A case study of the attitudes and preparedness of a group of secondary mathematics teachers towards statistics

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The new secondary Australian mathematics curricula have more statistics than the existing Queensland senior mathematics curricula. This paper discusses the attitudes to, and preparedness for, aspects of the implementation of the Australian Senior Mathematics Curricula within a group of Sunshine Coast (Queensland) mathematics educators. We found on the evidence presented that teachers value the importance of statistics, and see how technology can assist with teaching and learning statistics, but teachers are ambivalent towards statistics and feel less competent to teach statistics.

Background

In this section, we compare and provide some contrasts between the Australian mathematics curricula and east-coast state offerings, and describe terms for later reference and discussion.

The state of senior mathematics curricula

The Australian Curricula were developed to provide a national framework that addressed the goals of the Melbourne Declaration: to promote "equity and excellence" (MCEETYA, 2008, p. 7) and support "all young Australians to become successful learners, confident and creative individuals, and active and informed citizens" (MCEETYA, 2008, p. 8). The Australian Curricula were written with outcomes for "learning area knowledge, skills and understandings and general capabilities" (ACARA, 2012, p. 13). The senior Mathematics Curricula were released in 2014 (yet to be implemented beyond the ACT) as four distinct subjects: Essential Mathematics, General Mathematics, Mathematical Methods and Specialist Mathematics. Students must select one of the first three subjects; students who select Mathematical Methods may also select to study Specialist Mathematics. Each of these four new mathematics subjects has four-semester length units (1-4) studied over two years and loosely relate to Queensland's current four mathematics subjects: Prevocational

Mathematics, Mathematics A, Mathematics B and Mathematics C. The current Queensland Curriculum was written as a spiral curriculum where the school determines the order in which topics are taught and the topics are revisited and further extended generally at least three times during the two years of study. In contrast, the Australian Senior Curricula have been designed as four distinct units of work, in which the topics are not revisited, except where they can be linked to other topics. For Queensland there is some change of focus with the adoption of the new national curricula, with the most notable being the inclusion of considerably more statistics (Table 1).

Table 1. Comparison of Australian Senior Mathematics Curricula with current Queensland Senior Mathematics Curricula.

ACARA Curriculum details		Prevocational Maths	Maths A	Maths B	Maths C
Essential Mathematics					
1(4)	Reading and interpreting graphs and tables (including two-way tables of counts)	Y	Y		
	Drawing graphs (column; bar; line, etc.)	Y	Y	Y	
2(1)	Classifying data		Y	Y	
	Presenting data in graphs	Y	Y	Y	
	Summarising and interpreting data (means, medians, standard deviations, quartiles, outlier, range, etc.)	Y	Y	Y	
	Comparing datasets (back-to-back stemplots; boxplots, etc.)		Y	Y	
3(4)	Censuses, surveys and simple survey procedures		Y		
	Sources of bias in data collection		Y		
	Bivariate scatterplots		Y		
	Lines of best fit (including correlation coefficients)		Y	Y	
4(1)	Probability expressions ("possible"; "probable"; etc.)				O
	Simulations (relative frequency as probability; etc.)		Y	Y	
	Simple probabilities (sample space; tree diagrams; etc.)		Y		
	Probability applications (probability in games; etc.)				
General Mathematics					
2(1)	Statistical investigation process (identifying a problem, posing questions, data collection; interpretation; etc.)		Y	Y	
	Understanding one variable (categorical and numerical; discrete and continuous; graphs; means; standard deviation)		Y	Y	
	Comparing numerical data (IQR; boxplots; median; etc.)		Y	Y	
3(1)	Identifying and describing associations between two categorical variables (two-way tables; percentages; etc.)		Y	Y	
	Associations between two numerical variables (scatterplots; correlation coefficients)		Y		
	Fitting linear models to numerical data (response and explanatory variables; least-squares lines; residual plots)		Y	Y	
	Association and causation (including confounding)				
4(1)	Time series analysis				
	Describing patterns in time series				
	Analysing time series				
	Data investigations (cf. statistical investigations; see 2(1))		Y	Y	

The learning outcomes of each of the Australian Senior Mathematics Curricula include: “understanding concepts and techniques; applying reasoning skills and solving problems; communicating arguments and strategies when problem solving; interpreting mathematical and statistical information; and ascertaining the reasonableness of solutions to problems” (ACARA, 2014 a, b, c, d). This paper focuses on understanding of the concepts and makes the assumption that teachers are not able to support students to achieve the other learning outcomes if they do not understand the concepts.

ACARA Curriculum details		Prevocational Maths	Maths A	Maths B	Maths C
Mathematical Methods					
1(3)	Language of events and sets				
	Fundamentals of probability (0≤ P(A)≤ 1; etc.)				O
	Conditional probability and independence				
	Combinations (not permutations)				Y
3(3)	Discrete random variables		O	Y	
	Bernoulli distributions				
	Binomial distributions		O	Y	
4(2)	Continuous random variables			Y	
	Normal distributions		O	Y	
4(3)	Random sampling (bias; graphical displays; etc.)		Y		
	Sample proportions (including standard error for proportions)				
	Confidence intervals for proportions				
Specialist Mathematics					
1(1)	Permutations (factorials; etc.)				Y
	Unions of sets			O	
	Pigeon-hole principle				Y
	Combinatorics				Y
4(3)	Sample means (including $\bar{X}$ as a random variable and the corresponding standard error)				
	Confidence intervals for means				

Note: The comparisons are indicative rather than definitive as some classifications are unclear. “Y” means content is mostly covered; “O” means content is optional. The left-most column indicates the unit and topic where the content appears in the national curriculum; X(y) means Unit number X, Topic number y.

Table 1 compares the Australian Senior Mathematics Curricula with the current Queensland Senior Mathematics Curricula, and shows that some topics in the new curricula do not currently appear in the current Queensland curricula, notably topics in time series and sampling distributions of means and proportions (including confidence intervals).

By comparison and contrast, currently New South Wales and Victoria have four or five subjects of senior mathematics. Victoria's five subjects are called Foundation Mathematics, General Mathematics, Mathematical Methods, Further Mathematics and Specialist Mathematics. Foundation Mathematics is a Year 11, two Unit, two semester subject designed for students who are not seeking university entrance, including vocational education and training students. The emphasis is on using mathematics in practical contexts and this is evident in the Handling Data unit that contains topics such as presenting, using and interpreting a wide range of data. The statistics component in the Victorian General Mathematics subject, also a two Unit, two semester subject, is similar to General Mathematics in the new Australian mathematics curricula, but includes the "design, construction and evaluation of probability simulation models" (VCAA, 2010, p. 39) rather than the statistical investigation process, which is in the latter. Mathematical Methods, a four Unit, 4 semester subject, in Victoria includes the topics of probability and random variables in the Australian Curriculum for Mathematical Methods, but not sampling distributions or confidence intervals for proportions. Further Mathematics, which continues General Mathematics, covers topics from the Australian General Mathematics and Essential Mathematics curricula. Specialist Mathematics, a two Unit course assuming concurrent study with Units 3 and 4 of Mathematics Methods has no statistics content.

The New South Wales curricula include Mathematics General, Mathematics and Mathematics Extension 1 (previously 2/3-Unit Mathematics) and Mathematics Extension 2 (previously 4-Unit Mathematics). Mathematics Extension 2 contains no statistics or probability. The Mathematics and Mathematics Extension 1 subject includes simple probability (tree diagrams, permutation, combinations and the binomial distribution). Mathematics General includes a Data and Statistics Strand, in which students learn to interpret and compare sets of related data (using summary statistics such as means and standard deviations), create graphical displays, apply normal distributions, and explore the connection between samples and populations.

The new Australian mathematics curricula are therefore most closely aligned of the three with the current Victorian curricula, and least closely aligned to that of New South Wales; Queensland's current curricula is somewhere in between. Mathematics teachers in Queensland and New South Wales will be facing an increase in the amount of statistical content under the new senior mathematics curricula if they were to teach all subjects.

In our reading of the curricula, three issues arise. Firstly, the General Mathematics Curriculum refers to both statistical investigations (2(1);

ACMGM026) and data investigations (4(1); ACMGM066). According to the Curriculum, the "data investigation process *implement(s)* the statistical investigation process" (emphasis added), though the differences in classroom implementation are not clear and we are careful to avoid presumption. Secondly, Specialist Mathematics 4(3) uses a formula for the confidence interval for the mean (ACMSM141) which combines z-value with sample standard deviations, which is incorrect (e.g., Wild & Seber, 2000, Section 7.6). In computing confidence intervals for means, a z-value is appropriate when the population standard deviation is known (which is almost never the case), and a t-value is used when the population standard deviation is estimated by the sample standard deviation. Thirdly, the language used across the Curricula is not always consistent which may lead to confusion. For example, in Essential Mathematics (3(4); ACMEM140), the language "independent variable" is used for the x-variable in regression, but "explanatory variable" is the language used for the same concept in General Mathematics (3(1); ACMGM055).

On teacher attitudes

More than other areas of learning, mathematics and statistics often generates a broader affective response from people as well as a cognitive one, which "supports the view that affect plays a significant role in mathematics learning and instruction" (McLeod, 1992, p. 575). The affective domain includes a wide range of terms including beliefs, feelings, confidence, anxiety, values, motivation and emotions with a variety of definitions. McLeod's (1992) seminal work involved an extensive review of the literature on affect in mathematics education research. He divided the affective domain into beliefs, attitudes and emotions.

Negative teacher attitudes and beliefs towards statistics may hamper the teachers' learning and classroom delivery of statistics and consequently their students' learning. Negative attitudes or beliefs will also hinder the development of statistical dispositions of the teachers and their students as well as the desire to apply their statistical knowledge outside the classroom (Gal & Ginsburg, 1994). With the focus of the Australian Curricula on problem solving (both routine and non-routine) (ACARA, 2014 a, b, c, d),

> the creation of a problem-solving environment for learning statistics requires that teachers build an emotionally supportive atmosphere where students **feel** safe to explore, conjecture, hypothesize, and brainstorm; are motivated to struggle with and keep working on problems which may not have right or wrong solutions and may require extended investment of energy; feel comfortable with temporary confusion or a state of inconclusive results; and are not afraid to experiment with applying different (statistical) tools or methods. (Gal & Ginsburg, 1994; bold appears in the original)

For our purposes, beliefs, attitudes and emotions are defined as follows:

Beliefs develop over time as a consequence of experiences (McLeod, 1992) and therefore are influenced by classroom experiences (Schoenfeld, 1989). They are premises that a person has confidence in and can be considered in terms of their perspectives about statistics, one's ability to learn statistics and the social context of the learning (Chick & Pierce, 2011; Eichler, 2011).

Attitudes "refer to affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (McLeod, 1992, p. 581). They may arise from a recurring emotional response to an experience or item.

Emotions are feelings or reactions to situations. Repeated emotional reactions to statistics, either positive or negative, will become routine and lead to a positive or negative attitude towards statistics (Gal & Ginsburg, 1994).

This paper reports on the survey outcomes of attitudes of some teachers to statistics, and their attitude to teaching statistics, in light of the additional statistical topics in the Australian senior mathematics curricula. These attitudes as well as the beliefs of teachers will impact on how the teaching and learning of statistics will occur in the classroom (Eichler, 2011).

Methods

Several mathematics teachers in the Sunshine Coast region of Queensland expressed concerns to the authors about the increase in statistics content in the Australian senior mathematics curricula (compared to the existing Queensland senior mathematics curricula). This issue of changes in the statistical content in the new curricula was raised formally at a meeting of mathematics teachers on the Sunshine Coast (the MATHS network http://mathsnetwork.weebly.com, the support network for mathematics teachers on the Sunshine Coast) during February 2014. Consequently, the second MATHS meeting for 2014 in May included a speaker who spoke to the new Australian mathematics curricula (www.australiancurriculum.edu.au) and changes that were likely to impact Queensland teachers, complemented by a hands-on activity about using statistics.

This second MATHS meeting attracted about 40 attendees, which included at least 12 pre-service teachers (PSTs), who were at various stages of their studies at the University of the Sunshine Coast (USC). All PSTs had completed a first-year introductory statistics course but may not have completed a curriculum course.

Attendees were asked to complete a short, one-page survey consisting of demographic questions plus 21 five-point, ordinal-scale questions to evaluate the attitude of the teachers towards statistics. Survey questions were taken from the Students Attitudes toward Statistics and Technology Scale (SASTSc) instrument developed by Anastasiadou (1996). Some items from the SASTSc instrument (notably all questions relating to the Technology Cognitive Competence domain, which assessed attitudes to computers) were not included as they were not suitable (the original SASTSc survey was developed with students in mind). The purpose of our survey was to provide a snapshot of a self-selected sample of practising teachers' and PSTs' attitudes towards statistics in four domains:

1. Statistics cognitive competence (which we call "Cognitive"): Attitudes concerning knowledge and skills applied to statistics (five items);
2. Technology: Attitudes to learning statistics with technology interpreted in the broader sense to include computers and graphics calculators (five items);
3. Value: Attitudes to the worth and usefulness of statistics in personal and professional life (five items); and
4. Affective: Emotions associated with statistics (six items).

The attendees who completed the survey had a variety of mathematics education qualifications, career locations (how long they had been teaching), and school roles (Table 2). Four respondents had no or limited mathematics education at university (teaching "out of field"); three of these teachers were mathematics Heads of Department (HOD). Seven attendees had mathematics degrees (two were Heads of Department). Note that the attendees are not a random sample of teachers and PSTs, since those who attended such a gathering are more likely to have some intrinsic motivation to do so.

Table 2. The demographic characteristics of the respondents to the attitude survey.

		School role			
Characteristic	**Total**	**Teachers**	**HoD**	**PST**	**Others**
Levels of maths education (n=31)					
No or limited maths at uni	4	1	3	0	0
With engineering degree	2	0	1	1	0
Minor in B.Ed	9	2	0	6	1
Major in B.Ed	9	4	1	4	0
Maths degree	7	2	2	1	2
Where in career (n=30)					
Retired	1	0	0	0	1
Nearing retirement	3	1	1	0	1
Mid-career	10	4	6	0	0
Early career	4	4	0	0	0
Pre-service	13	0	0	12	1
Total for Role in school	31	9	7	12	3

Note: "Others" include one retired teacher and two non-teachers. One respondent did not answer all questions

In addition, two retiring teachers, a mid-career teacher who had recently arrived from interstate and two PSTs from USC participated in a follow-up focus group. The participants were asked about their expectations from the network, their professional development needs, teachers teaching mathematics 'out of field', potential speakers for the MATHS network meetings, what they could offer the network, and about mentoring PSTs and early career teachers.

The third MATHS meeting was held in August, in which hands-on activities were offered to teachers to help teachers develop their students' understanding of statistical concepts.

At the fourth MATHS meeting in December, attendees were surveyed regarding topics in the new Australian senior mathematics curricula. Attendees were given a list of topics in the new curricula, and were asked if they had taught that topic before (Yes or No), their knowledge of the topic (on a three-point ordinal scale from 1 (Poor) to 3 (Good)), their level of confidence to teach the topic (on a three-point ordinal scale, from 1 (Low) to 3 (High)), and their willingness to participate in professional development activities to support the teaching of these topics (respondents could select up to four topics).

Results and discussion

At the May meeting, attendees were asked 21 questions to assess various domains of their attitude to statistics (Table 3), with all questions rated on a scale of 1 (Strongly disagree) to 5 (Strongly agree). In all cases, larger numbers represent more favourable responses.

Figure 1 compares teachers' scores across the four domains. Each point represents a teacher's mean response across all items in that domain. In general, teacher attitudes to statistics were favourable. Strong evidence exists that the mean domain scores differ between the four domains (Kruskal-Wallis test: $\chi^2 = 11.7$; df = 3; $p = 0.009$). The mean score for the Affective domain is the lowest of the four domains (mean score: 3.7). We cannot conclude that the mean scores on the Affective and Cognitive domains are different (Table 4), but both are lower than the mean scores on the Value and Technology domains. The means across the domains must be compared carefully, but in summary attendees valued the importance of statistics, and saw how technology could assist with teaching and learning statistics (cf. Chance et al., 2007), but appear ambivalent towards, and less knowledgeable about, statistics as a content area.

Figure 1 shows the distribution of the individual teachers' mean scores over each of the four domains. Each point represents the mean rating for one teacher across all items in that domain. The grey arrows represent the mean of all the teachers' scores for that domain. Small amounts of randomness were added to each point in the vertical direction to avoid overplotting.

Figure 2 shows the scores in each domain across the career stage of the teachers. The vertical lines represent the overall mean score for that domain across all teachers. The numbers at the left side of each graph are the mean of

Table 3. Summaries of the responses to the Students Attitudes toward Statistics and Technology Scale (SASTSc).

Question	Mean	Median	Percentage SA or A	Sample size
Cognitive domain				
I can learn statistics easily	4.1	4	88	32
I can understand statistical reasoning easily	3.9	4	84	32
I am confident with statistics	3.8	4	75	32
I can understand statistical inference easily	3.8	4	69	32
I can solve difficult statistical test-hypothesis problems	3.3	3	44	32
Technology domain				
I like to use computers to make statistical graphs	4.5	5	94	31
Technology makes the learning of statistics easier	4.2	4	88	32
Technology helps me understand statistics	4.2	4	84	31
Technology makes the learning of statistics more interesting	4.2	4	77	31
I prefer to use technology to evaluate statistical problems	4.0	4	76	29
Value domain				
Statistics is valuable	4.4	4	100	32
Statistics helps me to understand reports in the newspapers	4.2	4	84	32
Statistics is a part of our daily life	4.2	4	80	30
Statistics helps me to understand economics	4.0	4	75	32
Statistics helps me to understand politics	4.0	4	74	31
Affective domain				
I am not afraid of statistics	4.0	4	81	32
Statistics is interesting	3.9	4	75	32
I like learning statistics	3.7	4	59	32
Learning statistics is enjoyable	3.6	4	55	31
Statistics is not a frustrating discipline	3.5	4	55	31
I get a lot of satisfaction solving statistical problems	3.6	4	55	31

Note: Items within each domain are ordered from most to least positive. Larger numbers represent more favourable scores.

Table 4. Mean scores for individual attendees across the four domains.

Domain	Mean score	P-value (unadjusted)	P-value (adjusted)
Affective	3.7	(Reference)	(Reference)
Cognitive	3.8	0.61	0.61
Value	4.1	0.0091	0.018
Technology	4.2	0.0040	0.012

Note: *p*-values for comparing are adjusted for multiple testing using the method Holm (1979).

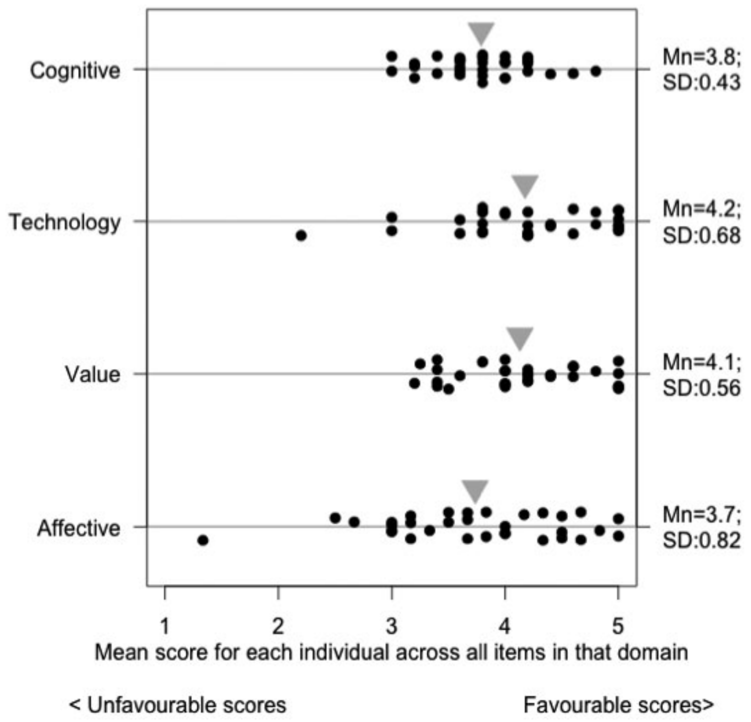

Figure 1. Distribution of the individual teachers' mean scores over each domain.

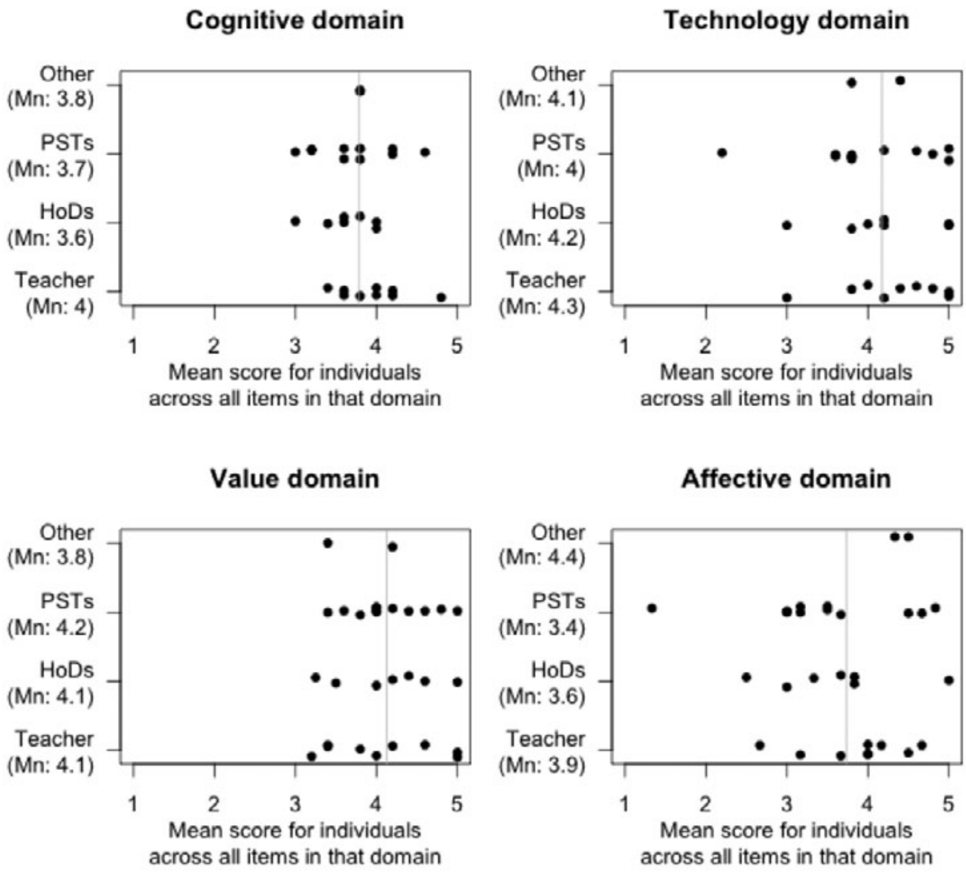

Figure 2. The distribution of teachers' scores on each of the four domains, separated by teachers' role in the school.

all the individual scores within that subset of respondents in that domain. Small amounts of randomness are added to each point in the vertical direction to avoid overplotting. Although the sample sizes are small (so no formal analyses are performed), no substantial differences can be seen across the different teacher roles. The lowest score of all is for one person (a PST) who scored about 1.3 (out of 5) in the affective domain. One respondent scored 2.2 in the Technology domain (this respondent was a different PST).

In the Cognitive and Value domains, the teachers' mean scores across items in the domain were 3.0 or more. In contrast, the mean scores in the Affective domain show many teachers scoring a mean below 3.0 across the Affective domain items. Only one teacher had a mean across the Technology domain items below 3.0. The Affective domain has a greater spread of scores indicating a larger range in the emotions attached to statistics.

Interestingly, PSTs self-report higher Cognitive scores, on average, than HoDs as do teachers. The reasons for this are unclear, but perhaps suggests PSTs are over-confident in their knowledge, and that some Heads of Department are more aware of what they do not know. Alternatively, PSTs may have recently completed studies in statistics and feel relatively more confident to teach statistics than before studying.

The evidence (Table 5) shows a significant relationship between the teachers' mean scores in the Affective and Cognitive domains: teachers who reported better skills are more likely to report a positive attitude towards statistics. Interestingly, the correlation between teachers' mean Technology scores were uncorrelated with their mean scores on the Affective domain.

Table 5. Spearman correlations between the teachers' mean responses on each domain.

	Technology	**Value**	**Affective**
Cognitive	*0.44* (0.01)	0.28 (0.11)	*0.38* (0.03)
Technology		0.28 (0.13)	0.12 (0.52)
Value			*0.44* (0.01)

Note: Values in brackets are *p*-values. Correlations significant at the 5% level are shown in italics.

Twenty attendees were surveyed during the December MATHS network meeting (Table 6). The demographics were similar to those who responded during the May MATHS meeting, except that only three PSTs attended in December rather than 13 in May. Responses from the surveys could not be linked, though many people were at both meetings.

Unsurprisingly, the topics that are not currently in the Queensland curricula have been taught by fewer teachers, and teachers also report less confidence to teach these topics and less knowledge of these topics. These topics are also more likely to be the areas for which teacher professional development is needed. This was recognised by some in the focus group:

Table 6. *The results from the survey from the December MATHS meeting.*

	Number who have taught topic before	Mean amount of reported knowledge	Mean level of reported confidence to teach	Number who would like help
Time series	7	1.8	1.8	8
Standard error (proportions)	4	1.7	1.8	12
Standard error (means)	5	1.8	1.8	7
Confidence intervals (proportions)	8	1.9	1.9	10
Confidence intervals (means)	8	1.9	1.9	7
Sampling distributions	9	2.0	1.9	4
Binomial distribution	14	2.3	2.1	2
Surveys	11	2.1	2.1	1
Investigation	13	2.2	2.3	6
Samples	15	2.4	2.3	1
Samples and populations	15	2.4	2.3	1
Correlation and regression	13	2.3	2.3	0
Normal distribution	16	2.5	2.4	0
Graphs	17	2.5	2.5	1
Permutations and combinations	15	2.5	2.5	1
Data types	17	2.7	2.6	0
Two-way tables	15	2.5	2.6	1
Probability	16	2.6	2.6	1
Standard deviation, IQR, etc	17	2.8	2.9	0
Means, median, etc	18	2.9	3.0	0

Note: The content topics, how many teachers (n = 20) have taught that content before, how much knowledge they have (1 to 3 scale; 3 is more knowledgeable), how confident they feel to teach it (1 to 3 scale; 3 is a high level of confidence), and the number who flagged this as one of the four topics they would like additional support with. Content topics are ordered by mean level of confidence to teach the topic. Topics in bold are those that appear in the new Australian senior mathematics curricula but do not appear anywhere in the current Queensland senior mathematics curricula.

Interviewer: What do you think are the greatest needs for professional development?

Teacher (nearing retirement): [...] the statistical frameworks that are being alluded to in the Australian curriculum, which a lot of people haven't addressed ever, which worries me. The topics that are coming on that are based around the curriculum, which they haven't seen. And perhaps haven't seen even at a tertiary level. I think there's a bit of a hole that if we don't prepare our people earlier, we're going to have a lot of trouble developing and seeing good teaching going on there.

Another teacher, also nearing retirement, noted: "The amount of statistics sort of worries me a bit. Plus I find it a bit dry." This comment suggests that the teacher believes that his training in statistics is either insufficient or has been under-utilised for many years. The comment also suggests either a negative attitude within the Affective domain, or that the teacher believes that the treatment of statistics in the Australian Curricula is dry.

Conclusions and implications

Queensland teachers will need to master additional statistical content to successfully deliver the new secondary Australian mathematics curricula. The evidence presented indicates that, while teachers value the importance of statistics and see how technology can assist with teaching and learning statistics, they are ambivalent towards statistics and feel under-prepared to teach statistics.

For the MATHS network, the invitation presented is for activities and panel sessions around the additional topics to be offered. At the state and national level, the window of opportunity to close gaps in understanding of, and pedagogy in, statistics should be taken up with some urgency. The authors are keen to learn from the experiences of other educational collectives in other regions.

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References

Anastasiadou, S. D. (2010). The development and validation of a new scale for monitoring students' attitudes to learning statistics with technology. Paper presented at the *7th Congress of the European Society in Mathematics Education*. Reszow, Poland.

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2012). *The shape of the Australian Curriculum*. Retrieved from http://www.acara.edu.au/verve/_resources/the_shape_of_the_australian_curriculum_v4.pdf

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2014a). *Essential Mathematics*. Retrieved from http://www.australiancurriculum.edu.au/seniorsecondary/mathematics/essential-mathematics/curriculum/seniorsecondary#page=1

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2014b). *General Mathematics*. Retrieved from http://www.australiancurriculum.edu.au/seniorsecondary/mathematics/general-mathematics/curriculum/seniorsecondary#page=1

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2014c). *Mathematical Methods*. Retrieved from http://www.australiancurriculum.edu.au/seniorsecondary/mathematics/mathematical-methods/curriculum/seniorsecondary#page=1

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2014d). *Specialist Mathematics*. Retrieved from http://www.australiancurriculum.edu.au/seniorsecondary/mathematics/specialist-mathematics/curriculum/seniorsecondary#page=1

Chance, B. Ben-Zvi, D., Garfield, J. & Medina, E. (2007). The role of technology in improving student learning of statistics. *Technology Innovations in Statistics Education, 1*(1), 1–26.

Eichler, A. (2011). Statistics teachers and classroom practice. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching statistics in school mathematics-challenges for teaching and teacher education* (pp. 175–186). Dordrecht, The Netherlands: Springer.

Estrada, A., Batanero, C. & Lancaster, S. (2011). Teachers' attitudes towards statistics. In *Teaching statistics in school mathematics-challenges for teaching and teacher education* (pp. 163–174). Dordrecht, The Netherlands: Springer.

Gal, I. & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: Towards an assessment framework. *Journal of Statistics Education, 2*(2) [online] http://www.amstat.org/PUBLICATIONS/JSE/v2n2/gal.html

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics, 6*, 65–70.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575–596). New York: MacMillan & National Council of Teachers of Mathematics.

Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA). (2008). *Melbourne declaration on educational goals for young Australians*. Melbourne, Vic.: MCEETYA [online] http://www.curriculum.edu.au/verve/_resources/National_Declaration_on_the_Educational_Goals_for_Young_Australians.pdf

Pierce, R. & Chick, H. (2011). Teachers' beliefs about statistics education. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching statistics in school mathematics-challenges for teaching and teacher education* (pp. 151–162). Dordrecht, The Netherlands: Springer.

Wild. C. J. & Seber, G. A. F. (2000). *Chance encounters: A first course in data analysis*. Brisbane: John Wiley & Sons.