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This paper explores teachers' perceptions of their learners' proficiency in statistical literacy, reasoning and thinking. Research in Statistics education has prompted a move away from the teaching of statistical skills, towards focusing on the development of statistical literacy, reasoning and thinking. The recent South African Grade 10–12 Mathematics curriculum change reflects this move. A specific challenge for South Africa is that teachers should understand the new intended outcomes of statistics when assessing learners. The participants (*n* = 66) included Grade 12 Mathematics teachers (females = 40%) from a district in the Free State, South Africa, selected through convenience sampling. A quantitative research approach was used by administering a 13-item Likert scale questionnaire with the Grade 12 Mathematics teachers. The responses were summarised descriptively as frequencies and percentages. The results indicated that two in three teachers perceived their learners to obtain acceptable proficiency in statistical literacy as defined by the literature. In contrast, only one in three teachers perceived their learners usually or almost always to be proficient in statistical reasoning and statistical thinking as defined by the literature. The findings of this study showed that about half of the Mathematics teachers do not see the connection between the action words in the curriculum, and the aspects of statistical reasoning and statistical thinking to be assessed. The large percentage of teachers uncertain about the proficiency of their learners in statistical reasoning and statistical thinking leads to the conclusion that teachers need to be provided with pre-service or in-service training strengthening their Subject Matter Knowledge and Pedagogical Content Knowledge related to the key intended outcomes of statistics assessment, that is, proficiency in statistical literacy, reasoning and thinking.

Keywords: *Statistical literacy; statistical reasoning; statistical thinking*

Introduction

The South African Mathematics curriculum for Grade 10–12 includes Statistics as one of the major strands (Department of Basic Education, 2011). Recent Statistics education reforms are aimed at changing attitudes towards Statistics and improving its teaching and learning (Tishkovskaya & Lancaster, 2012). Ben-Zvi and Garfield (2005) suggest that the focus in teaching Statistics has to be on developing statistical literacy, reasoning and thinking. Tishkovskaya and Lancaster (2012) expand on this recommendation by listing three major foci for contemporary statistics teaching: (a) developing statistical literacy and critical thinking skills; (b) integrating authentic assessment techniques that address learners' ability to evaluate and utilise statistical knowledge, communicate and justify statistical results, and produce and interpret computer output; and (c) developing the skill of communicating Statistics through a variety of innovative instructional techniques that are being employed currently in many successful Statistics classes.

The inclusion of Statistics and probability in the South African Mathematics curriculum for Grade 10–12 comes with specific demands on teachers (Wessels, 2008). There is a need for Mathematics teachers to know how to develop learners' statistical literacy, reasoning and thinking (Ben-Zvi & Garfield, 2005), that is, the relevant Pedagogical Content Knowledge (PCK). A specific challenge for South Africa is that teachers should understand the constructs underpinning these intended outcomes in statistics and probability (i.e. the Subject Matter Knowledge) when assessing their learners (Wessels & Nieuwoudt, 2011). The Grade 10–12 Mathematics curriculum (Department of Basic Education, 2011) does not mention specifically the constructs of statistical literacy, reasoning and thinking when describing the teaching and learning of Statistics. However, there are some elements for developing statistical literacy, reasoning and thinking skills outlined in the Curriculum and Assessment Policy Statement (CAPS).

The Purpose and Research Question

As part of a larger exploration of the extent to which teachers develop learners' statistical literacy, reasoning and thinking skills, the following question was formulated:

> What are teachers' perceptions of learners' proficiency in statistical literacy, reasoning and thinking in Grade 10–12?

The answers to this investigation will form part of the explanations of the strategies chosen by mathematics teachers to develop learners' statistical literacy, reasoning and thinking.

Literature Review

The purpose of this critical review of the literature was to try to understand and describe statistical literacy, reasoning and thinking. In order to understand and describe these statistical learning outcomes one must look at their definitions.

Statistical Literacy
Statistical literacy includes basic and important skills that may be used in understanding statistical information or research results (Chance, delMas & Garfield, 2003; delMas & Garfield, 2010). These skills include being able to organise data, construct and display tables, and work with different representations of data. Furthermore, delMas and Garfield (2010) confirm that statistical literacy also includes an understanding of concepts, vocabulary and symbols, and of probability as a measure of uncertainty. Rumsey (2002) provides a more utilitarian definition of statistical literacy as people's ability to interpret and critically evaluate statistical information and data-based arguments appearing in diverse media channels, and their ability to discuss their opinions regarding such statistical information.

Statistical Reasoning
Statistical reasoning is defined as 'the way in which people reason with statistical ideas and make sense of statistical information' (delMas & Garfield, 2010, p. 3). Statistical reasoning may involve connecting one concept to another (e.g. centre and spread), or it may combine notions about data and chance. Reasoning means understanding and being able to explain statistical processes and interpret statistical results. According to Garfield and Chance (2000), statistical reasoning involves making interpretations based on sets of data or statistical summaries of data where students need to combine ideas about data and chance to make inferences and interpret statistical results. Lovett (2001) claims that statistical reasoning entails the usage of statistical ideas and tools to summarise a situation, specify assumptions and draw conclusions from the data. Besides that, Martin (2009) characterises statistical reasoning as formulating judgments and conclusions based on the data from sample surveys, observational studies, or experiments.

Statistical Thinking

Chance et al. (2003) define statistical thinking as understanding why and how statistical investigations are conducted, for instance, knowing when to inspect and explain variability, and being able to associate the data with the appropriate analysis method to investigate a specific problem. Furthermore, Chance et al. (2003) point out that statistical thinking involves an understanding of the nature of sampling, how inferences are made from samples to populations and why designed experiments are necessary in order to establish causation. Statistical thinking includes an understanding of how models are used to simulate random phenomena, how data are produced to estimate probabilities, and how, when and why existing inferential tools can be used to aid an investigative process. delMas and Garfield (2010) explain that statistical thinking also includes being able to understand and utilise the context of a problem in forming investigations and drawing conclusions, and recognising and understanding the coherence of the entire process (from question posing to data collection to choosing analyses to testing assumptions). This is supported by Campos, Ferreira, Jacobini and Wodewotzki (2015), who point out that a characteristic of statistical thinking is the ability to take a global view and to understand interactions in the statistical process. Finally, statistical thinkers are able to critique and evaluate the results of a problem solved or a statistical study. delMas and Garfield (2010) claim that statistical thinking is a higher order of thinking than the other two constructs discussed earlier.

There is no consensus among Statistics educators regarding the definitions of these three statistical learning outcomes (Ben-Zvi & Garfield, 2005). Considering the various definitions found in the literature, for the purposes of this paper, statistical literacy, reasoning and thinking are considered three progressive levels of cognitive outcomes with statistical literacy the most basic and statistical thinking the most accomplished level (Ben-Zvi & Garfield, 2007; Franklin & Garfield, 2011).

Teaching Statistical Literacy, Reasoning and Thinking

Teachers will need to be able to understand and describe statistical literacy, reasoning and thinking before embarking on teaching Statistics. To enable learners to develop and demonstrate an understanding in statistical literacy, reasoning and thinking, delMas (2002) listed words or verbs that provide orientations to teachers in assessing statistical outcomes. For instance, when assessing statistical literacy, teachers should ask learners to identify or to describe graphs, distributions and relationships. They could ask their learners to rephrase or translate statistical findings, or to interpret the results of a statistical procedure. When assessing statistical reasoning, learners may be required to explain why or how results were produced or why a conclusion is justified. Furthermore statistical thinking is assessed when an instruction challenges learners to apply their understanding to real-world problems, to critique and evaluate the design and conclusions of studies, or to generalise knowledge obtained from classroom examples to new and somewhat novel situations.

In South Africa, the CAPS (Department of Basic Education, 2011) for Mathematics does not mention statistical literacy, reasoning and thinking specifically, but the document provides teachers with specific aims and abilities to be developed. Furthermore, the CAPS document (Department of Basic Education, 2011, pp. 11–15, 27, 39, 48) provides examples of words or verbs as indicators for conceptual understanding and skills proficiency in Statistics assessment. These words and verbs provide guidelines for learners to demonstrate or develop statistical literacy, reasoning and thinking (delMas, 2002). Despite the importance of these words or verbs, teachers need to realise which statistical learning outcomes they are developing in Statistics. Thus, effort must be made to ensure that teachers understand how vital their competence is of developing learners' statistical literacy, reasoning and thinking in Statistics classes, that is, their statistics-specific PCK. It is important to make sure that assessments focus on the knowledge and skills viewed as most important for students to learn. For example, if a lesson goal is for learners to be able to read, interpret and critique statistical concepts and graphs used in the media, a student assessment should be described in the course syllabus that is designed to determine if students have developed these competencies. Therefore, to promote or develop statistical literacy, reasoning or thinking, teachers should perceive the nature of the tasks supporting these outcomes in Statistics classes.

In countries such as Kenya and Uganda, Statistics and probability are offered at secondary school level. Modern Kenyan society in general and industry in particular need people with an understanding of statistics and the ability to communicate its use (Odhiambo, 2002). According to Gichohi (2014), there is a need to review the scope of Statistics education in the primary and secondary school curricula in Kenya. In Uganda, Opolot-Okurut (2011) found that teacher education programmes should address the deficiency of teachers' subject matter knowledge and pedagogical content knowledge related to statistics, because no pre-service training programme specifically offers statistics teaching methods. According to Wessels (2008), Statistics education in South Africa is still in its infancy: much needs to be done to prepare mathematics teachers to teach the broadened Statistics Curriculum in such a way that learners are statistically literate when they leave school. Consequently it is clear that Statistics must be presented in a manner that seeks to acknowledge the changes resulting from the curriculum transformation in South Africa as well as from the developments in Statistics research abroad. This requirement challenges teachers to consider and continually assess their knowledge on developing learners' statistical literacy, reasoning and thinking.

Methodology

Sample and Sampling Technique
The target population of this study consists of all the Grade 12 Mathematics teachers in public schools in the Free State province, South Africa. A purposeful sampling method was used to select the Motheo district in the Free State as a sample for this research. There were 66 Grade 12 Mathematics teachers (females = 40%) who participated out of 79 Grade 12 Mathematics teachers in the district. A convenience sampling technique was used to select the Grade 12 Mathematics teachers in the Motheo district according to their availability and the rapidity with which data could be gathered.

Research Instrument
The data for this study were drawn from a teacher questionnaire used in a larger study consisting of four sections, namely sections A–D (Kalobo, 2014). Section C of the questionnaire with 13 items explored teachers' perceptions of the proficiency of their learners in statistical literacy, reasoning and thinking (see Appendix A). The Grade 12 Mathematics teachers were required to choose an appropriate response from a five-point Likert-scale ranging from rarely to sometimes, uncertain, usually and almost always. Core issues related to statistical literacy, reasoning and thinking were used to build the teachers questionnaire. For statistical literacy, the core issues involved learner abilities to display data using charts, represent data, read graphs and use statistical vocabulary in questions 39, 40, 41 and 42, respectively. The core issues in statistical reasoning focused on learner abilities to make sense of statistical information, make interpretations, connect statistical concepts and explain trends in questions 33, 37, 38 and 43, respectively. Finally for statistical thinking, the core issues involved learner abilities to conduct investigations, identify types of graphs, evaluate data, draw conclusions and move from specific observations to generalisations or use inductive reasoning, in questions 34, 35, 36, 44 and 45, respectively.

Validity and Reliability
For the reliability of the instrument, a pilot study was carried out with 10 Grade 12 Mathematics teachers from districts that were not part of the sample (Fraenkel & Wallen, 2003). The data were analysed using the Statistical Package for Social Sciences (SPSS). The Cronbach's α coefficient was also calculated to determine the internal consistency of the questionnaire. Cronbach's α reliability coefficient normally ranges between 0 and 1. The closer the α coefficient is to 1.0, the greater the internal consistency is of the items in the scale (George & Mallery, 2003). Although the researcher expected some threat to the internal consistency owing to the differences across schools in the Motheo district (Leedy & Ormrod, 2010), the α-value of 0.942 was seen to be an excellent measure for determining the questionnaire's reliability. Content validity was strengthened by involving three Mathematics

subject specialists and two academic mathematics educators in scrutinising the scope and depth of the questionnaire items (Fraenkel & Wallen, 2003).

In this study the findings cannot be generalised to Grade 12 Mathematics teachers of other districts in the Free State because of the small size of the sample (Cohen, Manion & Morrison, 2011). Moreover, the teachers' questionnaire was not translated in Afrikaans to accommodate the respondents whose medium of instruction was Afrikaans. This might have posed problems to teachers in terms of clarity and meaning of some of the questionnaire items.

Procedure

A written information sheet, explaining the purpose of the study, was given to all participants. Informed consent was obtained from teachers involved in the research project during a CAPS training session, by the Free State Department of Education. Confidentiality of the data and freedom to withdraw at any time without penalty were guaranteed to participants before they gave consent to participation. An authorisation to conduct this research at schools in the Motheo district was obtained from the Free State Department of Education.

Data Analysis Methods

Descriptive statistics in the form of frequencies and percentages were used to summarise the data collected from the questionnaire. Clusters of items representing the understanding of statistics literacy, statistical reasoning and statistical thinking, respectively, were interpreted together.

Results

The questionnaire used a five-point Likert scale. In Table 1, the responses in the form of raw data are summarised as frequencies (f) for each question which are then expressed as percentages(%).

In Table 2, teachers' perceptions of learners' proficiency in statistical literacy (SL), statistical reasoning (SR) and statistical thinking (ST), respectively, are summarised as average frequencies f and average percentages(%).

Teachers' Perceptions of Learners' Proficiency in Statistical Literacy

This category, statistical literacy, involved four questions, namely questions 39, 40, 41 and 42 (see Appendix A). The responses to these questions in Table 1 indicate to what extent teachers consider

Table 1. Summary of questionnaire responses: frequencies and percentages (N = 66)

Question	Rarely		Sometimes		Uncertain		Usually		Almost always		Missing	
	f	%	f	%	f	%	f	%	f	%	f	%
33	3	4.5	12	18.2	23	34.8	20	30.3	6	9.1	2	3.0
34	3	4.5	14	21.2	27	40.9	11	16.7	9	13.6	2	3.0
35	3	4.5	13	19.7	26	39.4	13	19.7	9	13.6	2	3.0
36	2	3.0	10	15.2	13	19.7	29	43.9	10	15.2	2	3.0
37	1	1.5	14	21.2	35	53.0	8	12.1	6	9.1	2	3.0
38	2	3.0	13	19.7	30	45.5	16	24.2	4	6.1	1	1.5
39	2	3.0	9	13.6	13	19.7	34	51.5	7	10.6	1	1.5
40	1	1.5	9	13.6	8	12.1	40	60.6	7	10.6	1	1.5
41	3	4.5	7	10.6	11	16.7	35	53.0	9	13.6	1	1.5
42	3	4.5	10	15.2	12	18.2	29	43.9	11	16.9	1	1.5
43	3	4.5	10	15.2	32	48.5	12	18.2	8	12.1	1	1.5
44	4	6.1	17	25.8	23	34.8	14	21.2	7	10.6	1	1.5
45	3	4.5	14	21.2	30	45.5	13	19.7	5	7.6	1	1.5

Table 2. Statistical literacy, reasoning, and thinking average frequency and percentage

Question	Rarely		Sometimes		Uncertain		Usually		Almost always		Missing	
	f	%	f	%	f	%	f	%	f	%	f	%
SL average	2	3.4	9	13.0	11	16.7	34	52.3	9	12.9	1	1.5
SR average	2	3.4	12	18.6	30	45.5	14	21.2	6	9.1	2	2.3
ST average	3	4.5	14	20.6	24	36.1	16	24.2	8	12.1	2	2.4

their learners to be proficient in statistical literacy. These responses indicated respectively that 41 (62.1%), 47 (71.2%), 44 (66.6%) and 40 (60.8%) of the teachers agreed that learners usually or almost always understand the use of statistical vocabulary, can work with different representations of data, can read graphs that represent data and are able to display a given set of data using charts. The perceptions are reasonably consistent across the various aspects of statistical literacy. It is notable that the percentage of teachers suggesting that they are uncertain about their learners' understanding of these aspects of literacy is relatively low, varying from 12.1 to 19.7%.

It is evident from Table 2 that 43 (65.2%) of the teachers (so two out of three) indicated that usually or almost always their learners have developed an understanding of statistical literacy in their Statistics class.

Teachers' Perceptions of Learners' Proficiency in Statistical Reasoning

Statistical reasoning involved questions 33, 37, 38 and 43 (see Appendix A). Shown in Table 1, the responses to these questions indicate, respectively, that only 26 (39.4%) , 14 (21.2%), 20 (30.3%) and 20 (30.3%) of the teachers agreed that their learners usually or almost always are able to make sense of statistical information encountered in diverse contexts, connect one statistical concept to another statistical concept in Statistics activities, make interpretations based on sets of data and explain trends from a data display in a graph, respectively. Teachers' perceptions are not entirely consistent across the various aspects of statistical reasoning. In particular, few teachers consider their learners to be proficient in linking statistical concepts in a statistical activity (Q37) and a relatively large group of teachers report their learners to be proficient in the sense-making of statistical information (Q33), although this group is considerably smaller than for any of the scientific literacy aspects. It is notable that for all but one aspect (Q33), around half of the teachers are uncertain about their learners' proficiency in scientific reasoning.

From Table 2 one can conclude that on average only 20 (30.3%) of the teachers considered their learners usually or almost always to be proficient in statistical reasoning. Table 2 also shows the large percentage (45.5%) of teachers who are uncertain about their learners' proficiency across the aspects of statistical reasoning.

Teachers' Perceptions of Learners' Proficiency in Statistical Thinking

The category statistical thinking involved five questions, that is, questions 34, 35, 36, 44 and 45 (see Appendix A). Table 1 indicates to what extent teachers consider their learners to be proficient in statistical thinking. The responses show that 20 (30.3%), 22 (33.3%), 39 (59.1%), 21 (31.8%) and 18 (27.3%) of the teachers perceive their learners to usually or almost always understand how statistical investigations are conducted, what type of data leads to what type of graph, how to evaluate different datasets, how to draw conclusions from a data display in a graph and how to move from specific observations to generalisations of data, respectively. Teachers' perceptions are not entirely consistent across the various aspects of statistical thinking. Only teachers' perceptions of their learners' proficiency in evaluating different datasets (Q36) indicate a reasonable development of statistical thinking. In contrast, learners' proficiency in generalising from specific observations (Q45) is seen as achieved only by about a quarter of the respondents. It is striking that, apart from Q36, the responses indicate that around 40% of the teachers are uncertain about their students' proficiency in any of these aspects of statistical thinking.

Table 2 indicates that 24 (36.3%) of the teachers perceive that their learners usually or almost always are proficient in statistical thinking. On average, a similar percentage of the teachers are uncertain about the proficiency of their learners in statistical thinking. These two observations together mean that the percentage of teachers considering that their learners are rarely or sometimes proficient in statistical thinking is slightly higher than that for proficiency in statistical reasoning, that is, 17 (25.1%) for statistical thinking vs 14 (23.0%) for statistical reasoning.

Discussion

The focus in this study was to explore teachers' perceptions of learners' proficiency in statistical literacy, reasoning and thinking. The data show that around two out of three teachers consider that their learners are usually or almost always proficient in the various aspects of statistical literacy. However, only around one out of three teachers reports that their learners are usually or almost always proficient in the various aspects of statistical reasoning and statistical thinking. This difference may be related to the characteristics of the aspects of statistical literacy: these seem to be closer to content dealt with in a traditional mathematics curriculum, especially when a multiple representation approach (Ainsworth, 2006) is adopted. This interpretation is supported by the data showing that for Q36 focusing on the ability to evaluate different datasets close to two in three teachers consider their learners to be proficient, even though this ability is classified as an aspect of statistical thinking. Equally, a traditional perception of statistics teaching as developing skills, as highlighted by Ben-Zvi and Garfield (2005), will also cover aspects of statistical literacy more explicitly than most of the aspects of statistical reasoning and statistical thinking.

A second major finding is the fact that about 50 and 40% of the teachers are uncertain about their learners' proficiency in statistical reasoning and statistical thinking, respectively. This finding may be interpreted in two ways. Firstly, it may indicate that respondents were unclear about the *nature* of the learner abilities they were asked about. Since the pilot phase showed that terms in the questionnaire were unambiguous, it is more likely that respondents were unclear about the *relevance* of the learner abilities they were asked about. In other words, how do these aspects of statistical reasoning and statistical thinking apply to their statistics classroom? The constructs of statistical reasoning and statistical thinking are, according to delMas and Garfield (2010), the kinds of abilities learners need to develop in statistics. Although these abilities are not explicitly stated in the curriculum document, this document contains action words (verbs) that provide guidance in writing assessment (delMas, 2002). Those words (verbs) thus guide the demonstration of learners' understanding of statistical literacy, reasoning and thinking. The findings of this study show that about half of the Mathematics teachers do not see the connection between the action words in the curriculum, and the aspects of statistical reasoning and statistical thinking to be assessed. This finding points to a need for strengthening Subject Matter Knowledge with a focus on specific content knowledge for teachers (Ball, Thames & Phelps, 2008).

Even if teachers see the need for teaching the various aspects of statistical reasoning and thinking, a second interpretation of the large percentage of teachers uncertain about their learners' proficiency in statistical reasoning and statistical thinking may highlight the fact that teachers do not know how to assess these aspects of statistical understanding. This would indicate a need for supporting teachers' PCK specifically for statistics concepts, as suggested by Opolot-Okurut (2011) and Wessels and Nieuwoudt (2011) in Uganda and South Africa, respectively.

Conclusion and Recommendations

Prospects for the improvement of learners' proficiency in statistical literacy, reasoning and thinking must take into account the need for the teachers to understand these statistical learning outcomes, the need for the teachers to be able to describe statistical learning outcomes and the need for the teachers to be able to use verbs and words that enable learners demonstrate and develop an understanding in statistical outcomes.

Based on the findings obtained from the questionnaires the following recommendations are made. Mathematics teachers need to be provided with appropriate training on the intended outcomes of statistics (their Subject Matter Knowledge of statistics) during pre-service and in-service programmes. Finally, Mathematics teachers should be encouraged to assess their own knowledge of the teaching of statistics outcomes (their PCK of statistics) by reflecting on their teaching.

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References

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multile representations. *Learning and Instruction*, *16*(3), 183–198.

Ball, D.L., Thames, M., & Phelps, G. (2008). Content knowledge for teaching: What makes it special. *Journal of Teacher Education*, *59*, 398–407.

Ben-Zvi, D., & Garfield, J. (2005). *The challenge of developing statistical literacy, reasoning and thinking*. Dordrecht: Kluwer.

Ben-Zvi, D., & Garfield, J. (2007). How students learn statistics revisited: A current review of research on teaching and learning statistics. *International Statistical Review*, *75*(3), 372–396.

Campos, C., Ferreira, D., Jacobini, O., & Wodewotzki, M. (2015). Mathematical modelling in the teaching of statistics in undergraduate courses. In G. Stilman, W. Blum & M. Bienbenga (Eds.), *Mathematical modelling in education research and* practice (pp. 501–520). Heidelberg: Springer.

Chance, B., delMas, R., & Garfield, J. (2003). *The Web-Based ARTIST: Assessment resource tools for improving statistical thinking project*. Invited paper, Joint Statistical Meetings, San Francisco. Retrieved from https://apps3.cehd.umn.edu/artist/articles/AERA_2003.pdf

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). London: Routledge.

delMas, R. (2002). Statistical literacy, reasoning, and learning. *Journal of Statistics Education*, *10*(*3*). Retrieved from http://www.amstat.org/publications/jse/v10n3/delmas intro.html

delMas, R., & Garfield, J.B. (2010). A web site that provides resources for assessing students' statistical literacy, reasoning and thinking. *Teaching Statistics*, *32*, 2–7.

Department of Basic Education (2011). *Curriculum and Assessment Policy Statement (CAPS). Mathematics FET phases*. Pretoria: Department of Basic Education.

Fraenkel, J.R., & Wallen, N.E. (2003). *How to design and evaluate research in education* (5th ed.). Boston, MA: McGraw-Hill.

Franklin, C., & Garfield, J. (2011). Assessment of learning, for learning, and as learning in statistics education. In C. Batanero, G. Burrill, & Reading, C. (Eds.), *Teaching statistics in school mathematics—Challenges for teaching and teacher education: A joint ICMI/IASE study* (pp. 133–145). New York: Springer.

Garfield, J., & Chance, B. (2000). Assessment in statistics education: Issues and challenges. *Mathematical Thinking and Learning*, *2*(1–2), 99–125.

George, D., & Mallery, P. (2003). SPSS *for Windows step by step: A simple guide and reference*. 11.0 update (4th ed.). Boston, MA: Allyn & Bacon.

Gichohi, B.W. (2014). *A review of statistics education in Kenya*. Proceedings of the Ninth international conference on Teaching Statistics (ICOTS9, July, 2014), Flagstaff, AZ, USA; Voorburg, The Netherlands: International Statistical Institute. Retrieved from icots.info/9/proceedings/pdfs/ICOTS9_P22_Gichohi.pdf

Kalobo, L. (2014). *Statistics in the Further Education and Training (FET) Mathematics Curriculum: A teaching and learning perspective*. Unpublished doctoral thesis, University of the Free State, South Africa.

Leedy, P.D., & Ormrod, J.E. (2010). *Practical research. Planning and design* (9th ed.). Saddle River, NJ: Pearson Prentice-Hall.

Lovett, M. (2001). A collaborative convergence on studying reasoning processes: A case study in statistics. In D. Klahr & S. Carver (Eds.), *Cognitive and instruction*: *Twenty-five years of progress* (pp. 347–384). Mahwah, NJ: Lawrence Erlbaum.

Martin, G. (2009). *Focus in school mathematics: Reasoning and sense making*. Reston, VA: National Council of Teachers of Mathematics.

Odhiambo, J.W. (2002). *Teaching of statistics in Kenya*, 2. Proceedings of the ninth of the sixth international conference on Teaching Statistics (ICOTS6002), Cape Town, South Africa. Retrieved from iase-web.org/Conference_Proceedings.php?p=ICOTS_6_200

Opolot-Okurut, C. (2011). Statistics school curricula for Uganda. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching statistics in shool mathematics: Challenges for teaching and teacher education* (pp. 15–38). New York: Springer.

Rumsey, D.J. (2002). Statistical literacy as a goal for introductory statistics courses. *Journal of Statistics Education*, *10*(3), 6–13.

Tishkovskaya, S., & Lancaster, G. (2012). Statistical education in the 21st century: A review of the challenges, teaching innovations and strategies for reform. *Journal of Statistics Education*, *20*(2), 1–55.

Wessels, H. (2008). *Statistics in the South African School Curriculum: Content, assessment and teacher training*. Joint ICMI/IASE Study: Teaching Statistics in School Mathematics—Challenges for Teaching and Teacher Education, ITESM, Monterrey, Mexico. Retrieved from iase-web.org/documents/papers/rt2008/T1P3_Wessels.pdf

Wessels, H., & Nieuwoudt, H. (2011). Teachers' professional development needs in data handling and probability. *Pythagoras*, 32(1), article 10.

Appendix A: Questionnaire on Statistics for Completion by Grade 12 Mathematics Teachers

Section C: Teachers' Views on Learners' Statistical Literacy, Reasoning and Thinking
Read carefully. Use the provided scale to tick the most appropriate answer. Remember there is no right or wrong answer.

		Rarely	Sometimes	Uncertain	Usually	Almost always
33	My learners can make sense of statistical information they encounter in diverse contexts	1	2	3	4	5
34	My learners understand how statistical investigations are conducted	1	2	3	4	5
35	My learners know what type of data leads to what type of graph	1	2	3	4	5
36	My learners can evaluate different data	1	2	3	4	5
37	My learners are able to make interpretations based on sets of data encountered in diverse contexts	1	2	3	4	5
38	My learners are able to connect one statistical concept to another statistical concept in Statistics activities	1	2	3	4	5
39	My learners understand the use of statistical vocabulary in Statistics	1	2	3	4	5
40	My learners are able to work with different representations of data	1	2	3	4	5
41	My learners are able to read graphs that represent data	1	2	3	4	5
42	My learners can display a given set of data by using charts	1	2	3	4	5
43	My learners can explain trends from a data display in a graph	1	2	3	4	5
44	My learners can draw conclusion from a data display in a graph	1	2	3	4	5
	My learners are able to move from specific observations to generalisations of data	1	2	3	4	5