

TEACHERS' ATTITUDES TOWARDS STATISTICS¹

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Abstract. Teachers' attitudes towards statistics play a significant role in assuring success in implementing any new statistical curriculum. In this chapter attitudes and their component factors are conceptualised, and the primary instruments available to assess attitudes are reviewed. Following this, the research on teacher attitudes toward statistics is summarized. Finally, some implications for training teachers in statistics are discussed.

1. INTRODUCTION

Teacher training in statistics is generally focused on improving the cognitive aspects of instruction with little attention paid to the emotional component of learning. However, this latter factor “can impede learning of statistics, or hinder the extent to which students will develop useful statistical intuitions and apply what they have learned outside the classroom” (Gal & Ginsburg, 1994, p. 1).

The focus of this chapter is attitudes towards statistics, which might influence a person's statistical behaviour inside and outside the classroom and their willingness to attend statistics courses in the future (Pajares, 1996; Bandura, 1997; Gal, Ginsburg, & Schau, 1997). This is particularly relevant in the preparation of teachers, since positive attitudes towards statistics would help them to understand that statistics is useful in their students' professional and personal lives, and that their students can be trained to understand and use statistics (Schau, 2003). In addition, statistics teachers would be more likely to transmit to their students a positive view of statistics and an appreciation for the potential uses of statistics in future personal and professional life (Gal & Ginsburg, 1994).

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This chapter clarifies the differences among attitudes, emotions, and beliefs, and then describes components of teacher attitudes and instruments measuring these attitudes. This is followed by a summary of the scarce research related to teachers' attitudes towards statistics that tries to identify affective factors that teachers associate with both statistics learning and the importance of continuing professional development in statistics. Finally, some recommendations about how teacher training may attempt to improve teacher's attitude towards statistics are included.

2. ATTITUDES TOWARDS STATISTICS

2.1. *Conceptualizing attitudes*

McLeod (1992) analysed the mathematics education affective domain and discriminated between emotions, attitudes, and beliefs. These are distinguished by the stability of the affective responses that they represent, the degree to which cognition plays a role in the response, and in the time that they take to develop:

- Emotions are feelings or states of consciousness, distinguished from cognition (Philipp, 2007). They involve positive (e.g., satisfaction) and negative (e.g., panic) responses triggered by one's immediate experiences, for example, while studying statistics. Emotions are transient and hard to measure but can be intense and serve as a source for development of attitudes (Gal et al., 1997). They may involve little cognitive appraisal and may change rapidly (McLeod, 1992).
- Beliefs are psychologically held premises or propositions about the world that are thought to be true (Philipp, 2007). They are largely cognitive in nature, and are developed over a relatively long period of time (McLeod, 1992). Beliefs include ideas about statistics, about oneself as a learner of statistics, and about the social context of learning that together provide a context for statistics experiences (Gal, et al., 1997; Chick & Pierce, this book; Eichler, this book).
- Attitudes can be viewed as "affective responses that involve negative or positive feelings of moderate intensity" (McLeod, 1992, p. 581). More recently Philipp (2007) described attitudes as manners of acting, feeling, or thinking that show a person's

disposition or opinion towards a topic. They are relatively stable, resistant to change, and comprise a larger cognitive component and less emotional intensity than emotions. They develop as repeated positive or negative emotional responses and are automatized over time (Gal et al., 1997).

Consequently, the sequence of beliefs, attitudes, and emotions represents increasing levels of affect and intensity of response, from cold beliefs related to liking or disliking mathematics, to strong emotional reactions such as feeling frustration when not being able to solve non-routine problems. The sequence also represents decreasing levels of cognitive involvement and response stability (McLeod, 1992).

In summary, attitudes collectively form an important psychological construct that is often used to understand and predict an individual's reaction to an object and how behaviour can be influenced (Fishbein & Ajzen, 1975). Attitudes are expressed along a positive-negative continuum, e.g., like-dislike, pleasant-unpleasant, and may represent, for example, feelings towards a teacher, a topic, or an activity. They change more slowly than emotions because they are more cognitively based (Philipp, 2007). Attitudes towards a topic derive from positive or negative experiences over time devoted to learning. Students may have had such experiences—in the case of statistics—at school or in informal learning out of school. Students may have a fuzzy understanding of what statistics might be about, or be unaware about life domains where statistics may be used, and this lack of knowledge can affect their attitudes. In other cases, students transfer their negative feelings towards mathematics into statistics (Gal & Ginsburg, 1994). All of these considerations are applicable to prospective teachers or in-service teachers with no specific training in statistics.

2.2. Components in attitudes

As suggested earlier, several authors conceptualize attitudes as a multidimensional concept. Wise (1985), for example, distinguished between attitudes toward a course in basic statistics that the students were taking (course subscale) and attitudes toward the use of statistics in their field of study in the future (field subscale). Three of the generally

accepted components of the term 'attitude' (Aiken, 1980; Auzmendi, 1991; Olson & Zanna, 1993; Gómez Chacón, 2000) are: (a) *Affective*: feelings about the object in question, (b) *Cognitive*: the person's self-perception as regards the object, and (c), *Behavioural*: the person's inclination to act toward the attitude object in a particular way. Schau, Stevens, Dauphine, and del Vecchio (1995) assumed four dimensions: (a) *Affect*: feelings concerning statistics; (b) *Cognitive competence*: perception of self-competence, knowledge and intellectual skills when applied to statistics; (c) *Value*: appreciation of the usefulness, relevance and worth of statistics in personal and professional life, and (d) *Difficulty*: perceived difficulty of statistics as a subject.

Depending on the above established sub-constructs, over the last two decades a large number of tools to measure attitudes toward statistics have been developed. Below we describe only the most widely used instruments.

3. MEASURING ATTITUDES TOWARDS STATISTICS

Since attitude is a psychological construct it cannot be directly measured and the use of only a single statement or question to assess attitude will not provide reliable responses. The most common approach is to use a Likert-type survey that requires individuals to decide on their level of agreement with a number of statements related to the different components of attitudes. Responses are generally on a five-point scale (i.e., strongly agree, agree, neither agree nor disagree, disagree, strongly disagree). For example, the sentence "I enjoy taking statistics courses" is related to the affect component and strong agreement suggests a positive attitude in this component. At the same time the sentence "I am under stress in the statistics class" is related to a negative attitude, also in the affect component. Scores in items that are presented in negative form should be reversed, before the scale and component scores are formed by adding the scores in the different items. Three of the most widely used scales measuring attitudes towards statistics are described below:

- *Statistics Attitude Survey* (SAS; Roberts & Bilderback, 1980; Roberts & Saxe, 1982).
The first instrument to measure attitude toward statistics, this scale was designed to be one-dimensional, with 33 Likert-type items, each of them with five response possibilities ranging from strongly disagree to strongly agree.

- *Attitudes Toward Statistics* (ATS; Wise, 1985). The ATS is a 29-item, Likert-type scale with five response possibilities consisting of two subscales. The *Field* (20 items) and *Course* (nine items) subscales respectively aim to measure attitudes toward the particular statistics course in which students are enrolled and the use of statistics in their fields of study.
- *Survey of Attitudes Towards Statistics* (SATS; Schau, et al., 1995; Cashin & Elmore, 2005). The scale consists of 28 items measuring four components of students' attitudes toward statistics: *Affect* (six items measuring feelings concerning statistics), *Cognitive competence* (six items assessing perception of self competence, knowledge, and intellectual skills when applied to statistics), *Value* (nine items that concern appreciation of the usefulness and worth of statistics in personal and professional life) and *Difficulty* (seven items measuring the perceived difficulty of statistics, as a subject).

These and other instruments have been extensively used to measure attitudes towards statistics in undergraduate students (see Carmona, 2004, for a survey). There is little research; however, concerning teachers' attitudes towards statistics and most of it has dealt only with prospective teachers. In the next section we summarise research measuring teachers' attitudes towards statistics and then analyse research that identifies variables affecting these attitudes.

4. TEACHER ATTITUDES TOWARDS STATISTICS

The scarce research describing teachers' attitudes towards statistics deals with three different themes: (a) measuring teachers' global attitudes towards statistics (Begg & Edwards, 1999; Estrada, 2002; Estrada, Batanero, Fortuny, & Díaz, 2005; Chick & Pierce, 2008) and comparing these attitudes with those of undergraduate students in other fields (Onwuegbuzie, 1998; 2003); (b) focussing on a specific part of teachers' *cognitive competence*, namely their *attitudes towards their role as continuing learners of statistics* (Lancaster, 2007), and (c) analysing teachers' attitudes in relation to the teaching of statistics (Begg & Edward, 1999; Watson, 2001).

4.1. Teacher global attitudes towards statistics

Begg and Edwards (1999) used interviews, an unspecified survey scale, and concept maps to study attitudes in a sample of 22 in-service and 12 prospective primary teachers. Results showed negative attitudes in the affective component, with the teachers expressing feelings like “fear”, “horror” or “lack of interest”. As regards value, some teachers considered statistics important, since “It helps us make sense of our world” or “It helps us compare and organize things, shows trends and enables us to predict”. Despite the teachers’ concern about how statistics can be manipulated, they generally disagreed with the statement “Statistics are fairly worthless”. Most of the teachers thought that a good understanding of mathematics was not needed to grasp basic statistical concepts. They did not consider themselves good with statistics, although they were confident about their ability to read and understand statistical terms and graphs in the media.

Estrada (2002) measured the attitudes towards statistics in 66 in-service and 74 prospective primary school teachers. She developed her own scale that contained 25 items taken from SAS, ATS and another scale (Auzmendi, 1991) built in Spain. In her scale Estrada complemented the three classical attitude components (affect, cognition, behaviour), with another three possible components: (a) *Social*: perception of the value of statistics in society; (b) *Educational*: interest in learning and teaching statistics; and (c) *Instrumental*: perceptions of the use of statistics in other areas. Results of this study showed neutral attitudes towards statistics in both groups with better scores in items measuring the instrumental role of statistics (e.g., “I understand better the results of elections when they are presented through statistical graphs”) and the educational value of the topic (e.g., “You should learn statistics in school”). Lower scores corresponded to items measuring confidence in statistics (e.g., “Reality can be manipulated with statistics”) and affect (e.g., “I enjoy taking statistics courses”).

Later Estrada et al. (2005) gave the SATS instrument to a sample of 367 prospective primary school teachers in Spain. Results showed moderately positive attitudes on cognitive competence items (e.g., “I can learn statistics”) and value items (e.g., “Statistics is worthless”) having the highest scores. Correlations were found between the subscales Affect and Cognitive Competence, and Affect and Value. Consequently liking or disliking

statistics was related in these teachers to their perception of self-capacity to learn statistics and to the value given to statistics.

Chick and Pierce (2008) gave 10 items taken from SATS to 27 prospective primary school teachers. Results showed that the teachers had neutral attitudes. As regards the value of statistics, even if they agreed with the item “To be an intelligent consumer, it is necessary to know something about statistics” a majority also agreed that “When buying a new car, asking a few friends is preferable to consulting an owner satisfaction survey in a consumer magazine”.

Onwuegbuzie (1998; 2003) used ATS to compare prospective teachers’ attitudes toward statistics with those of graduate students enrolled in other courses and found that teachers in his sample had fewer positive attitudes towards statistics than did other graduate students.

4.2. Teachers’ attitudes towards their role as continuing learners of statistics

Continuing professional development is an important strategy to remedy the lack of teachers’ statistical content and pedagogical content knowledge (Hill & Ball, 2004) and therefore it is important to motivate teachers to participate in professional development in statistics (Gould & Peck, 2004).

Lancaster (2007) investigated cognitive competence as continuing students of statistics in a sample of 56 prospective primary school teachers in the United States of America that had received a course with statistical content. The questionnaire, a Likert-type survey with five response possibilities for each question, posed six questions such as “Would you be interested in participating in a workshop or other professional development that focuses on improving your knowledge of statistics for the grade level you wish to teach?” and “Do you agree that attending a workshop or other professional development that focuses on improving your knowledge of statistics would improve your ability to teach statistics at your desired grade level?” Results indicated that the teachers’ attitudes toward statistics affected their willingness to participate in activities related to statistics in the future.

The prospective teachers who were still in the early part of their mathematical

training, and had an experienced instructor with a reputation as a motivational teacher, had higher cognitive competence for statistics than did prospective teachers who were in the late part of their mathematical training and were learning statistical concepts in a class with a novice instructor. Though the numbers involved with this comparison were relatively small, these results underscore the possibility that instructor competence and teaching style may affect student attitudes and beliefs toward statistics.

4.3. Teacher attitudes towards their ability to teach statistics

Two studies have focused on teacher attitudes toward statistics as a subject to teach. In their research Begg and Edwards (1999) analyzed the teachers' attitudes towards teaching statistics and found that about 75% of the practicing teachers in their sample felt secure when teaching the topic. These teachers were confident in their statistical abilities and showed low interest in continued professional development in statistics.

Watson (2001) designed and administered a multi-faceted survey to 15 primary school teachers and 28 secondary school teachers in Australia with the aim of assessing professional development needs for teachers arising from changes in the mathematics curriculum. The survey included Likert-type questions, open-ended questions, and the option of an interview. A part of the survey measured the teacher confidence to teach specific statistical concepts. Teacher confidence was highest for "graphical representations" and lowest for "odds". Teachers were asked what type of professional development they would prefer. Four out of every ten indicated school-based sessions while two out of every ten indicated independent readings or a University course. Of those who provided responses to this question, many believed that there was a need for more professional development opportunities.

In summary, research described in this section show poor or neutral attitudes in prospective teacher. This might be explained by the fact that prospective teachers' attitudes depend on their previous experiences with statistics, which is often restricted to studying statistics in school or studying statistics with a very formal mathematical approach. Moreover, if a teacher has low cognitive competence, then he/she may be less likely to be motivated to participate in continuing professional development in statistics. Results related

to teachers' confidence to teach statistics are scarce and inconclusive, so more research is needed in this area.

5. VARIABLES THAT AFFECT TEACHER ATTITUDES TOWARDS STATISTICS

Research that has tried to identify factors affecting the attitudes of teachers focuses mainly on three themes: (a) the relationship between attitudes and statistical knowledge (Nasser, 2004, Estrada et al., 2005, Estrada & Batanero, 2008); (b) relating prospective teachers' attitudes to other affective variables (Lancaster, 2007; 2008); and (c) assessing differences in attitudes in prospective and practicing teachers (Estrada et al., 2005; Estrada & Batanero, 2008).

5.1. Relating prospective teachers' attitudes and statistical knowledge

Nasser (2004) used SATS to examine the relationships among attitudes towards statistics, anxiety, mathematical aptitude, and statistics achievement of 167 prospective teachers in Egypt taking part in an introductory statistics course. Teachers' achievement in statistics was assessed using ten open-ended questions including descriptive statistics (frequency tables, central tendency, variation, distributions, and association) and inferential statistics (estimation, hypothesis tests). Nasser found a small positive effect of attitudes toward statistics on achievement in statistics.

Estrada et al. (2005) also analysed the relationship between prospective teachers' attitudes and their statistical knowledge as assessed by nine open-ended items taken from the *Statistical Reasoning Assessment (SRA)* questionnaire (Garfield, 2003). The particular SRA items used in this study assessed understanding of the main statistics content in the Spanish primary school curriculum: reasoning about data, graphs, average and spread, uncertainty and sampling bias. The authors found a significant, and worrying, percentage in the sample of prospective teachers who did not understand some of the elementary statistical concepts they will have to teach to their future students. There was a significant correlation between attitudes and the number of statistics courses previously taken by the participants, as well as between attitudes and performance on SRA items. Detailed analyses of scores showed that attitudes improved consistently with the number of courses and

knowledge of statistics.

In order to understand prospective teachers' attitudes and misconceptions better, Estrada and Batanero (2008) carried out a complementary study of a new sample of prospective teachers (n=121) who were only given the ten SATS items that had yielded lower scores in the Estrada et al. (2005) study. These participants were asked to first complete the ten items and then justify their responses. A qualitative analysis of their open justifications served to classify the main reasons for positive and negative scorings in the Estrada and Batanero (2008) study. The main explanations given for positive attitudes included: (a) considering statistics as an easy topic, e.g., "pretty logical and simple"; (b) satisfactory learning experiences, e.g., "the teacher explained it well"; (c) novelty of the topic, e.g., "I like topics that are non routine"; (d) perception of the usefulness of statistics for a teacher, e.g., "you have to know about statistics to be able to teach it to children"; and (e) the formative value of statistics, e.g., "essential in many different kinds of work". The main reasons for negative scoring were: (a) lack of previous knowledge or training, e.g., "I only studied statistics at primary school and I hardly remember anything"; (b) difficulty with statistical reasoning, e.g., "you need too much logical thinking"; (c) content too formal, e.g., "symbols and equations are too strange"; (d) considering that statistics is not valued in society, e.g., "statistical knowledge is not required when you look for a job"; and (e) lack of knowledge of applications, e.g., "I found no possible applications of statistics".

Onwuegbuzie (1998; 2003) also examined attitudes and knowledge among teachers. He concluded that attitudes towards statistics have a strong relation to achievements on statistics; however, the impact on reasoning abilities in statistics is not so high because statistical reasoning abilities are more strongly tied to mathematics outcomes than to statistics outcomes.

In summary, the research reported above related attitudes to statistics achievement. Positive attitudes increase when students have good learning experiences and perceive value for their own professional work or for their students' education. Negative attitudes are linked to perceived difficulty, lack of knowledge, and overly formal content.

5.2. Relating prospective teachers' attitudes to other affective variables

Lancaster (2007) also investigated the effect of several variables on prospective teacher attitudes towards their role as continuing students of statistics, examining: (a) attitudes towards statistics measured by the ATS instrument; (b) current self-efficacy to use statistics that has been learned; (c) current self-efficacy to learn statistics in the future; and (d) knowledge of basic statistical concepts, measured by the ARTIST scales (delMas, Garfield, Ooms, & Chance, 2005). Current statistics self-efficacy was defined by Finney and Schraw (2003) as confidence in one's ability to solve specific tasks related to statistics, and self-efficacy to learn statistics was defined as confidence in one's ability to learn the skills necessary to solve specific tasks related to statistics. The results of the study showed no correlations between the affective variables, a result also found by Tempelaar (2003) in his study with undergraduates.

Current self efficacy to learn statistics in the future predicted the teachers' beliefs that continuing professional development in statistics would benefit them in their classroom teaching. Furthermore, current self-efficacy to use statistics that has been learned combined with attitudes toward the current course served to predict current self-efficacy to learn statistics in the future. These results confirm suggestions by Finney and Schraw (2003) that, for research into statistics attitudes, specific affective measures are more likely than general affective measures to provide meaningful results.

5.3. Comparing prospective and in-service teachers' attitudes towards statistics

In her study, Estrada (2002) compared the attitudes towards statistics of in-service primary school teachers and prospective primary school teacher's and related these attitudes with gender, number of previous statistics courses, specialty (topic in which the prospective teachers were specializing or topic the teachers taught), and number of years of teaching experience in mathematics (for in-service teachers). The results of Estrada favoured the prospective teachers group; that is, attitudes seemed to deteriorate with the actual practice of teaching. When analyzing the items in which there were significant differences by group, in-service teachers were more critical of the use of statistics in the media. Because they found statistics to be more useful for everyday life and gave it more

value for the education of citizens, the prospective teachers tended to assume that they would include statistics in their teaching and found it easier to understand as well as more interesting than in-service teachers did. The number of previous mathematics courses with a statistics component taken had a significant effect, with attitudes improving as this number increased. There was no difference by gender and only a small difference regarding the specialty in which the prospective teachers were majoring. In the case of in-service teachers attitudes became less positive as teachers get older. The analysis of the specific items suggests that senior teachers had a greater tendency to suppress statistics when possible and found statistics more difficult than younger teachers. Finally, the results also suggested that teachers who did not use statistics (or used it very little) in their professional lives (e.g., in assessment or to compare performances of different groups) tended to have poorer attitudes towards statistics.

6. IMPLICATIONS FOR RESEARCH INTO TRAINING TEACHERS IN STATISTICS

Students learn statistics more effectively in settings where collaboration is encouraged, and where progressive teaching methods such as discovery learning and problem solving are the focus. To successfully implement such strategies, teachers must possess the necessary attitude structures as well as good knowledge of mathematical and didactic aspects of school learning of statistics (Wilson & Cooney, 2002). The first step in achieving these aims is to continue with research aimed at assessing teachers' attitudes toward statistics and finding possible explanatory variables. This research is particularly needed as regards secondary school teachers, where no research is currently available.

Secondly, reported research also suggested that a main influence on teachers' attitudes is their previous knowledge of statistics as well as good learning experiences (non-abstract, with examples of applications in everyday and professional life). Attention is drawn from these results to the need to find more methods to improve teachers' knowledge and provide them with examples that statistics is valuable and that basic statistics can be taught in an attractive and easy way. Teacher educators are then responsible for creating an emotionally and cognitively supportive environment in statistics training, where

prospective teachers explore different statistical methods, gain confidence in their own ability to learn, and learn to value the role of statistics in modern society.

REFERENCES

- Aiken, L. R. (1980). Attitudes measurement research. In D. A. Payne (Ed.), *Recent developments in affective measurement* (pp. 1-24). San Francisco, CA: Jossey-Bass.
- Auzmendi, E. (1991, April). Factors related to statistics: A study with a Spanish sample. Paper presented at the *Annual Meeting of the American Educational Research Association*. Chicago, IL.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.
- Batanero, C., Burrill, G., Reading, C., & Rossman, A. (Eds.) (2008), *Joint ICMI/IASE Study: Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education. Proceedings of the ICMI Study 18 and 2008 IASE Round Table Conference*. Monterrey, Mexico: International Commission on Mathematical Instruction and International Association for Statistical Education. Online: www.stat.auckland.ac.nz/~iase/publications.
- Begg, A., & Edwards, R. (1999). Teachers' ideas about teaching statistics. *Proceedings of the 1999 combined conference of the Australian Association for Research in Education and the New Zealand Association for Research in Education*. Melbourne: AARE & NZARE. Online: www.aare.edu.au/99pap/beg99082.htm.
- Carmona, J. (2004). Una revisión de las evidencias de fiabilidad y validez de los cuestionarios de actitudes y ansiedad hacia la estadística (Revising the reliability and validity evidence of attitudes and anxiety towards statistics questionnaires). *Statistics Education Research Journal*, 1(1), 5-28. Online: www.stat.auckland.ac.nz/~iase/serj/.
- Cashin, F., & Elmore, P. (2005). The Survey of Attitudes Toward Statistics scale: A construct validity study. *Educational and Psychological Measurement*, 65, 509-524.
- Chick, H. L., & Pierce, R. U. (2008). Teaching statistics at the primary school level: Beliefs, affordances, and pedagogical content knowledge. In C. Batanero, G. Burrill, C. Reading, & A. Rossman (2008).
- delMas, R., Garfield, J. B., Ooms, A., & Chance, B. (2006). *The ARTIST scales*. Online:

<https://app.gen.umn.edu/artist/>.

- Estrada, A. (2002). *Análisis de las actitudes y conocimientos estadísticos elementales en la formación del profesorado* (Analysing attitudes and elementary statistical knowledge in the training of teachers). Unpublished Ph.D. dissertation. Universidad Autónoma de Barcelona, Spain.
- Estrada, A., & Batanero, C. (2008). Explaining teachers' attitudes towards statistics. In C. Batanero, G. Burrill, C. Reading, & A. Rossman (2008).
- Estrada, A., Batanero, C., Fortuny, J. M., & Diaz, C. (2005). A structural study of future teachers' attitudes towards statistics. In M. Bosch (Ed.), *Proceedings of the Fourth Congress of the European Society for Research in Mathematics Education* (pp. 508-517). Barcelona: IQS Fundemi. Online: ermeweb.free.fr/CERME4/.
- Finney, S. J., & Schraw, G. (2003). Self-efficacy beliefs in college statistics courses. *Contemporary Educational Psychology*, 28, 161 – 186.
- Fishbein, M., & Ajzen, I (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research*. London: Addison-Wesley.
- Gal, I., & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: towards an assessment framework. *Journal of Statistics Education*, 2(2). On line: www.amstat.org/publications/jse/.
- Gal, I., Ginsburg, L., & Schau, C. (1997). Monitoring attitudes and beliefs in statistics education. In I. Gal & J. B. Garfield (Eds.), *The assessment challenge in statistics education* (pp. 37-51). Voorburg, Netherlands: IOS Press.
- Garfield, J. B. (2003). Assessing statistical reasoning. *Statistics Education Research Journal*, 2(1), 22-38. On line: www.stat.auckland.ac.nz/~iase/serj/.
- Gómez-Chacón, I. (2000). Affective influences in the knowledge of mathematics, *Educational Studies in Mathematics*, 43(2), 149-168.
- Gould, R., & Peck, R., (2004, July). Preparing secondary teachers to teach statistics. Paper presented at the 10th *International Congress on Mathematics Education*. Copenhagen 2004.
- Hill, H., & Ball, D. L. (2004). Learning mathematics for teaching: Results from California's mathematics professional development institutes. *Journal for Research in*

- Mathematics Education*, 35(5), 330-351.
- Lancaster, S., (2007). *Preservice teachers and statistics: Interrelationships between content confidence, knowledge, and attitudes; pedagogical beliefs; classroom practices; and teacher interest in professional development in statistics*. Unpublished Ph.D. dissertation. University of Oklahoma, Norman.
- Lancaster, S. (2008). A study of preservice teachers' attitudes toward their role as students of statistics and implications for future professional development in statistics. In C. Batanero, G. Burrill, C. Reading, & A. Rossman (2008).
- McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grows (Eds.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 575-596). New York: Macmillan and National Council of Teachers of Mathematics.
- Nasser, F. M. (2004). Structural model of the effects of cognitive and affective factors on the achievement of Arabic-speaking prospective teachers in introductory statistics. *Journal of Statistics Education*, 12(1). Online: www.amstat.org/publications/jse/.
- Olson, J. M., & Zanna, M. P. (1993). Attitude and attitude change. *Annual Review of Psychology*, 44, 117-154.
- Onwuegbuzie, A. J. (1998). Teachers' attitudes toward statistics. *Psychological Reports*, 83, 1008-1010.
- Onwuegbuzie, A. J. (2003). Modelling statistics achievement among graduate students. *Educational and Psychological Measurement*, 63, 1020-1038.
- Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66(4), 543-578.
- Philipp, R. A. (2007). Mathematics teachers' beliefs and affects. In F. Lester (Ed.). *Second handbook of research on mathematics teaching and learning* (pp. 257-315). Charlotte, NC: Information Age Publishing and National Council of Teachers of Mathematics.
- Roberts, D. M., & Bilderback, E. W. (1980). Reliability and validity of a statistics attitude survey. *Educational and Psychological Measurement*, 40, 235-238.
- Roberts, D. M., & Saxe, J. E. (1982). Validity of a statistics attitude survey: A follow-up study. *Educational and Psychological Measurement*, 42, 907-912.

- Schau, C. (2003, August). Students' attitudes: The other important outcome in statistics education. Paper presented at the *Joint Statistical Meeting of the American Statistical Association*, San Francisco, CA.
- Schau, C., Stevens, J., Dauphine, T., & del Vecchio, A. (1995). The development and validation of the survey of attitudes towards statistics. *Educational and Psychological Measurement*, 55(5), 868-875.
- Tempelaar, D. (2003). Statistical reasoning and its relationship to attitudes towards statistics and achievement. *Proceedings of the International Statistical Institute 54th session*, Berlin, Germany. Online: www.stat.auckland.ac.nz/~iase/publications.
- Watson, J. M. (2001) Profiling teachers' competence and confidence to teach particular mathematics topics: The case of chance and data. *Journal of Mathematics Teacher Education*, 4(4), 305-337.
- Wilson, M. S., & Cooney, T. J. (2002). Mathematics teacher change and development: The role of beliefs. In G. C. Leder, E. Pehkonen, & G. Torner (Eds.), *Beliefs: A hidden variable in mathematics education?* (Vol. 31, pp. 127-148). London: Kluwer Academic Publishers.
- Wise, S. L. (1985). The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement*, 45, 401-405.