason to make meaning of the variation they see (English, 2018). Some studies with elementary-aged children have developed learning trajectories for children's understanding of data and data representations that enable them to see variation. Frameworks have been developed to analyse how data is viewed from seeing it as "case" to seeing it as "aggregate" (Konold, et al 2015), learning to "read", "read between", "read beyond" (Friel et al., 2001), and "read behind" the data (Shaughnessy (2007).

To make sense of, or read any visual representation requires the knowledge and use of certain reading conventions, and forms of data representation are no different (Munzner, 2014). Curcio's (1987, 2010) seminal work on graph comprehension (including tables), developed three levels of graph reading. The levels apply regardless of the graph form used: *reading the data*, a literal reading of the graph that 'lifts' information directly from the graph, *reading between the data*, where the reader's ability to combine and integrated data enables the graphical information to be interpreted and *reading beyond the data*, where the reader is able to make predictions or inferences from the data by drawing from knowledge that is not explicitly or implicitly stated in the graph. This latter process requires inference to be made "on the basis of information in the reader's head, not in the graph" (p. 9), and is where data and task context intersect in data analysis. Shaughnessy (2007) proposed an additional level, *reading behind the data*, to focus on making connections between the context and the graphical representation by looking for possible causes of variation and relationships among variables in the data. Reading behind the data can support children to notice and acknowledge variation in the data, such as spread or skew, and search for its source. Children also adopt a "loose hierarchy" of different perspectives when questioning, organising, and interpreting data, seeing data as *pointers*, *case values*, *classifiers* and as *an aggregate*, with the statistical persective focused on perceiving and reasoning about data as a whole set (Konold et al., 2015, p. 309). Different questions and contexts, however, require analysis that engages and co-ordinates different perspectives; for example, locating an outlier in relation to other values in the distribution in ways that highlight variability (Konold et al., 2015). These are important approaches to data reading and interpretation, as distribution, trend and variability are big ideas in statistics, and in young children inferential reasoning begins with informal inference and eventually attention to variation (Ben-Zvi, 2004; Makar, 2016).

In 2001, Friel et al. noted that the use of tables for display and as an organising tool for children's data exploration needed increased attention and that instructional materials that enable children to gain deep knowledge about graphs needed to be planned. Consideration must be given to the types of data representations young children are provided with and the data context that facilitates their interpretation. Being able to read data (find values or relationships in a data representation) does not ensure that the data reader makes connections between what is read and the data context in ways that are essential for statistical reasoning. Early studies found children's interpretation of graphs to be developmental, and context and task dependent (Curcio, 1987; Friel et al., 1997). The way that data are organised and represented take many forms, including picture graphs, bar, circle, and line graphs (Curcio, 2010; Watson & Moritz, 2001). Suggested progression for introducing graphical data representation with young children focuses on a gradual transition that begins with connecting objects with data representation as one-to-one correspondence and moving these to more abstract representations such as picture, bar, and line graphs (Curcio, 1987; Leavy, 2008; Mulligan, 2015; Oslington et al., 2020, Watson, 2018). The emphasis for young children should thus be on graphical displays that help students to tally responses, such as co-ordinating simple tables (Oslington et al., 2018). Case-data tables are examples of simple tables that display a set of varying cases of repeated observations as raw data in rows. Case-data tables are not structured to display patterns or trends in data but use the column-row structure to show that the values belong to the same case (Konold et al., 2017).

2. BACKGROUND LITERATURE

Children's data exploration and problem-solving support the development of statistical knowledge and decision making, recognised in a range of recent studies (e.g., English, 2012; Fielding-Wells, 2018; Fielding-Wells & Makar, 2015; Leavy & Hourigan, 2018; Watson, 2018; Watson & Fitzallen, 2021). Such studies have focused on authentic problems and the collection, organisation, and representation of data so that children make sense of their own data context. Some studies have challenged even young children to engage with data in such a way that they develop, through experience, concepts such as distribution, sampling, aggregation, and predictive and inferential reasoning (diSessa, 2004; Makar & Rubin, 2009; Oslington et al., 2020). By engaging in meta-representational practices children can become aware of the interrelationships between data context and statistical reasoning. For example, when provided with small data tables as a stimulus, English (2012) found that 6-year-olds could recognise common values, total numbers across rows, and note high and low values. Both 5- and 6-year-olds could make reasonable predictions for missing values in the context of small, familiar data sets. In another study of high-ability Grade 2 students, Mulligan (2015) described children not only making reasonable temperature predictions but representing the data in drawings and graphs freehand.

In another study of Grade 3 students' predictions and representations of a data table, half of the children were found to frequently ignore the data table, instead favouring idiosyncratic predictive strategies and autobiographical memory without engaging with the context of the data (Oslington et al., 2020). Children's representations of these data were predominately empty grids or copies of the table. There were, however, children who showed sophisticated predictive reasoning with their representations, embedding conceptual understanding of statistical features such as distribution, range, and patterns of change over monthly intervals.

Recently, a large cross-sectional study (Guimarães et al., 2021) analysed data from 325 students from first to fifth grades, to glean insights into the students' understanding about representations in tables. The students solved six problems, four of interpretation of a single and a double entry table with qualitative and quantitative variables, and two involving the construction of a table from a database or set of figures that needed to be classified. The results showed that students' performance progressed by grade level, and their performance in table interpretation was better than in table construction. First graders were able to construct tables with one variable; however, a table with two variables proved to be very difficult, even for fifth graders. In all grades the students had difficulties in making decisions based on the data presented and understanding the function of a table as a representation of data.

3. METHODOLOGY

A design-based descriptive study of fourteen 5-year-old children explored the reasoning young children bring to interpreting data tables and the ways that the modelling activities from a picture storybook supported children's statistical reasoning. The study employed educational design research methodology underpinned by a models and modelling perspective (Lesh & Doerr, 2003), which provided the principles for designing the statistical problem tasks as data modelling activities.

The study participants were a class of fourteen children (nine boys and five girls) aged 5 years (mean age 5 years 2 months) in their first term of formal schooling in a public school in South Australia. The classroom teacher, of six years experience, engaged the children in several lessons employing the four tasks, which the researcher (author) observed. Four data modelling activities adapted from a related study with first and second graders (English, 2009b, 2012) with a "recycling" problem context were implemented consecutively in three sessions per week over five weeks. Three commercially available (Bethel, 2008, 2009; Child, 2009) and one purposefully written (English, 2009a) picture storybooks were an integral element of the study, chosen to initiate and frame the data modelling activities, provided the data context for the modelling problem. The books played a dual role. First, they were selected to stimulate the children's interest in modelling activities and shape their engagement with core statistical ideas. Second, they provided the data context children could draw on when analysing the data (Kinnear, 2013, 2018).

3.1. TASKS AND PROCEDURES

Each of the four modelling activities followed the same task structure. Task 1 was a modelling warm–up activity, where the picture storybook was read twice to the whole class by the teacher to capture the children's spontaneous responses to and comments about the story. Task 2 was a whole-class activity to introduce the modelling problem. Task 3 was a model-eliciting activity where the data problem was posed. In this task the children worked collaboratively in teacher-assigned mixed gender groups of three children to find a solution. Task 4 was a presentation-discussion, where children reported their modelled solutions to the class. The researcher (author) collected digital video data for both whole group and small group work for all four modelling activities. Data collected included observation data using three video cameras set up on tables where the children worked independently in small groups of three without teacher interaction. The children produced a range of representations such as pictographs, drawings and informal tables for each modelling activity. The researcher transcribed all video data and described the children's vocal emphasis, facial expression, and body movements. Data for all four modelling activities were deductively and inductively analysed using iterative cycles (Lesh & Lehrer, 2000), from which several themes emerged (Kinnear, 2013). For the modelling activity reported here, common strategies and themes that emerged from the children's interpretations of the data are described and supported by excerpts of transcript from the video data. Particular attention was paid to the children's concept of zero and their interpretation of missing values from the data. For reporting purposes, pseudonyms are used to maintain the children's privacy and anonymity.

3.2. DATA-MODELLING ACTIVITY: *LITTERBUG DOUG*

"Litterbug Doug" was the third data-modelling activity in the activity sequence. The activity focused on reading, interpreting, and extending data represented in a pictorial data table with the purpose of the modelling problem focused on data prediction. The picture storybook used for this activity was *Litterbug Doug* (Bethel, 2009). In the story, the character, Litterbug Doug, has rats for friends, and because he does not recycle, he has upset the people in his town by creating enormous piles of smelly rubbish. He is taught to recycle by another character, Michael Recycle, and in his new reformed role, becomes a litter policeman, collecting rubbish in the park to keep the town clean and tidy. The children's responses to Litterbug Doug showed that what interested them was not that he was a reformed recycler, but that he was a problematic character (Kinnear, 2018). He was messy, lazy and forgetful, and needed to be taught to "be good", and the children saw him as a problem to be solved. Although Litterbug Doug's rubbish problem was solved in the story itself (he was taught to recycle and on the last page of the book he became a litter policeman) it is what brought the problem about that held the children's attention and piqued their interest (Kinnear, 2018).

Task 2 in the modelling activity introduced the children to a data table, as a way for Litterbug Doug as the Litter Policeman to keep a record of how much and what sort of rubbish he collected on each day. The children were given a data table (Figure 1) with pictorial and numerical icons representing Litterbug Doug's data collected over three consecutive days, with the fourth day left blank.

What Litterbug Doug collected	Monday	Tuesday	Wednesday	Thursday
	2	5	4	
	4	3	2	
	2	6	3	
	1	4	2	
	2	3	0	

Figure 1. Case-data table for the Litterbug Doug data modelling problem

The teacher systematically scaffolded reading the table by introducing and naming the *data table, columns* and *rows,* using hand gestures to model identifying and locating information on the table. Prior to the children being given the modelling activity, the teacher used an A3 size data table on a stand next to him, and posed a question to the whole class, asking what they noticed about the numbers in the data table on the different days. The children were invited to move to and use the data table as they provided spontenous responses to the teacher's question.

This simple case-data table (Figure 1) depicted tallies and organised the small data set using a column-row structure to show which values belonged together (Konold et al., 2017; Mulligan, 2015; Oslington et al., 2018). The category row header pictured items from the picture storybook illustrations and days of the week, were used to structure the data. The data values in the table were between zero and six, quantities that the children who were in their first few weeks of formal schooling, were more likely to have direct experience with and knowledge of (Bjorklund & Palmer, 2020). Presented as a grid structure, a table can promote understanding of mathematical co-linearity (Mulligan, 2022; Mulligan et al., 2020). Accordingly, the table's structure was intended to support the co-ordination of the data and establish connections to the data context, facilitating children noticing and locating data of interest.

4. RESULTS

The findings indicated that the children could lift information directly from the table, and therefore "read the data", and also "read between the data" by combining and integrating data (Curcio, 1987, 2010). The structure of the table, including that each value in a row belonged to the same pictured category, may have facilitated children's reading of the data values from left to right, as for reading words on a page in the children's instructional language. The children were able to use their existing number knowledge to compare the quantities represented by the values and to interpret this information. The eight children who provided spontaneous responses to the teacher's initiating question referred only to the data context. The children, however, also sought to explain the presence of zero or the absence of values in the data table using information found in, or inferred from, the illustrations and narrated events in the picture storybook. The book provided an authentic and accessible narrative for the children, acting as a "cognitive hook" that garnered their interest in the context and in exploring the relationship between it and the data. An important observation was that the children used their explanations as a reasoning tool, which supported them when making sense of the representation of data (Gil & Ben-Zvi, 2011). The children also made connections between what they gleaned from the picture storybook (as data context) and the numerical values to explain the zero and the absence of quantity in the "Thursday" column.

This finding highlighted the children's ability to locate the story within the distribution of values to identify and compare the range of values, and to find the lowest and the most frequent values. The children mostly took a case-value view of the data, a "take" on the data that served the question that they were originally asked, "What do you notice about the data table?" The case-value lens is a critical building block for developing an aggregate perspective, as it enables data to maintain its connection to the context that provides its meaning (Konold et al., 2015). Surprisingly, some children also approached the data through a "classifier" lens, attending to the frequency of "zero" and clustering the imagined "Thursday" zeros as the same value. This also revealed that the children noticed the spread of the data and therefore viewed it in an emerging or "pre-aggregate" lens (English, 2012; Konold et al., 2015). The table's grid structure and row-column bounding of values facilitated not only the children's reading and comparing of individual values, but also supported their developing concept of data as a whole set (Konold et al., 2015; Leavy & Hourigan, 2018).

4.1. INTERPRETING ZERO AND THE ABSENCE OF QUANTITY

All the children spontaneously noticed both the values and absence of values in the table and revealed a sustained interest in no data in the "Thursday" column. They recognised the numeral zero in the "cheese row" of the data table, and that it represented "zero quantity". Several children saw the absence of data values in the blank Thursday column as also representing zero quantity. Without any prompting from the teacher, children explained the zero quantity using knowledge that they had gleaned or inferred from the picture storybook plot and illustrations.

Children's justifications included comments such as, "He maybe didn't like mouldy old cheese," while another commented quizzically, after reading each of the data values in the cheese row: "Um, I don't know why, um, why Litterbug Doug didn't collect any cheese." The teacher indicated the zero value in the cheese row with his hand and asked, "On this day?" to which the child nodded in agreement. Both these children speculated that there was a connection between zero and the actions of the story character, Litterbug Doug. Next, several children provided animated responses to the absence of quantity in the Thursday column. Each of the children moved to the A3 table and gestured, in conjunction with their verbal explanations, demonstrating a systematic approach to make the connection between the data table and the events in the story explicit. For example, Isabel used her hand to gesture carefully along each category row in the data table, and up and down the Thursday column, systematically and carefully as she explained what she saw:

> Um, I noticed that um, he probably, I um, think he didn't collect any mouldy cheese that day, actually, I think he didn't collect any apple cores this day, or tin cans this day, or any newspapers this day or banana skins this day or smelly old old mouldy cheese this day um, that's because um this is the day when Michael Recycle showed, um, um Litterbug Doug help.

The teacher then asked, "So you think this is the day that Michael Recycle helped him?" Isabel responded, "Yes, to throw away all his garbage." Her explanation drew directly from the plot in the picture story book when Michael Recycle arrived and taught Litterbug Doug to recycle and clean up.

Similarly, Jade used the events in the story to explain the blank Thursday column. She explained verbally and through hand and body movements that this was the result of there being nothing left to collect on Thursday. She reasoned that Litterbug Doug had used every available piece of rubbish to create the problematic mounds of smelly rubbish that had so offended the town inhabitants, which ultimately led to Litterbug Doug needing to be taught to be good. She ran her hand along each category row of the data table, carefully reading each and every value for "Monday", "Tuesday" and "Wednesday" along each row. Next, she touched each blank cell in the "Thursday" column with her hand, working her way from top to bottom, and said:

> And there's nothing there, nothing there, nothing there, and nothing there because he didn't really collect anything on Thursday because he didn't wanna do that because he had his mound um of rubbish (crouches down) go bigger, bigger bigger, bigger, bigger, bigger, bigger, bigger, bigger, bigger (slowly rises and uses her hand to show the increased size) and that's why he didn't collect anything on this day, 'cause there wasn't any more things that, there wasn't any more apple cores, and tin cans and newspapers and banana skins and cheese (touches each category picture on the data table) and the um, and because on that day, the old, this was all gone and this was all gone, this was gone, this was all gone and this was all gone (touches each empty cell in the "Thursday" column) and that's why there was none on Thursday.

Carl also explained the changes he observed in the data values in the table, and why he thought the Thursday column was blank, providing two different explanations for the differences he observed. Like Jade, he linked to the data values in the table as a record of what was available on any given day, and his knowledge of the events in the book. He reasoned that Thursday was the day when other characters in the picture story book helped Litterbug Doug to clean up. Gesturing with his hand across the category rows in the data table, Carl said:

> Ah, Monday he could only find 2 apple cores, on Tuesday he could only find 5 apple cores and on Wednesday he could only find 4 apple cores, on Monday he could only find 4 cans and on Tuesday he could find 3 and only 2 here, mmm (pauses) and on this day (indicates 'Thursday' column) Thursday, Michael Recycle come on that Thursday then, then every person helped to get rid of all the rubbish and recycle it.

Another child, Toby, made a connection between the zero value and the blank column, drawing on Litterbug Doug's preferences to explain it. He ran his hand up and down the Thursday column, stating, "This has nothing on it," then touched the zero in the cheese row and explained:

Toby:	That one probably is from all of them because he doesn't like anything on this day (runs his finger up and down the Thursday column), maybe it goes with the zero (touches the zero in the cheese column)
Teacher:	So, you think that day's blank because he didn't collect anything and you think it goes with the zero?
Toby:	(Nods) Maybe he couldn't, it probably goes with the zero.

Toby reasoned that if Litterbug Doug had not collected any cheese on Wednesday, this may explain his not collecting cheese on Thursday.

5. DISCUSSION

The findings indicate not only the children's awareness of and interest in zero, but that zero may have been considered an exceptional point that drew their attention further towards the data as a whole and its distribution (Ben-Zvi, 2004). The minimum value of zero in the data table and particularly the absence of values, seemed to be surprising or significant to the children. A number of children both recognised the numeral zero and had an understanding of the numeral zero as representing "no quantity," affirming research that many children in their first year of school understand the concept of zero and are able to connect the zero numeral to zero quantity in subitising tasks (Clarke et al., 2006; Gervasoni & Perry, 2015). The children's intense interest in zero is also evidence of their seeing the data using a case-value perspective, with zero (or the absence of a data value read as data) as a single case of interest in the distribution, reaffirming also that the children had "read the data" (Curcio, 2010; Konold et al., 2015). This approach is in keeping with findings by Leavy and Hourigan (2021) that zero is a distracting data value for children that draws children's attention away from seeing data as an aggregate.

The children appear to have found the data table more readily accessible and comprehensible than graphical representations such as bar graphs. Friel et al. (2001) highlighted the difficulties associated with scale that reading graphical representations such as bar graphs raise for students. They noted that younger children have differentiated needs for success in reading graphs. By reducing the complexity of the data being explored and by using smaller sets of data and fewer categories for comparison, children pay attention to the spread and variation within the data. Asp et al.'s (1994) study with 4th grade children's interpretation of bar graphs found that when a scaled graph indicated a category with a zero value, children read a quantity into the category. That study used bar graphs and collected data through interviews, so the task and data collection method differed from this study, where data were presented as numerical values in a table. A table of information is often used as an intermediate step in organising data before graphs are made, and the benefits of this foundational role may further explain the findings as it does not present the scaling and abstract representational complexities that picture graphs introduce. The findings suggest that various design elements may have facilitated both reading and contextualising the data values, and that coordinating the pictorial and numerical data in a table may have supported successfully reading and interpretation. Accordingly, a simple case-data table may hold potential for in early statistical learning experiences, as both an access point and a scaffold for young children's data reading and interpretation (English, 2012; Mulligan, 2015; Oslington et al., 2018).

This finding supports research that children can and will use context knowledge to draw inferential conclusions about data that are grounded in evidence and go beyond particulars (Lehrer & English. 2018). It further supports research that this occurs when children are familiar with the data context and where there is a fit between the data provided and children's prior knowledge (Kinnear, 2013; Leavy & Hourigan, 2018; Masnick et al., 2007; Mooney et al., 2006; Watson, 2018). The study highlighted that the children engaged with the data context to interpret what they found in the data table, an action described as "a first step towards inference" (Watson, 2006, p. 190). They paid attention to the 'informal' understanding of variation in the data, a starting point for children's engagement with statistics (Ben-Zvi, 2004; Watson, 2018). The children did not simply observe the data but used their knowledge from the data context to explain the data, interpretation that required logic or pragmatic inferences (Curcio, 2010). These findings reflect other studies on students' informal inferential reasoning where children use hypothetical, contextualised reasons or generate hunches to explain the data (Gil & Ben-Zvi, 2011; Leavy & Hourigan, 2019; Makar & Rubin, 2009). Although general agreement is not found amongst researchers about what components are necessary for informal inferential reasoning, the children in this study used their observations about data with context in mind to explain the inconsistencies in data (Makar & Rubin, 2009; Reading, 2009).

As expected, the data values in the table did not provide patterns that may have assisted the children to see or form such connections, and that unlike Leavy and Hourigan (2021) there were no patterns in the data that shifted the children's focus away from the data context. The children were able to infer from the data by reading "beyond the data," using information not available from reading the data table to explain it. The study highlights the semiotic process where children systematically used gestures and speech to read each of the positive values in all the data categories, before coming back to the data value of interest.

The findings further support the use of data modelling as particularly accessible to young children as they involve concepts and skills that are "mostly straightforward extensions of basic ideas" (Lesh et al., 2008, p. 116). The study supports the growing field of research where children show the capability and competency in their existing number and spatial knowledge and reasoning skills to develop models that will organise data and solve data-modelling problems (Chick et al., 2018; English, 2012; Estrella, 2018; Fielding-Wells & Makar, 2015; Fielding & Makar, 2022; Frischemeier, 2019, 2020; Leavy & Hourigan, 2016, 2018).

6. CONCLUSION

This study provides insight into unexpected starting points for developing inferential reasoning from young children's interpretion of data tables. The data showed evidence of children's interest in particular values that are puzzling or absent in a distribution and this can inform designing task contexts to sign-post variability in later development. Using case-data tables in relevant contexts may help children to develop a formal understanding of distribution, which is required to describe and predict data sets (Bakker & Gravemeijer, 2004). The study has drawn attention to the value of zero in particular as it plays an important role in statistics in later years, including understanding ratio scales, deviation scores, interval scales, and graphing axes and determining statistical significance. Children's interest in zero may provide pedagogical and conceptual leads in approaching new learning in statistics for young children.

It was not intended nor possible to generalise about the findings from this study as it was framed as an exploratory descriptive study limited to spontaneous responses from a single, small class of 5-year old children. It provides, however, new insights into future research directions. Current curricula for young children limits their engagement with data modelling and informal statistics. This study provides some direction for curriculum reform that acknowledges the possibilities of engaging in statistical concepts in the first years of schooling. Further research should explore how using picture storybooks as data contexts can contribute to children's early interpretation, construction and representation of tables and other key mathematical concepts. An emerging research focus on data exploration with young children can shift attention to the role of statistical thinking, particularly given young children's high exposure to visual representations of data in their everyday lives.

ACKNOWLEDGEMENTS

The author thanks Professor Lyn English, Queensland University of Technology, for her supervision and assistance in the primary analysis of the doctoral study.

The author's doctoral research was funded by an Australian Research Council Project (DP 0984178) [ARC: Chief Investigators - L. D. English and R. Lesh]. Ethics approval for this study was obtained from the Queensland University of Technology Human Research Ethics Committee (Approval number 1000000536) and the South Australian Department of Education and Children's Development (Approval number DECS CS/10/251-2.2).

REFERENCES

Asp, G., Dowsey, J., & Hollingsworth, H. (1994). Students' understanding of pictographs and bar graphs. In G. Bell, B. Wright, N. Leeson & G. Geeke (Eds.), *Challenges in mathematics education: Constraints on construction.* Proceedings of the 17th Annual Conference of Mathematics Education Research Group of Australasia, Lismore (pp. 57–65).

Bakker, A., & Gravemeijer, K. P. E. (2004). Learning to reason about distribution. In D. Ben-Zvi, & J. Garfield (Eds.), *The challenge of developing statistical literacy, reasoning, and thinking* (pp. 147–168). Kluwer Academic Publishers.

Ben-Zvi, D. (2004). Reasoning about variability in comparing distributions. *Statistics Education Research Journal 3*(2), 42–63.https://doi.org/10.52041/serj.v3i2.547

Ben-Zvi, D., Bakker, A., & Makar, K. (2009). Towards a framework for understanding students' informal statistical inference and argumentation. In *Sixth International Forum for Research on Statistical Reasoning, Thinking and Literacy* (SRTL-6). *Brisbane*.

Bethel, E. (2008). *Michael Recycle*. Koala Books.

Bethel, E. (2009). *Litterbug Doug*. Koala Books.

Biehler, R., Frischemeier, D., Reading, C., & Shaughnessy, M. (2018). Reasoning about data. In D. Ben-Zvi, K. Makar & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 139–192). Springer. https://doi.org/10.1007/978-3-319-66195-7_5

Bjorklund, C., & Palmer, H. (2020). Preschoolers' reasoning about numbers in picture books. *Mathematical Thinking and Learning, 22*(3), 195–213. https://doi.org/10.1080/10986065.2020.1741334

Boels, L., Bakker, A., Drijvers, P., & Van Dooren, W. (2019). Conceptual difficulties when interpreting histograms: A review. *Educational Research Review, 28,* Article 100291. https://doi.org/10.1016/j.edurev.2019.100291

Chick, H., Fitzallen, N., & Watson, J. (2018). "Plot 1 is all spread out and Plot 2 is all squished together": Exemplifying statistical variation with young students. In J. Hunter, P. Perger, & L. Darragh, (Eds.), *Making waves, opening spaces.* Proceedings of the 41st annual conference of the Mathematics Education Research Group of Australasia, Aukland (pp. 218–225).

Child, L. (2009). *Charlie and Lola: Look after your planet.* Penguin Books.

Clarke, B., Clarke, D., & Cheeseman, J. (2006). The mathematical knowledge and understanding young children bring to school. *Mathematics Education Research Journal, 18*(1), 78–103. https://doi.org/10.1007/BF03217430

Cobb, G. W., & Moore, D. S. (1997). Mathematics, statistics, and teaching. The American Mathematical Monthly, *104*(9), 801-823. https://doi.org/10.2307/2975286

Curcio, F. (1987). Comprehension of mathematical relationships expressed in graphs. *Journal for Research in Mathematics education, 18*(5), 382–393. https://doi.org/10.2307/749086

Curcio, F. (2010). *Developing data-graph comprehension in Grades K–8* (3rd ed.). National Council of Teachers Mathematics.

diSessa, A. A. (2004). Metarepresentation: Native competence and targets for instruction. *Cognition and Instruction, 22*(3), 293–331. https://doi/org/10.1207/s1532690xci2203_2

Downton, A., Cheeseman, J., MacDonald, A., McChesney, J., & Russo, J. (2020). Mathematics learning and education from birth to eight years. In J. Way, C. Attard, J. Anderson, J. Bobis, H. McMaster

& K. Cartwright (Eds.), *Research in mathematics education in Australasia 2016-2019* (pp. 209–244). Springer. https://doi.org/10.1007/978-981-15-4269-5_9

English, L. D. (2009a). *Baxter Brown's messy room.*[Unpublished picture storybook written for ARC Discovery Grant DP 0984178]. Queensland University of Technology.

English, L. D. (2009b). Promoting interdisciplinarity through mathematical modelling. *ZDM Mathematics Education, 49*(1&2), 161–181. https://doi.org/10.1007/s11858-008-0106-z

English, L. (2012). Data modelling with first-grade students. *Educational Studies in Mathematics, 81*, 15–30. https://doi.org/10.1007/s10649-011-9377-3

English, L. (2018). Young children's statistical literacy in modelling with data and chance. In A. Leavy, M. Meletiou-Mavrotheris & E. Paparistodemou (Eds.), *Statistics in early childhood and primary education: Supporting early statistical and probabilistic thinking* (pp. 295–313). Springer. https://doi.org/10.1007/978-981-13-1044-7_17

Estrella, S. (2018). Data representations in early statistics: Data sense, meta-representational competence and transnumeration. In A. Leavy, M. Meletiou-Mavrotheris, & E. Paparistodemou (Eds.), *Statistics in early childhood and primary education* (pp. 239–256). Springer. https://doi.org/10.1007/978-981-13-1044-7_14

Fielding-Wells, J. (2018). Scaffolding statistical inquiries for young children. In A. Leavy, M. Meletiou-Mavrotheris, & E. Paparistodemou (Eds.), *Statistics in early childhood and primary education* (pp. 109–127). Springer. https://doi.org/10.1007/978-981-13-1044-7_7

Fielding-Wells, J., & Makar, K. (2015). Inferring to a model: Using inquiry-baed argumentation to challenge young children's expectations of equally likely outcomes. In S. Zieffler, & E. Fry (Eds.), *Reasoning about uncertainty: Learning and teaching informal inferential reasoning* (pp. 1–28). Catalyst Press.

Fielding, J., & Makar, K. (2022). Challenging conceptual understanding in a complex system: supporting young students to address extended mathematical inquiry problems. *Instructional Science*, *50*, 35–61. https://doi.org/10.1007/s11251-021-09564-3

Frischemeier, D. (2019). Primary school students' reasoning when comparing groups using modal clumps, medians, and hatplots. *Mathematics Education Research Journal*, *31*, 485–505. https://doi.org/10.1007/s13394-019-00261-6

Frischemeier, D. (2020). Building statisticians at an early age: Statistical projects exploring meaningful data in primary school. *Statistics Education Research Journal*, *19*(1), 39–56. https://doi.org/10.52041/serj.v19i1.118

Friel, S. N., Bright, G. W., & Curcio, F. R. (1997). Understanding students' understanding of graphs. *Mathematics Teaching in the Middle School, 3*(3), 224–227. https://doi.org/10.5951/MTMS.3.3.0224

Friel, S. N., Bright, G. W., & Curcio, F. R. (2001). Making sense of graphs: Critical factors influencing comprehension and instructional applications. *Journal for Research in Mathematics Education, 32*(2), 124–158. https://doi.org/10.2307/749671

Gal, I. (2005). Statistical literacy. In D. Ben-Zvi, & J. Garfield (Eds.), *The challenge of developing statistical literacy, reasoning, and thinking* (pp. 47–78). Kluwer Academic Publishers. https://doi.org/10.1007/1-4020-2278-6_3

Garfield, J. B., & Ben-Zvi, D. (2007). How students learn statistics revisited: A current review of research on teaching and learning statistics. *International Statistical Review*, *75*(3), 372–296. doi: 10.1111/j.1751-5823.2007.00029.x

Gervasoni, A., & Perry, B. (2015). Children's mathematical knowledge prior to school and implications for transition. In B. Perry, A. MacDonald, & A. Gervasoni (Eds.), *Mathematics and transititon to school: International perspectives.* Springer. https://doi.org/10.1007/978-981-287-215-9_4

Gil, E., & Ben-Zvi, D. (2011). Explanations and context in the emergence of student's informal inferential reasoning. *Mathematical Thinking and Learning*, *13*(1&2), 87–108. https://doi.org/10.1080/10986065.2011.538295

Guimarães, G., Evangelista, B., & Oliveira, I. (2021). What students in the first grades of elementary school know about tables. *Statistics Education Research Journal*, 20*(2)*, 1–17. https://doi.org/10.52041/serj.v20i2.358

Kinnear, V. (2013). *Young children's statistical reasoning: A tale of two contexts*.[Doctoral dissertation, Queensland University of Technology].

Kinnear, V. (2018). Initiating interest in statistical problems: The role of picture storybooks. In A. Leavy, M. Meletiou-Mavrotheris, & E. Paparistodemou (Eds.), *Statistics in early childhood and primary education: Supporting early statistical and probabilistic thinking* (pp. 183–199). Springer. https://doi.org/10.1007/978-981-13-1044-7_11

Konold, C., Finzer, W., & Kreetong, K. (2017). Modeling as a core component of structuring data. *Statistics Education Research Journal, 16*(2), 191–212. https://doi.org/10.52041/serj.v16i2.190

Konold, C., Higgins, T., Khalil, K., & Russell, S. J. (2015). Data seen through different lenses. *Educational Studies in Mathematics, 88*(3), 305–325. https://doi.org/10.1007/s10649-013-9529-8

Langrall, C., Jansem, S., Nisbet, S., & Mooney, E. (2011). The role of context expertise when comparing data. *Mathematical Thinking and Learning 13*(1&2), 47–67. https://doi.org/10.1080/10986065.2011.538620

Leavy, A. (2008). An examination of the role of statistical investigation in supporting the development of young children's statistical reasoning. In O. Saracho & B. Spodek (Eds.), *Contemporary perspectives on mathematics in early childhood education* (pp. 215–232). Information Age Publishing.

Leavy, A., & Hourigan, M. (2016). Crime scenes and msytery players! Using driving questions to support the development of statistical literacy. *Teaching Statistics 13*(1), 29–35. https://doi.org/10.1111/12088

Leavy, A. M., & Hourigan, M. (2018). Inscriptional capacities of young children engaged in statistical investigations. In A. Leavy, M. Meletiou-Mavrotheris, & E. Paparistodemou, (Eds). *Statistics in early childhood and primary education: Supporting early statistical and probabilistic thinking.* Springer. https://doi.org/10.1007/978-981-13-1044-7

Leavy, A., & Hourigan, M. (2019). Expanding the focus of early years mathematics education: Statistics and probability. In O. N. Saracho (Ed.), *Handbook of research on the education of young children* (pp. 99–112). Routledge. https://doi.org/10.4324/9780429442827-7

Leavy, A., & Hourigan, M. (2021). Data modelling and informal inferential reasoning: Instances of early mathematical modelling. In J. M. Suh, M. Wickstrom, & L. D. English (Eds.), *Exploring mathematical modeling with young learners* (p. 67–93). Springer. https://doi.org/10.1007/978-3-030-63900-6_4

Lehrer, R., & English, L. (2018). Introducing children to modeling variability. In D. Ben-Zvi, K. Makar, & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 229–260). Springer. https://doi.org/10.1007/978-3-319-66195-7_7

Lehrer, R., & Schauble, L. (2002). Children's work with data. In R. Lehrer, & L. Schauble (Eds.), *Investigating real data in the classroom: Expanding children's understanding of math and science* (pp. 1–26). Teachers College Press.

Lehrer, R., & Schauble, L. (2004). Modeling variation through distribution. *American Education Research Journal, 41*(3), 635-679. https://doi.org/10.3102/00283120410036 35

Lehrer, R., & Schauble, L. (2005). Developing modeling and argument in the elementary grades. In T. Romberg, T. Carpenter, & F. Dremock (Eds.). *Understanding mathematics and science matters* (pp. 29-53). Lawrence Erlbaum Associates.

Lesh, R., Caylor, E., Gupta, S., & Middleton, J. A. (2008). A science need: Designing tasks to engage students in modelling complex data. *Educational Studies in Mathematics, 68*(2), 113–130. https://doi.org/10.1007/s10649-008-9118-4

Lesh, R., & Doerr, H. M. (2003). Foundations of a models and modeling perspective on mathematics teaching, learning and problem solving. In R. Lesh & H. M. Doerr (Eds.), *Beyond constructivism: Models and modeling perspectives on mathematics problem solving, learning and teaching* (pp. 3-33). Lawrence Erlbaum Associates.

Lesh, R., & Lehrer, R. (2000). Iterative refinement cycles for videotape analyses of conceptual change. In A. E. Kelly & R. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 665–708). Lawrence Erlbaum.

Makar, K. (2016). Developing young children's emergent inferential practices in statistics. *Mathematical Thinking and Learning, 18*(1), 1–24. https://doi.org/10.1080/10986065.2016.1107820

Makar, K. (2018). Theorising links between context and structure to introduce powerful statistical ideas in the early years. In A. M. Leavy, M. Meletiou-Mavrotheris, & E. Paparistodemou(Eds). *Statistics* *in early childhood and primary education: Supporting early statistical and probabilistic thinking* (pp. 3–20). Springer. https://doi.org/10.1007/978-981-13-1044-7_1

Makar, K., Bakker, A., & Ben-Zvi, D. (2011). The reasoning behind informal statistical inference. *Mathematical Thinking and Learning*, *13*(1&2), 152–173. https://doi.org/10.1080/10986065.2011.538301

Makar, K., & Rubin, A. (2009). A framework for thinking about informal statistical inference. *Statistical Education Research Journal*, *8*(1), 82–105. https://doi.org/10.52041/serj.v8i1.457

Masnick, A. M., Klahr, D., & Morris, B. J. (2007). Separating signal from noise: Children's understanding of error and variability in experimental outcomes. In M. C. Lovett, & P. Shah (Eds.), *Thinking with data* (pp. 3–26). Lawrence Erlbaum.

Mooney, E., Langrall, C., & Nesbit, S. (2006). Developing a model to describe the use of contextual knowledge in data explorations. In A. Rossman & B. Chance (Eds.), *Working cooperatively in statistics education.* Proceedings of the 7th International Conference on Teaching Statistics (ICOTS7), Salvador, Brazil. http://iase-web.org/documents/papers/icots7/2A4_MOON.pdf?1402524964

Moore, D. S. (2006). *The basic practice of statistics.* W. H. Freeman.

Mulligan, J. (2015). Moving beyond basic numeracy: Data modeling in the early years of schooling. *ZDM Mathematics Education*, *47*(4), 653–663. https://doi.org/10.1007/s11858-015-0687-2

Mulligan, J. T. (2022). Pathways to early mathematical thinking in kindergarten: The pattern and structure mathematics awareness program. In A. Sharif-Rasslan, & D. Hassidov (Eds.), *Special issues in early childhood mathematics education research* (pp. 155–170). Brill Publishing. https://doi:10.1163/9789004510685_007

Mulligan, J., English, L., & Oslington, G. (2020). Supporting early mathematical development through a 'pattern and structure' intervention program. *ZDM Mathematics Education*, *52*(4), 663–676. https://doi.org/10.1007/s11858-020-01147-9

Munzner, T. (2014). *Visualization analysis and design.* CRC Press.

Oslington, G., Mulligan, J., & Van Bergen, P. (2018). Young children's reasoning through data exploration. In V. Kinnear, M. Y. Lai, & T. Muir (Ed.), *Forging connections in early mathematics teaching and learning* (pp. 191–212). Springer. https://doi.org/10.1007/978-981-10-7153-9_11

Oslington, G., Mulligan, J., & Van Bergen, P. (2020). Third-graders' predictive reasoning strategies. *Educational Studies in Mathematics*, *104*(1), 5–24. https://doi.org/10.1007/s10649-020-09949-0

Pfannkuch, M. (2011). The role of context in developing informal statistical inferential reasoning: A classroom study. *Mathematical Thinking and Learning*, *13*(1&2), 27–46. https://doi.org/10.1080/10986065.2011.538302

Pfannkuch, M., Ben-Zvi, D., & Budgett, S. (2018). Innovations in statistical modeling to connect data, chance and context. *ZDM Mathematics Education*, *50*(7), 1113–1123 https://doi.org/10.1007/s11858-018-0989-2

Pfannkuch, M., & Wild, C. (2004). Towards an understanding of statistical thinking. In D. Ben-Zvi & J. Garfield (Eds.), *The challenge of developing statistical literacy, reasoning, and thinking* (pp. 17–46). Kluwer Academic Publishers. https://doi.org/10.1007/1-4020-2278-6_2

Reading, C. (2009). Cognitive development of informal inferential reasoning. *57th Session of the International Statistical Institute - Statistics: Our past, present & future*, Durban, South Africa.

Schaeffer, R. L. (2006). Statistics and mathematics: On making a happy marriage. In G. Burrill (Ed.), *Thinking and reasoning with data and chance: Sixty-eighth NCTM yearbook* (pp. 309–321). National Council of Teachers of Mathematics.

Shaughnessy, J. M. (2007). Research on statistics learning and reasoning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 957–1010). National Council of Teachers of Mathematics.

Suh, J. M., English, L. D., & Wickstrom, M. (Eds.). (2021). *Exploring mathematical modeling with young learners*. Springer. https://doi.org/10.1007/978-3-030-63900-6

van den Heuvel-Panhuizen, M., Iliada E., & Robitzsch, A. (2016). Effects of reading picture books on kindergartners' mathematics performance. *Educational Psychology*, *36*(2), 323–346. https://doi.org/10.1080/01443410.2014.963029 van den Heuvel-Panhuizen, M., & van den Boogaard, S. (2008). Picture books as an impetus for kindergarteners' mathematical thinking. *Mathematical Thinking and Learning*, *10*, 34–373. https://doi.org/10.1080/10986060802425539

Watson, J. (2006). *Statistical literacy at school: growth and goals.* Lawrence Erlbaum.

Watson, J. (2018). Variation and expectation for six-year-olds. (pp. 55–73). In A. M. Leavy, M. Meletiou-Mavrotheris, & E. Paparistodemou (Eds), *Statistics in early childhood and primary education: Supporting early statistical and probabilistic thinking* (pp. 3–20). Springer. https://doi.org/10.1007/978-981-13-1044-7_4

Watson, J., & Fitzallen, N. (2021). What sense do children make of "data" by Year 3? In Y. H. Leong, B. Kaur, B. H. Choy, J. B. W. Yeo, & S. L. Chin (Eds.), *Excellence in mathematics education: Foundations and pathways*. Proceedings of the 43rd annual conference of the Mathematics Education Research Group of Australasia, Singapore (pp. 409–416).

Watson, J., & Moritz, J. (2001). Development of reasoning associated with pictographs: Representing, interpreting, and predicting. *Educational Studies in Mathematics*, *48*(1), 47–81. https://doi.org/10.1023/A:1015594414565

Wild, C., & Pfannkuch, M. (1998). What is statistical thinking? *Proceedings of the 5th International Conference on Teaching Statistics (ICOTS5), Singapore.* http://www.stat.auckland.ac.nz/~iase/publications/2/Topic3c.pdf

Wild, C. J., & Pfannkuch, M. (1999). Statistical thinking in empirical inquiry. *International Statistical Review*, *67*(3), 223–248. https://doi.org/10.1111/j.1751-5823.1999.tb00442.x

Wild, C., Utts, J., & Horton, N. (2018). What is statistics? In D. Ben-Zvi, K. Makar, J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 5–36). Springer. https://doi.org/10.1007/978-3-319-66195-7_1

Zieffler, A., Fry, E., & Garfield, J. (2018). What is statistics education? In D. Ben-Zvi, K. Makar, J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 71–99). Springer. https://doi.org/10.1007/978-3-319-66195-7_2

VIRGINIA KINNEAR
Faculty of Arts and Education, School of Education
Deakin University (Melbourne Campus)
221 Burwood Highway
Burwood, Victoria, 3125, Australia