

# Teaching Statistics: Teacher Knowledge and Confidence

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This paper reports on research in progress that explores primary school teachers' ideas about statistics and the teaching of statistics. Data on teachers' attitudes and beliefs was collected through interviews and the use of belief and attitude scales. Issues related to teachers' lack of statistical training, confidence in teaching statistics and their views about essential knowledge for teaching statistics are explored.

## Introduction

Recent changes to school curriculum documents in New Zealand place considerable emphasis on statistics. The mathematics curriculum, in particular, includes statistics as one of six major strands of study (Ministry of Education, 1992). Statistics is now no longer peripheral to the primary school curriculum but is part of 'mainstream' mathematics from the beginning of school onwards.

While changing a curriculum document may come at the 'stroke of a pen' successful implementation of curricula reforms is often problematic. A recognised key player in the curriculum reform process is the teacher (Shaughnessy, 1992). Recent work in the area of teacher thinking and mathematics education sees changes to teachers 'world view' of mathematics as important in bringing about change in mathematics education (Steffe, 1990). A teacher's 'world view' of mathematics is thought to be related to deeper beliefs and knowledge. Ernest (1989) for example, states that:

It depends fundamentally on the teacher's system of beliefs, and in particular on the teacher's conception of the nature of mathematics and mental models of teaching and learning mathematics. Teaching reforms cannot take place unless teachers' deeply held beliefs about mathematics and its teaching and learning change (p 249).

This paper sees teachers as possessing a rich store of knowledge and experience in regard to statistics. Gaining a greater understanding of what teachers think and understand is seen as important as their 'ideas' form part of the dialectic in the process of learning. If we expect teachers to help students, we also need to deal with teachers' own ideas and understandings.

### *Teachers' Ideas about Statistics*

At the wider societal level we know that statistical notions are pervasive (eg. in the media) and that people are easily influenced by common probabilistic misconceptions (eg. purchasing lotto tickets). As teachers and even mathematics education researchers are, apparently, not immune from these 'misconceptions' (Shaughnessy, 1992) it is important to explore the statistical notions that teachers take into their classrooms. A perusal of the literature reveals that teachers' ideas about teaching statistics have received little attention. In New Zealand research in this area is almost non-existent. Among the aspects highlighted by overseas researchers are such issues as; the lack of preparedness of teachers for teaching statistics (Greer & Ritson, 1993); teachers lacking in essential knowledge and understanding of many statistical concepts (Russell & Mokros, 1990 and Bright, Berenson & Friel, 1993); teachers 'avoiding' teaching statistics due to a lack of confidence (Gal, 1992); a correlation between 'personal confidence' and teaching confidence and the suggestion that teacher confidence may be 'misplaced' due to teachers understanding of concepts (Callingham, Watson, Collis and Moritz, 1995); and lastly, work by Rubin and Rosebery (1988) in the USA concluded that teacher's prior

knowledge of statistics is not necessarily structured to facilitate the statistical reasoning required by the new statistics curriculum initiatives.

### ***Focus of Paper and Background to the Research Approach***

This paper focuses on primary teachers' views about their knowledge and confidence related to teaching primary school statistics. The work reported was undertaken as part of a larger study which adopted a broad approach to teachers' ideas subsuming knowledge, beliefs, attitudes, concepts, perceptions and understandings under the umbrella term of 'ideas'. Teachers' 'ideas' here refers to the thought structures of the teacher; the knowledge, beliefs and attitudes stored as schemas in the mind of the teacher (Ernest, 1989).

The larger study used a number of research techniques including semi-structured and clinical interview approaches, concept maps and survey scales. This report, however, focuses on only a part of the data and considers just the responses to the 'survey scales' and some of the interview data. Interviews were used as they are generally regarded as a useful means of exploring someone else's ideas or thinking about something (Merriam, 1988). The principal reason for including survey scales in the larger study was for triangulation and comparison purposes and not for their efficacy as research instruments. One of the main drawbacks in using these survey scales is that one has little idea about what each rating actually means. Other researchers (eg. Gal & Ginsburg, 1994) currently working in the statistics education area advocate a more open-ended approach when using such 'scales' in the belief that the additional information gained will provide insights into how the scales have been used and thus help explain why people think what they do. Hence, in this study respondents were also asked to 'talk aloud' as they completed the scales. In the tradition of research on teachers' beliefs, attitudes and conceptions, the study reported here is generally interpretive in nature and predominantly qualitative.

## **Method**

### ***Sample***

Twenty two inservice primary teachers were surveyed using a semi-structured interview format. The sample is best described as an 'opportunistic' sample. Under this approach friends or colleagues were asked to provide contacts with primary teachers and these teachers in turn provided other contacts. This method of selecting the sample was a deliberate choice as initial efforts at more formal approaches in schools captured only teachers with an interest in mathematics. The 'opportunity' approach largely eliminated this self-selection bias. Care was taken in selecting the sample to ensure a spread of primary teachers from Years 1 to 8. Despite the small sample size it is reasonably representative of the New Zealand primary teaching work force in that it favours female teachers with a significant amount of teaching experience. Background data collected from the teachers indicated that they were fairly well qualified with more than half holding at least a Bachelors degree or its equivalent. Very few however had studied any mathematics or statistics at a tertiary level beyond what was required in their teacher training programmes. More than half of the group had dropped school mathematics by year 10 with most of this group reporting difficulties with mathematics at school. In addition, only four of the group gave mathematics as their principal area of teaching interest while more than half indicated language and arts areas.

### ***Procedure***

Participants were each interviewed using a semi-structured interview format. Each interview took approximately 60 minutes and focussed on getting the teachers to talk about their views of statistics and the teaching of statistics. The survey scales were introduced about 35 minutes into the interview and teachers were encouraged to 'talk aloud as they completed the 'scales'.

### *Instruments*

In addition to the semi-structured interview two forms of scale and rating were used to collect the information presented in this study. The first of the scales, a beliefs and attitude scale (BAS) assessed levels of agreement with statements about statistics and its teaching while the second, a confidence rating scale (CRS), asked teachers to rate on a numerical scale, their confidence in teaching particular topics or concepts in statistics. The statements included in the BAS, as well as the structure of the larger study itself, were organised along the lines of Ernest's (1989) model for exploring teachers beliefs, knowledge and attitudes about mathematics and its teaching. This model casts a wide net and includes beliefs, attitudes and knowledge (including both subject content knowledge and pedagogic content knowledge), rather than trying to deal with them as separate and distinct constructs. The BAS was made up of 37 statements about statistics education, including statements on mathematics. Most of the statements can be grouped into subscales along the lines of the components in Ernest's model. Examples of subscales include; beliefs about the nature of statistics and mathematics, beliefs about how to teach statistics and mathematics, knowledge of teaching mathematics and statistics with an emphasis on pedagogic content knowledge, and attitudes towards statistics and the teaching of statistics. The statements themselves came from a variety of sources within the mathematics and statistics education literature (eg. Meredith, 1993 and Callingham et al., 1995). Teachers were asked to rate on a continuous scale their level of agreement or disagreement with each of the 37 statements. The scale is similar to that used in Callingham et al's. (1995) study. A sample scale is shown below.



The confidence rating scale (CRS) was adapted from a similar survey by Bright et al.(1993) and used terms or ideas from levels 1 - 4 in the 'Mathematics in the New Zealand Curriculum' (Ministry of Education, 1992). Teachers were presented with a scenario of having to teach a statistics unit to a standard 2 (Yr 4) or a Form 2 (Yr 8) class and were asked to indicate their level of confidence in dealing with each of the terms or ideas at a particular class level. Teachers were given a choice of three categories to indicate their level of confidence (1=Not confident, 2=Somewhat confident and 3=Very confident).

### *Analysis*

Data from the interview transcripts and survey scales was summarised according to emergent themes relating to the guiding questions of the study. As analysis work is still in progress on the larger study the BAS scale data presented here is in a non-numerical form so that the original data is not lost. Instead a visual format, a stem and leaf approach, is used. Each teachers' response to a statement is placed on the one scale with the lower numbers representing teachers working lower down the school.

## **Results and Discussion**

As the results discussed here come from a larger study, currently in progress, the findings are preliminary in nature. In discussing the results I first present some general findings from the survey scale (BAS and CRS) data. Second, the two interrelated themes of teacher confidence and essential knowledge for teaching statistics are explored by augmenting the survey scale data with data from the interview and 'talk aloud' approaches.

### *Some Preliminary Findings*

- Most of the teachers view teaching statistics as the same as teaching mathematics. However, they do acknowledge that some aspects are different (eg.. the hands-on, pervasive nature of statistics). In addition, while the teaching of

statistics is generally located in mathematics it is not always taught there. Its interdisciplinary character is recognised by most.

- Most do not see ability in mathematics as a constraint to understanding basic statistical concepts. On the contrary most see statistics as providing students who have had difficulties with mathematics as giving them another 'chance'.
- Most see their role as teachers as being to facilitate student learning. Teaching for them is not a case of communicating their understanding of statistics or giving answers to help students learn. They largely see their role as being to explore ideas with the children.
- While nearly all teachers were sceptical of the way statistics is often used, particularly by politicians, they acknowledge its value and usefulness to society.
- Statistics is generally regarded as an integral and necessary part of the primary school curriculum.
- While many teachers expressed doubts about their own statistical knowledge, particularly of more 'formal, traditional' statistics, nearly all said they were comfortable with everyday statistical notions as are found in the media.
- Most teachers expressed considerable confidence about teaching statistics as long it was at their usual class teaching level. 'Anxieties' usually only became apparent when teachers were asked to move out of their particular class level or to deal with unfamiliar material.
- Although many of the teachers reported they would like to learn more statistics this is not seen as a priority for their teaching.
- Most of the teachers indicated that group work was a common practice when teaching statistics.

The use of technology was generally considered advantageous but not essential for teaching statistics.

- While most of the teachers regard statistical knowledge as being important they do not necessarily see this as being the most important component in their teaching. Having appropriate statistical activities, for example, is seen as just as important or more important than statistical knowledge 'per se'.
- The teachers also reported that their own understanding of mathematics and statistics had been transformed in the process of teaching it.

### ***Teacher Confidence***

In this section I first consider teacher background and self concept with respect to statistics and then discuss their confidence with respect to teaching statistics.

*Teacher background and self concept with respect to statistics.* I begin this section on teacher confidence by first reiterating a few pertinent background characteristics of the sample. Firstly, more than half the teachers surveyed have at least a degree or its equivalent, with only one specialising in mathematics. Secondly, more than half of the group reported having difficulties with mathematics or statistics during their education. Of the rest only four indicated success in mathematics or statistics during their education. Lastly, more than half said their key area of teaching interest was in language and arts. Only a few gave mathematics as their key area of teaching interest.

Considering the teachers backgrounds my initial expectation was that they would have a low opinion of their own mathematical and statistical abilities. Results however revealed quite a range of views. This can be seen in the response pattern, shown below, to the statement 'I am good at statistics'.

			8		17	10		
TEACHERS		22	20	12	15	3		
(n=22)	6	19	16		18	5	21	
		13	11	7	9	14	4	1 2

SA |-----|-----|-----|-----|-----|-----| SD

Further, most teachers feel comfortable with the everyday statistics found in the media. The response pattern to the statement 'I can easily read and understand the statistical terms, graphs and charts in the media (newspaper and television)' showed:

		9		2									
TEACHERS	19	18	22		21								
(n=22) 6	10	8		15									
	7	13	12		14				20				
	11	16	1	17	5	3			4				

SA |-----|-----|-----|-----|-----|-----| SD

Analysis of relevant interview data revealed other aspects with most teachers expressing reservations about their statistical knowledge based on either the class level they reached in their education or on how they performed in school or other courses. This can be seen in one teachers comment that 'I am not very good at maths because I actually dropped out of school in the fourth form (year 10).' Another factor that influenced self concept was their teaching experiences. All felt that their knowledge was sufficient for the levels they were teaching. This is clearly seen in a comment by the teacher just mentioned above: 'I feel comfortable because what I am teaching is really at a very simple level'. Many teachers, however, expressed doubts about their knowledge when asked to move away from their usual teaching level or in regard to more formal, traditional statistics. The same teacher, mentioned above, commented in this regard:

'I would totally freak out. If somebody suddenly said to me look, you either teach at an intermediate level (yrs 7 and 8) or you are out of a job, then I would be out of my tree. Literally, because I know or I am almost 90% sure that somewhere along the line I would be tripped up on statistics'.

To add a further dimension this particular teacher qualified her view by saying:

No I guess I wouldn't (freak out) because I am not that sort of person. What would happen is every night I would be honing up on what I was to teach the next day. I would literally be going one step ahead of the kids and hoping that no kid asked me some curly question.

*Confidence with respect to teaching statistics:* Regardless of self concept nearly all teachers said they were confident or felt secure when teaching statistics. This can be seen in the response patterns to the following statements:

- Generally I feel secure about the idea of teaching statistics.

		19											
		20											
		22		3									
TEACHERS		13	8	9									
(n=22)	6	14	5	21									
	7	16	12	15	11	17	4	10	18	2	1		

SA |-----|-----|-----|-----|-----|-----| SD

- I would find it difficult to explain to someone what an average is.

TEACHERS		21								15			
(n=22)		22							10	8	20		
	6	2							3	14	1	17	
		12	4			7			5	9	18	19	
										11	16	13	

SA |-----|-----|-----|-----|-----|-----| SD

A further indication of the confidence of these teachers with regard to their teaching of statistics comes from their views about whether they would give priority to inservice or

professional development work in statistics when compared to the other strands in the mathematics curriculum. Even though most have had little training or inservice in statistics three quarters said it would either not be a priority or it would only be of low priority. Nearly all of this group said they felt confident with their teaching in statistics and instead would give priority to other strands in the mathematics curriculum, with algebra being mentioned most often.

These response patterns coupled with the interview data suggest that the teachers feel quite confident in respect to teaching statistics. Further analysis showed that as long as the teachers are working at their usual class teaching level their confidence is high. The view that teachers may be 'reluctant' (Gal, 1992) to teach statistics because of a lack of confidence gained only minimal support in this study.

Other concerns held by teachers with respect to confidence in teaching statistics relate to teachers lack of familiarity with statistical concepts and terms. Nearly every one of the teachers was unfamiliar with one or more of the terms taken from the curriculum for the CRS scale. Results from the CRS scales showed a clear pattern in terms of confidence. Teacher confidence is lowest on the newer ideas in the statistics curriculum such as, stem and leaf graphs and probability. Not surprisingly, teacher confidence is highest on the 'older' more familiar statistics curriculum topics such as, data collection, bar graphs and pictographs. This finding lends support to Callingham, Watson, Collis and Moritz's, (1995) suggestion that teacher confidence may be misplaced due to their understanding of statistics.

### ***Knowledge Essential for Teaching***

Some of the anomalies between teachers perceptions of their own statistical abilities (or lack of) and their high teaching confidence are illuminated further when one looks at the teachers' views about whether statistical knowledge is essential for teaching. Much of the literature on teachers and statistics education points to concerns regarding teachers 'preparedness' for teaching statistics (eg. Greer & Ritson, 1993 ). These concerns about teachers 'preparedness' appear to have their origins in teachers lack of statistical training. The jump from lack of statistical training to having difficulty teaching statistics is readily made, and assumed, by many of the researchers in statistics education. Hawkins (1990), for example, goes as far as portraying lack of statistical knowledge in medical disease terminology with the 'disease' being passed on to students. As was noted in the teacher confidence section the teachers themselves do not necessarily see their lack of statistical training as a problem for their teaching. The results in this study suggest that while teachers acknowledge the value of statistical knowledge 'per se' they are somewhat ambivalent, as a group, about how important it actually is. The teachers appear more concerned about the 'how' of teaching and consequently place more emphasis on finding appropriate ideas and activities than in gaining more statistical training. The response patterns below are indicative of these trends.

- A good understanding and knowledge of statistics is essential knowledge for teaching statistics.

			22		19				
			17		15				
TEACHERS			20		18				
(n=22)	13	3	21	1		6	12		
	4	8	10	16	2	7	5	14	9
									11

SA |-----|-----|-----|-----|-----|-----| SD

- Statistics knowledge is more important than knowing how to provide appropriate statistical activities for pupils.

						22	18		
						14	2		
TEACHERS	21					15	3	19	
(n=21)	10	17	6	12	9	1			
	16		13	5	11	4	7		
SA	----- ----- ----- ----- ----- -----								SD

This concern and interest in more appropriate activities is reinforced by the interview data. When the teachers were asked about what they would want in an inservice course on statistics nearly all said they would want more ideas and activities for use in their classrooms. Only a couple of the teachers said they would want further work on statistics itself. One teacher did not want any inservice on statistics at all as 'their school had, had enough on it already'.

### Implications and Concluding Comment

These preliminary findings, if confirmed by the larger study, have a number of implications for curriculum development, teacher development, research and the teaching of statistics. The first implication is that the high teacher confidence ratings when coupled with the little interest shown in professional development in statistics do not bode well for reform efforts in regard to statistics education. Apart from finding good class activities the primary teachers surveyed are, by and large, not looking for additional statistical training input.

Secondly, the fact that the teachers lowest confidence ratings were recorded on the 'newer' areas of the statistics curriculum suggests their positive orientation towards the teaching of statistics may be based on teaching what is familiar to them. The newer curriculum initiatives in this area may have had only minimal impact.

Thirdly, while the considerable teacher confidence, coupled with low interest in gaining further statistical training could largely be due to the level (primary school) at which the study was conducted a number of other issues arise of a more philosophical nature. Perhaps, for example, teachers ideas about teaching and the nature of statistical knowledge itself already reflect, to some extent, the 'constructivist' philosophy behind the mathematics curriculum, or more so than do researchers who are calling for more statistical training. The apparent concern over teachers lack of statistical knowledge may be reflective of a view of teaching not necessarily consistent with the 'constructivist' philosophy underpinning the New Zealand mathematics curriculum. Concerns about the importance of the statistical knowledge of primary teachers may be more reflective of transmission models of teaching which emphasise the passing on of knowledge. The implication here being that you need to know something in order to be able to pass it on. It could be argued, on the other hand, that if we re conceptualise teaching along constructivist lines as more a process of negotiating meaning then teacher knowledge of statistical notions requires further examination. As such other aspects of teacher knowledge and understanding may be come more critical in the teaching / learning process.

Fourthly, the findings raise issues in regard to researching teachers ideas. I would argue that it is more useful to research from the perspective of exploring what teachers do understand and then how what they do understand impacts on the teaching and learning process rather than identifying what teachers don't understand or can't remember, as is often the case.

The primary teachers surveyed in this study appear positively oriented towards the teaching of statistics. While this may be good for statistics education generally it is not necessarily good news for teacher development and efforts at curriculum reform in statistics. This study reinforces the view that teacher's 'ideas' are an important element

of the curriculum reform process and that it is more useful to start with where teachers' ideas are than where they are not..

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