HOW THE CURRICULUM SHAPES TEACHERS' THINKING: A COMPARISON OF NEW ZEALAND AND AUSTRALIAN TEACHERS' THINKING ABOUT STATISTICS

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As part of a larger project considering teachers' mathematical knowledge for teaching, focus groups of teachers in Australia and New Zealand were asked to respond to stimulus material including student responses to test items. Statistics questions were included. The New Zealand curriculum, which includes statistics in its title, has a stronger focus on statistics than does the Australian Curriculum – Mathematics. It was notable that New Zealand teachers placed more emphasis on statistical understanding, especially at the higher levels of schooling. In contrast, Australian teachers focussed on algebraic reasoning and functions, and did not engage with statistical questions as enthusiastically as their peers in the different country. Although Australia and New Zealand are often considered to be very similar, it is evident that the curriculum context elicited different responses. The implications of this finding will be discussed.

INTRODUCTION

The curriculum defines what is valued and should be taught in schools (Li & Lappan, 2014). It may include content, pedagogical approaches, and expected achievement standards depending on the nature and structure of the document. Teachers work within the curriculum expected in their system, and as such, the curriculum itself influences teachers' knowledge. Indeed Shulman (1987) included knowledge of the curriculum as one of the key aspects of knowledge for teaching.

Statistics and probability have been included as recognised components in the mathematics curriculum for over two decades (Australian Education Council, 1991; National Council of Teachers of Mathematics, 1989; Ministry of Education, 2012). In Australia the most recent iteration of the mathematics curriculum includes statistics and probability as one of three content strands in the school curriculum from Foundation (start of schooling) to Year 10. In the final years of schooling, four mathematics courses are available. The lowest of these, Essential Mathematics includes statistical skills such as graph reading, and the most popular course, General Mathematics has considerable statistical content. The two highest level courses, however, have a greater focus on calculus although there is some inclusion of statistical reasoning in some units (Australian Curriculum, Assessment and Reporting Authority (ACARA), 2013). In the New Zealand Curriculum (Ministry of Education, 2007), one of the eight learning areas is named as Mathematics and Statistics, and within that, statistics is one of three content strands. Throughout all levels of schooling, from Years 1 to 13, the statistics strand has three components, namely Statistical investigations, Statistical literacy, and Probability. Therefore the curriculum continues to provide an emphasis on statistical ideas across the years of schooling.

Despite this longevity the acceptance and encouragement of teachers to engage with statistical ideas has been somewhat patchy (Callingham, Watson & Burgess, 2012). Teachers tend to be less confident about teaching in the areas of statistics and probability (Watson, 2013) and there is anecdotal evidence that these topics may be left until the end of the school year, and fitted into classroom teaching in the few lessons left. The power of the curriculum to influence teachers' practice is somewhat unexplored. Hence there was interest in exploring what teachers coming from two different curriculum structures and traditions thought about teaching statistics.

METHOD

As part of a study about teachers' knowledge for teaching, *Powerful Knowledge*, teachers in New Zealand and Australia participated in focus group discussions. The purpose of these groups was to identify aspects of teachers' knowledge for teaching mathematics. Groups were presented with stimulus items and examples of students' work at a level appropriate to their teaching, and asked to comment on what their own students might do and how they might intervene to develop

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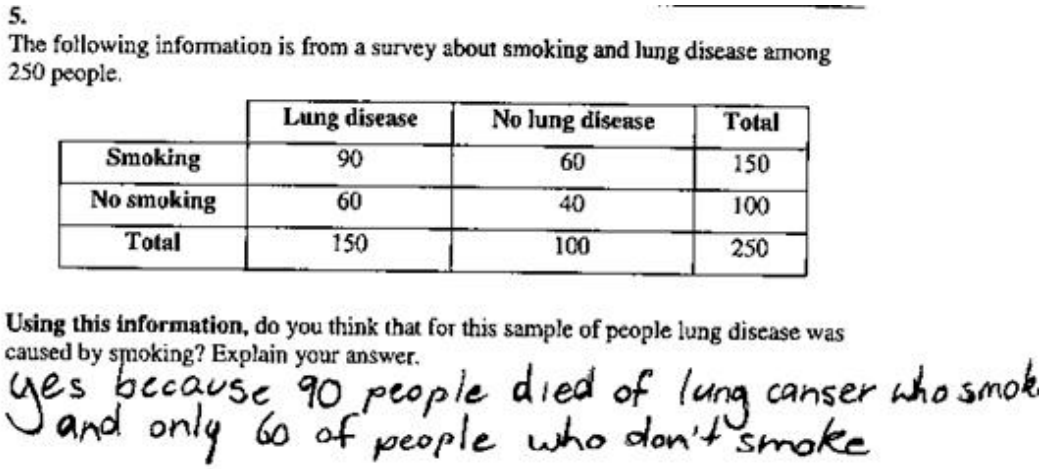
students' thinking. Among the stimulus material presented to secondary teachers was an example of a two-way table (LUNG), first used by Batanero, Estepa, Godino, and Green (1996), and later by Watson and Callingham (2005). The version used as a stimulus item is shown in Figure 1. The item was used as a discussion starter for a broader consideration of what it meant to teach mathematics.

This is a student's response to a test question.



5.
The following information is from a survey about smoking and lung disease among 250 people.

	Lung disease	No lung disease	Total
Smoking	90	60	150
No smoking	60	40	100
Total	150	100	250

Using this information, do you think that for this sample of people lung disease was caused by smoking? Explain your answer.

yes because 90 people died of lung canser who smok and only 60 of people who don't smoke

What can you infer about the student's understanding?

Figure 1. Two-way table stimulus item

Teachers from secondary schools in three places responded to this stimulus. In Australia a group of four teachers in Tasmania and a single teacher in Victoria participated, and in New Zealand, four teachers took part. No specific demographic data were collected from the participants but they were identified by their systems and the researchers as having high levels of teaching expertise and experience in teaching mathematics. The sample was purposeful because the initial stage of the Powerful Knowledge project aimed to gather information from recognised 'expert' teachers. The discussion was recorded and transcribed for later thematic analysis using NVivo software. Only the discussion relating to the LUNG item is presented here, because of the relevance to teaching statistics.

RESULTS

From a consideration of the transcripts, three main themes arose: mathematical content, differences between mathematics and statistics, and pedagogical issues.

Mathematical Content

All groups identified proportional reasoning as the underlying skill required to make sense of the table. The New Zealand group, however, immediately placed this in the context of a probability table:

> Hmm. I would think that there would be steps previous to this where you would have to do some calculating of some probabilities, um, using the table first. So to get them using, understanding how to use the probability table. And then be able to move on to being able to do the comparing, because they're missing the boat about the totals and the proportion.

In contrast the Australian teachers focused strongly on the mathematical aspects with comments such as "They're not thinking proportionally" (MU008, TAS), and

> MS023 (VIC) …they're only focused in on the target data I'd call it, which is people with lung disease who smoked and didn't smoke, so they've taken purely those numbers but not looking at the proportional relationships at all.

The Tasmanian group went on to discuss the background general knowledge of the students, and the social context, suggesting that the data were contrived:

> MU008: But even though we know, like it's confirmed now that smoking does cause lung disease, you could still get a dataset looking like that though I don't believe the proportions being exactly the same.

The group also suggested that the students might be confused by the apparent conflict between their social contextual knowledge and the outcome suggested by the data:

> MS009: They would trust that the data is correct and trust that there would be an answer out of this one, really there is not a right answer to come out of this.
> MU008: And the thing is they know lung disease – I mean smoking is bad for you.
> MS011: See there's other factors.
> MU008: So that might influence them because according to these figures there is no difference and that's what they've learnt. I don't know what they'd do if they actually did the maths and find out that it's the same fraction whether that then goes saying it's a lot of rubbish, "I must be wrong because everyone knows smoking is bad for you" or what happens after that.

In contrast, the New Zealand teachers thought that the context could be helpful for students, especially if they had done some work on probability previously:

> MS037: If you do probability first you can introduce that whole idea, you know, giving a context, so, it depends whether you've done that as well, um... But, I mean it's a reasonably realistic context that they would have some understanding, so that shouldn't throw them too much.

The Victorian teacher discussed the problems students have with reading data:

> MS023: Students find tables, maps, graphs particularly difficult to read and interpret and when there's data that's not necessary they want to use it, or else there is data there they need to use and they don't use it. There seems no rhyme or reason to that.

The New Zealand group, however, thought that many students would be able to read the table using all cells:

> MS036: You could read the probabilities down, across. You've got the informal conditional which I'm finding that students can pick that up off a table … It's been one of the things I've been focusing on in the last few years.

It seemed that the New Zealand teachers were able to see the LUNG problem within the context of mathematical statistics, whereas the Australian teachers tended to dwell on the social context and perceived the skills as relatively basic mathematics, that in many instances their students struggled with.

Differences Between Mathematics and Statistics

There were a number of comments about the differences between mathematics and statistics. Some of these related to students, such as the implication in the Tasmanian discussion reported in the last section that students have a view of mathematics classes that expects there to be a single correct answer, and similar comments were made about teachers, In New Zealand this view was made explicit:

> MS034: If you have a generation of teachers where they're looking for a single answer, that's not what you do in statistics is it?
> MS035: It's not absolute, you know, there's no absolute right answer.
> MS037: That's right, yes, and you have to infer, and you have to write a bit more.

The Victorian teacher also discussed students' views:

> MS023: I think, as a secondary teacher, it's so hard to do because the culture of students, the more they have experienced maths the more they're expecting it to be formulaic, and you know, "You're going to tell us how to do it, and we're going to do it".

She went on to elaborate the point that students expected worked examples and were unwilling to work out ideas for themselves and lamented, "but I don't know how we change that culture".

Context was also a point of discussion. Again the New Zealand teachers articulated this concern clearly:

> MS036: With mathematics you start with mathematics and move to the context.
> MS037: Why can't you start off with context in maths?
> MS036: Yes you can, but I think with the statistics the context is everything.

The Australian teachers, however, tended to see the context as more of a vehicle for the mathematics, rather than integral to the statistics, or, as indicated earlier, potentially distracting for students.

Pedagogical Issues

The discussions about differences between the two domains led naturally to discussions about teaching statistics. Again there were differences in the ways in which the two countries talked about the issues. In Australia, teaching approaches tended to be discussed against the broader topic of making mathematics more challenging and less procedural:

> MS023: So it's this notion that mathematics is about a set of steps, then you get to the answer, and when you don't want to get to that answer there's only one way to get those steps to that answer, but I don't know how we change that culture, I mean we have to keep pushing that and saying, pushing back on that and keep giving them open-ended tasks to do, and I think that's the key to it, open-ended tasks. And stepping back from the idea that everything's got certain constraints, so many constraints that it's no longer a problem, it' just a procedure.
> It's much easier to turn my class around than it is to turn staff around.

The importance of content knowledge was also emphasized, especially among the Tasmanian group. For example:

> MS010: Like a classic question for me is probability. I never really had faith in the formula when I was in grade 12, so I always go back and do that from first principles.
> Well for statistics and probability I have Jane's main ideas there, Jane Watson's five main ideas and then I had that broken down a little bit further like the one around graph types for example, I know what the graph types are, so I sort of hold a map in my head of what the main ideas are …

In New Zealand, the content focus was more on fundamental statistical ideas, indicating a high level of understanding of what students needed to understand about statistics.

> MS037: And getting kids, hopefully, you know, exploring distribution and stuff, and talking about centre, and you know, bobbly bits and you know, things without having the stats names, you know.

The New Zealand group also tended to talk about the difficulties many teachers have with teaching statistics, particularly the processes:

> MS034: I'd say it's [teaching statistics] created a bit of tension from my perspective over the last couple of terms, is that people, well, a lot of teachers, are, um, uncomfortable with the different nature of teaching that's required for statistics. It does require, it requires you to teach differently, it requires you to think
> MS035: That's right, yes, differently, and it requires that you get different things out of the kids.

They went on to discuss the higher levels of literacy skills required in statistics, with the expectation that reports will be written:

> MS034: I wonder if maths teachers aren't really always equipped with literary skills, literacy, with literacy skills that they need for statistics.

There was also agreement among the New Zealand that teaching statistics had influenced their mathematics teaching, typified by this comment:

> MS036: Yeah, I think um, my teaching has evolved and I'm now teaching mathematics mathematically, and teaching statistics as a separate entity, so I think my teaching has separated, … but I still see some of my department teaching statistics with a mathematical perspective. And I think that's the issue that many teachers face, so to me the biggest difference with statistics is the context, you start with the context.

Statistics was also seen by the New Zealand teachers as being useful for getting to know a new class, because they could undertake an investigation that connected to the social lives of their students:

> MS037: They have a stats unit that can be used as an introductory unit where you can get, you know, get to understand, um, you know, who you have in your class. You can bring in a whole lot, easily, a whole lot of realistic situations, you know, based on their interests, so, you know, canvassing their interests, um, you can bring in so much data.

When looking at all of the transcripts, it was noticeable that the New Zealand teachers engaged more with the LUNG question than did the teachers from Australia. In New Zealand they were eager to discuss statistics and its place in the curriculum, whereas the Australian teachers addressed the question but did not enrich the discussion so much in other ways.

DISCUSSION AND CONCLUSION

Both the interest shown by teachers in engaging with the LUNG question, and the substance of their answers varied according to the location. All of the teachers were clearly skilled teachers, and could see the value in the question posed. The New Zealand teachers, however, appeared to bring somewhat different understandings to the discussion. Their focus was less procedural and, although the mathematics underlying the statistical ideas was clearly understood, this understanding was firmly embedded in the statistical context. Their teaching focus was more on developing the fundamental concepts of statistics, such as distribution, whereas the Australian teachers tended to discuss the skills that students needed, such as reasoning proportionally. The concerns about context, shown by the Tasmanian group was, in contrast, seen as a positive by the New Zealand teachers who felt that the LUNG context was well enough understood by their students so that they could focus on the more fundamental issue of understanding the probability table.

The nature and organization of the mathematics and statistics curriculum is a major difference between Australia and New Zealand. The evidence from this small, initial study is that the influence of the curriculum on teachers may be greater than expected. Statistics is highly valued and visible in the New Zealand curriculum. It is not seen as an add-on, or only for less capable students, but is integral to the desired outcomes for students. If statistics is to be taught and understood in ways that bring benefits to the wider society, the curriculum seems to be a key, influential starting point.

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