4. Monitoring Attitudes and Beliefs in Statistics Education

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Purpose

Students' attitudes and beliefs can impede (or assist) learning statistics, and may affect the extent to which students will develop useful statistical thinking skills and apply what they have learned outside the classroom. This chapter alerts educators to the importance of assessing student attitudes and beliefs regarding statistics, describes and evaluates different methods developed to assess where students stand in this regard, provides suggestions for using and extending existing assessments, and outlines future research and instructional needs.

INTRODUCTION

"I was terrified when I learned that I would have to take [statistics] because I have always had a mental block dealing with mathematical formulas."

"I have found math to be easy for me throughout school. I think statistics would be fun."

"My teacher said statistics can be misleading and in any case do not relate to people as individuals."

"Although I have never taken a statistics course, I hear they are very difficult and abstract."

These comments, written by high school and university students who had not learned statistics before, show that students may enter statistics education, at either the secondary or post-secondary levels, with strong feelings or ideas involving this subject. A central tenet of this chapter is that, while teachers of statistics are focusing on transmitting knowledge and skills, students may be having an easy or difficult time learning or applying statistics due to the attitudes and beliefs they carry with them. Despite the apparent importance of this topic, little has been written in the professional (i.e., research- or teacher-oriented) literature about possible ways to measure students' feelings, attitudes, beliefs, interests, or expectations in the area of statistics, and about issues and dilemmas involved in such assessment.

This chapter is organized in six parts. Part one presents a rationale for attending to belief and attitude issues by those teaching statistics (especially in secondary and college contexts). Part two surveys some definitional and background issues. Possible sources for students' beliefs and attitudes are examined in part three. Part four presents basic approaches for assessing statistics attitudes and beliefs, both for the purpose of illustrating what instruments are "out there," as well as to help clarify the various facets or components of statistics attitudes and beliefs. Additional ways to extend the range of information obtained in a survey of students' attitudes are introduced in part five. The last part discusses the current state of the field and outlines implications for practice.

WHY CONSIDER ATTITUDES AND BELIEFS IN STATISTICS EDUCATION?

Students' attitudes and beliefs regarding statistics deserve attention for three reasons: 1. their role in influencing the teaching/learning process (process considerations); 2. their role in influencing students' statistical behavior after they leave the classroom (outcome considerations); and 3. their role in influencing whether or not students will choose to enroll in a statistics course later on, beyond their first encounter with statistics (access considerations).

Process considerations

Increasingly, one of the stated goals of statistics education at all levels is to develop flexible statistical problem-solving, statistical literacy and related communication skills, and data-analyzing skills, as opposed to merely imparting computational and procedural skills (NCTM, 1989; Moore, 1990). The creation of a problem-solving environment for learning statistics requires teachers at all levels to build an emotionally and cognitively supportive atmosphere where students:

Feel safe to explore, conjecture, hypothesize and brainstorm and are *not afraid* to experiment with applying different (statistical) tools and methods,

Feel comfortable with temporary confusion or a state of inconclusive results as well as the uncertainty inherent in statistical and probabilistic situations,

Believe in their ability to navigate or "muddle through" intermediate stages, temporary roadblocks, and the decisions needed to reach a certain goal; and

Are *motivated* to struggle with and keep working on tasks or problems which may require extended investment of energy.

However, many students are not ready to embrace and function within a problem-solving-oriented learning environment in statistics education. Part of this lack of readiness is due to the attitudes they carry from their experiences with mathematics (and mathematics teachers). Statistics teachers should be able to assess and monitor students' feelings and ideas, so as to make sure all students either have or develop the dispositions described above and required to

function effectively in a problem-solving environment, and to detect those students who develop unproductive beliefs or negative attitudes, so that some assistance can be offered.

As students and later as teachers of statistics courses at the post-secondary level, the authors have seen and felt how attitudes and beliefs, especially negative ones, can have a direct impact on the classroom climate and on individual students' opportunity to learn. Strong negative emotional responses such as crying are obvious manifestations of student distress, but the presence of even one student with continuing negative attitudes in a class can create an uncomfortable atmosphere. Similarly, strong positive responses (for example, "aha–I've got it!") help create a positive climate.

Outcome considerations

Most students take a first (introductory) course in statistics either at the precollege level, or as a "terminal" elective or compulsory course at the college or graduate level, i.e., they will not have to take another course unless they wish to. (In addition, some students enter a quantitatively-oriented program, such as in statistics or business, where an introductory course is followed by more advanced statistics courses later on.)

Within the first two contexts, which include the majority of those learning statistics, two goals for an introductory course in statistics can be posited (see Gal & Ginsburg, 1994 and Chapter 1 in this volume):

- To prepare students to deal effectively with statistical situations in the world outside the classroom, and have the know-how as well as the dispositions needed to act as a smart citizen or consumer in a modern society.

- To prepare students to handle, use, or interpret research or statistical data in their academic or professional discipline.

These goals imply that students should emerge from statistics courses with a willingness and interest to think "statistically" in relevant situations. Teachers should aim to engender in students a positive view of statistics and an appreciation for the potential uses of statistics in future personal and professional areas relevant to *each* student.

Access considerations

Some students may have to take further statistics courses, after their first college course, in order to complete a program of advanced or graduate studies. In this regard, an introductory course should provide the foundations for understanding more advanced statistics. More importantly, students' early encounter with statistics should be positive, so as not to prevent otherwise promising students from entering a program with quantitative requirements due to their negative attitudes towards statistics or negative beliefs in their ability to understand statistical topics.

Overall, process, outcome, and access considerations in statistics education imply that it is incumbent upon statistics educators to know what are students' attitudes and beliefs towards statistics before, during, and after taking a statistics course.

DEFINITIONAL AND BACKGROUND ISSUES

There is a definitional challenge in discussing students' ideas, reactions, and feelings about statistics and learning statistics. Though the terms "attitudes" and "beliefs" have been frequently used by researchers and teachers in this regard, little explicit attention has been paid to the distinction between them. Researchers, for example, have often implicitly defined statistics' attitudes or beliefs as whatever their favorite assessment instrument measures. The extensive body of research on affective issues in mathematics education can be used to guide a discussion of affective responses to statistics education.

In conceptualizing the affective domain of mathematics education, McLeod (1992) distinguishes among emotions, attitudes, and beliefs. Emotions are fleeting positive and negative responses triggered by one's immediate experiences while studying mathematics or statistics. Attitudes are relatively stable, intense *feelings* that develop as repeated positive or negative emotional responses are automatized over time. Beliefs are individually held *ideas* about mathematics, about oneself as a learner of mathematics, and about the social context of learning mathematics that together provide a context for mathematical experiences. This description of attitudes and beliefs seems compatible with other research from within the social science field that explores affective and cognitive components of students' beliefs or attitudes regarding a school subject (Green, 1993; Edwards, 1990; Millar & Millar, 1990).

Applying McLeod's terminology to statistics education, we focus on beliefs and attitudes, rather than on emotions, which are transient and hard to measure but important in that they can be intense and serve as a source for development of attitudes.

Beliefs that would be important to consider by those involved in statistics education may include, but are not limited to:

- Beliefs about mathematics (e.g., is it hard/easy, requires innate skills, it can be mastered by anyone),
- Beliefs about the extent to which statistics is part of mathematics, or requires mathematical skills (e.g., statistics is all computations)
- Beliefs about what should happen or transpire in a statistics classroom, or expectations as to the culture of a statistics classroom (e.g., a lot of drill and practice with textbook problems, a lot of talking about real-world examples)
- Beliefs about oneself as a learner of statistics or mathematics (e.g., I am good at it, I don't have what it takes)
- Beliefs about the usefulness or value of statistics and its importance in one's future life or career (e.g., I will never use it and don't really need to know it)

Together, students' web of beliefs along these interrelated facets provides a context for their approach towards and interpretation of classroom experiences in statistics (and mathematics). Beliefs take time to develop and cultural factors play an important part in their development. They are stable and quite resistant to change, with a larger cognitive component and less emotional intensity than attitudes.

Attitudes towards statistics represent a summation of emotions and feelings experienced over time in the context of learning mathematics or statistics. They are quite stable with moderate intensity, and have a smaller cognitive component than beliefs. Attitudes are expressed along a

positive-negative continuum (like-dislike, pleasant-unpleasant), and may represent, for example, feelings towards a textbook, a teacher, a topic, a project or activity, the school, etc.

While the discussion above helps to distinguish between beliefs about and attitudes towards statistics and its learning, these conceptual clusters are clearly related. As McLeod (1992) argues, attitudes influence and are influenced by one's own beliefs. Therefore, below we unite the discussion of beliefs and attitudes, but address them separately where necessary. We use the inclusive phrases "attitudes and beliefs regarding statistics" with the understanding that there may be several targets to attitudes or facets of beliefs, as described above, and that students' beliefs and attitudes may differ for each target or facet in this regard.

SOURCES OF STUDENTS' ATTITUDES

Many of the existing research studies identify and measure attitudes toward or beliefs about statistics in students who have just enrolled in an introductory college level statistics course. What could be the sources for students' attitudes, if this is their first encounter with the discipline? Three sources for attitudes and beliefs are examined below.

First, students may have had previous experience with statistics in school-related contexts. This experience could have occurred through reading or doing research that uses statistics. Some students may have completed some statistics education before college; we expect the number to increase as the NCTM Standards (1989) are increasingly implemented in K-12. In addition, many students drop out of college level introductory statistics courses (Del Vecchio, 1994, found a drop rate in undergraduate introductory statistics courses at a major Southwestern U.S. research institution of about one-third); when they re-enroll in the course they bring with them attitudes developed during the previously unsuccessful experience with statistics.

Second, most people have "notions" of what statistics means based on their out-of-school lives. One project examined this issue using high school seniors who had not studied statistics in school (Gal & Ginsburg, 1994). A group of twelfth graders from a prestigious private school in the Philadelphia area, all of whom were college bound and in the process of applying to high-level universities or colleges, were asked, "What do people study when they take a statistics course? What comes to your mind when you hear the term statistics?" The following quotes illustrate the range of responses obtained:

> "When I hear the term statistics, I usually think of basketball statistics (% of shooting, number of rebounds, etc.) or survey statistics (as in 40% of teenagers hate peanut butter)."

> "I'm not exactly sure what people study when they take a statistics course, but I think it's along the lines of percentage and graphing, etc."

> "Numbers and figures of surveys come into my head. I think of people having a boring life if they make a profession of it, because I know it's a lot more complicated than what I said."

> "Although I have never taken a statistics course, I hear they are very difficult. Being a huge sports fan, when I think of statistics I think of how many goals or touchdowns someone has."

> "I imagine a statistics course as boring and factual as math. Statistics are gathered data (1000 people live in PA), information good for newspapers, writers, and lawyers."

> "Statistics is when someone takes the scores of many things, such as baseball statistics. Math is used a great deal in finding statistics."

Some of these statements contain elements that reasonably portray part of what actually happens in statistics classes and when people use statistics, but in others the information is tenuous or incorrect. Since almost all of the items on most attitude surveys include the word "statistics," it is important to realize that some high school or would-be college students convey some fuzziness regarding what the term "statistics" might be about or about life domains where statistics may be used. How this "fuzziness" affects the validity or usefulness of surveys of precollege students is thus a matter for some concern.

The third possible source is that students believe statistics is mathematics and so their attitudes toward mathematics are merely transferred to statistics. Several of the high school students' quotes, as well as the college students' quotes presented at the beginning of this chapter, support the strong presence of mathematics issues in statistics attitudes.

Schau (see Schau, Dauphinee, & Del Vecchio, 1992) asked students in graduate-level statistics classes to briefly describe their feelings regarding mathematics and statistics and regarding courses in these disciplines, including why they thought they had these feelings. Two general themes emerged: teacher (and class) characteristics, and achievement. At the beginning of the classes, students almost unanimously attributed positive feelings to satisfying past achievement, usually in mathematics. For example, students wrote:

> "At elementary school I excelled in arithmetic and this gave me the confidence to tackle areas of mathematics that were more challenging."

> "For some reason math was easy to me as I was growing up."

However, students attributed negative attitudes at the beginning of classes to poor teaching coupled with poor mathematics self-concept and achievement. For example, students wrote:

> "I had a couple of [mathematics] teachers that were sarcastic and I would feel stupid and helpless."

> "In algebra, I found the teacher impossible to understand and eventually gave up."

> "I had the same instructor for Algebra I and II and geometry. His methods of teaching included public humiliation if one did not understand the material."

The above informal findings suggest that those planning assessment of students' attitudes in statistics should discriminate aspects of attitudes towards statistics from attitudes towards mathematics. Also, assessments should seek to understand not only the range of attitudes and beliefs, but also their sources, as the same reported attitude may have different bases.

BASIC METHODS FOR ASSESSING ATTITUDES

A literature review of published literature and conference proceedings generated descriptions of nine instruments whose authors claim measure attitudes toward statistics; all use statements for which respondents mark their agreement or disagreement on 5-point or 7-point Likert-type scales. The most commonly mentioned and used include:

Statistics Attitude Survey (Roberts & Saxe, 1982),
Statistical Anxiety Rating Scale (Cruise, Cash, & Bolton, 1985),
Attitudes Toward Statistics (Wise, 1985),
Survey of Attitudes Toward Statistics (Schau, Stevens, Dauphinee, & Del Vecchio, 1995; Dauphinee, Schau & Stevens, 1997).

These four key instruments yield in between one and six scores on subscales that are supposed to represent distinct aspects of statistics attitudes. Dauphinee (1993) provided a thorough description and evaluation of many of these surveys. Two of them, the ATS and the SATS, are briefly described below.

A widely used survey is Steven Wise's (1985) Attitudes Toward Statistics scale (ATS). Wise developed the ATS to correct limitations he found in Roberts' Statistics Attitude Scale (see also Roberts and Reese, 1987), the only attitude survey existing at that time. The ATS uses 29 items to measure attitudes in two areas. The *field* scale (20 items) aims to measure a student's beliefs about the value of learning statistics and the use of statistics in his or her chosen field of study. The *course* scale (9 items) aims to measure affect associated with learning statistics and attitudes toward the course in which a student is enrolled. Example items (one positively and one negatively worded) include:

Field

Statistics is a worthwhile part of my professional training.
Studying statistics is a waste of time.

Course

I would like to continue my statistical training in an advanced course. (this item is the only positively worded one in this scale)
The thought of being enrolled in a statistics course makes me nervous.

After reviewing the existing statistics attitude surveys and considering post-secondary research and instructional assessment needs, Schau et al. (1995) determined that a good survey should exhibit seven important characteristics. It needs to include scales (and items) that (1) measure key aspects of statistics attitudes, (2) are based at least partly on input from introductory statistics students, since they will complete the survey. The survey should be (3) applicable in most post-secondary introductory statistics courses, (4) work both at the beginning of and throughout a course with only tense changes, and (5) be short and so minimally disruptive when administered in class. Scales should include items that (6) measure both positive and negative attitudes. Finally, (7) the number of scales and the items that constitute them should be supported when confirmatory statistical techniques, such as confirmatory factor analysis, are applied to students' responses.

Accordingly, Schau et al. (1995) developed the Survey of Attitudes Toward Statistics (SATS), which consists of 28 seven-point Likert-type items measuring four aspects of post-secondary students' statistics attitudes. The SATS has two forms, a “pre” form for students who have not yet taken a college statistics course, and a “post” form, for administration during or after a course. The items on both forms are identical except for some wording changes related to the timing of assessment. The availability of two forms enables comparison of attitude and belief patterns at different points in time in the learning process. Appendix A includes all items of the “post” version and scoring instructions.

Below are descriptions of the SATS scales, with examples of items, one positively and the other negatively worded, from the “pre” form. (A comparison to the “post” items listed in Appendix A will show the wording differences required due to timing of the assessment.)

Affect (6 items measuring positive and negative feelings concerning statistics):

I will like statistics. (item 1)
I am scared by statistics. (item 21)

Cognitive Competence (6 items measuring attitudes about intellectual knowledge and skills when applied to statistics):

I can learn statistics. (item 23)
I will have no idea of what's going on in statistics. (item 9)

Value (9 items measuring attitudes about the usefulness, relevance, and worth of statistics in personal and professional life:

I use statistics in my everyday life. (item 12)
I will have no application for statistics in my profession. (item 19)

Difficulty (7 items measuring attitudes about the difficulty of statistics as a subject):

Statistics formulas are easy to understand. (item 4)
Statistics is highly technical. (item 26)

Scores on these scales vary in their interrelationships. Scores on *affect* and *cognitive competence* are strongly related to each other. Scores on the *value* and *difficulty* scales are moderately related to those on the *affect* and *cognitive competence* scales but are not related to each other. The internal consistency of each of the scales is at least adequate, ranging from above .6 to above .8. Because statistics students and instructors identified these four aspects of statistics attitudes, and because a confirmatory analysis likewise identified 4 factors, Schau and her colleagues (Schau et al., 1995; Dauphinee et at., in press) believe that the SATS measures four important aspects of attitudes toward statistics.

In addition to the instruments described above, Green (1993) developed a paper-and-pencil modified semantic differential assessment of students' attitudes toward statistics. Some researchers (e.g., Pretorius & Norman, 1992) simply revised existing mathematics attitude

surveys by changing the word “mathematics” to “statistics” throughout all items, yielding an instrument that does not necessarily capture unique aspects of statistics.

Other measures of attitudes and beliefs related to statistics were developed as part of research and development projects, mainly those funded by the National Science Foundation. One example is a 25-item, Likert-type instrument developed in 1990 as part of the Statistical Reasoning in the Classroom Project at the University of Pennsylvania (Gal, 1993) for use with high school students and with adults at large. It was later modified for use in evaluating the ChancePlus Curriculum (Konold, 1990). Garfield (1996) used a modified 10-item version in course evaluations for the CHANCE project. This abbreviated form, dubbed SCAS (STARC-CHANCE Abbreviated Scale) and attached in Appendix B, illustrates an omnibus approach to assessment in a classroom context, where testing time is very limited. The form uses single items to enable some coverage of each of several issues related to outcomes of statistics instruction. The use of single items instead of longer scales reduces the reliability of assessment. Yet, it enables detection of students with extreme scores and identification of broad changes in students’ response patterns, thus being of some value for both teaching and evaluation purposes.

EXTENDING ASSESSMENTS OF ATTITUDES AND BELIEFS

It was earlier argued that statistics educators would need instruments for at least two key tasks: to perform initial assessment of students' attitudes, and to monitor changes in these attitudes during and after statistical education experiences. In addition, attitudinal measures may be used as part of summative assessment of the effectiveness of a statistical education experience. In all cases, the assessment results should inform preventive or remedial interventions or at least provide increased instructor and student awareness of attitudes.

It appears possible to use existing instruments such as the ATS or SATS in a limited fashion to meet these assessment goals at the college level. When used with secondary or younger students, response possibilities can be collapsed to three possibilities (such as NO, DON'T KNOW, and YES) or represented with a continuum of faces showing sad expressions for Disagree, neutral faces for Neither Agree nor Disagree, and happy faces for Agree (see Begg, this volume). A problem may exist, though, if students are unfamiliar with or have undeveloped notions of the meaning of the term statistics.

Instructors can examine class averages, distributions, or score profiles to determine the status of students' attitudes. If a class scores around or above neutral (e.g., a mean score of 4 on a 7-point scale) on each scale, for instance, the instructor knows that the class as a group does not have an attitude problem. If, however, the class falls much below neutral, the instructor may need to devote more class time to dealing with the negative attitudes. Determining what “much below neutral” means is an instructor-based decision. The scores can be used in a similar way to identify individual students who may have negative attitudes that may interfere with their learning.

However, instruments such as the ATS or SATS have not been designed to provide information about causal factors and about the sources of the attitudes and beliefs expressed by individual students. This information is essential to determine types of support or educational experiences that might be useful for ameliorating students’ negative attitudes. Several approaches can be used to obtain the “why” information. Educators can conduct interviews, lead focus group

discussions, utilize think-aloud protocols as individuals or groups of students solve problems, or ask students to write journals or histories of their present or past mathematical experiences. Such techniques have been proposed and implemented in the mathematics education field (see, e.g., Tobias, 1993). However, while potentially very informative, they may be impractical in large-class situations or where resources are limited.

To elicit more information about causal factors, instruments such as the ATS or SATS can be extended by adding *open-ended* questions that enable students to describe the intensity and frequency of specific emotional responses (most items normally indicate the existence of a certain attitude, but not how often or how strongly), explain what past experiences underlie their responses, and reflect or elaborate on the causes of their mathematics attitudes, their statistics attitudes, or both. Several methods for extending the basic Likert-type item format are illustrated below.

One approach is to administer a standard attitude survey such as the SATS, ATS, or SCAS, and then ask students to answer in an open-ended fashion the following questions regarding selected items:

Why did you respond as you did?
What aspect(s), if any, of statistics (or mathematics) make you feel this way?
What experiences form the basis for your response?

A related approach is to mark "attitude words" or "belief phrases" in certain items (the examples below use SATS items, one negatively- and one positively-worded), and ask students questions such as the above, with focus on the marked (underlined) parts:

Affect: I am scared by statistics; I will like statistics.

Cognitive Competence: I can learn statistics; I will have no idea of what's going on in statistics.

Value: I use statistics in my everyday life. Statistics is irrelevant in my life.

Difficulty: Statistics is highly technical; Statistics formulas are easy to understand.

Further, it is possible to create open-ended or guided-choice sentence-completion items, possibly based on Likert-type items from existing instruments, and ask students to complete them as well as explain their answers. Items might include (see Gal & Ginsburg, 1994, for more examples):

I think statistics is ... (e.g., useful, interesting, boring, frightening) ...because ...
I think statistics is about... (what topics? What skills?)
I expect that for me, personally, statistics may be later useful for... (write "not at all" if you so feel)
When I think about this course, I'm concerned that ...(write "not at all" if you so feel)

Instructors could also create Likert-type or open-ended items addressing statistical issues based on beliefs identified by Schoenfeld (1992) as typical regarding the nature of mathematics and mathematical activities. For example:

Mathematics (statistics) problems have one and only one right answer.

There is only one correct way to solve any mathematics (statistics) problem - usually the rule the teacher has demonstrated to the class.

Ordinary students cannot expect to understand mathematics (statistics); they should just memorize and apply what they have learned mechanically and without understanding.

Students who have understood the mathematics (statistics) they have studied will be able to solve (address) any assigned problem in five minutes or less.

Other than the commonly-held belief that statistics is heavily mathematical and that statistics is a somewhat difficult discipline, students' beliefs about statistics as a domain remain mostly unexplored. It would be interesting to determine if student beliefs about statistics parallel their beliefs about mathematics. It would also be instructive to examine the profile of scores across attitude scales for each student. Green (1993), for example, suggested that differential profile patterns may affect related behaviors and may be correlated with ease of attitude change.

Finally, completely open-ended questions could be used as part of an initial assessment, in addition to any of the item types presented earlier, to elicit students' responses about broader topics. For example:

Describe any concerns you may have about your educational experience involving statistics.

Describe the extent to which your prior academic background may assist or impede your learning of statistics.

What factors may cause your performance to be poor or good?

How do you feel about learning mathematics or math-related topics in general?

Responses to open-ended questions could be examined informally, or content-analyzed to yield qualitatively distinct response categories and computed percentages of frequent response types. This could be done by the instructor, or turned over to students to form the basis for classroom projects involving data analysis.

IMPLICATIONS

The process, outcome, and access considerations discussed at the beginning of this chapter suggest that statistics teachers should use assessments of attitudes to understand students' presuppositions and, with continuous monitoring, to identify areas of frustration for individual learners, guiding the provision of supportive interventions.

Only a small number of studies (less than 50) and a few instruments (about 10) have been published on the nature and correlates of statistics attitudes, and many of these studies are small-scale or limited. In comparison, a recent review by Helgeson (1993) noted that more than 700 studies have been published on students' attitudes towards science and that more than 50 different instruments have been developed over the years. Reviews of research on students' attitudes, even in established fields such as science education (Helgeson, 1993) or mathematics education (McLeod, 1992) repeatedly point to two problems in the research in those fields: lack

of theory-based work, including both construct issues with attitudes and lack of models to guide research, and narrow use of restricted research methods, including a heavy reliance on survey-type measures.

Existing instruments for measuring statistics attitudes are still in an experimental stage and may suffer from the same limitations as those noted in other fields. Yet, we believe that educators cannot ignore the possibility that attitudes, achievement, and persistence influence each other in statistics education in ways similar to those found in mathematics and in other areas. Existing research on attitudes in statistics education points to a small to moderate relationship between attitudes (measured by the ATS scale) and achievement in statistics at the post-secondary level (see Green, 1994; Waters, Martelli, Zakrajsek, & Popovich, 1988; Wise, 1985; Woehlke, 1991). Schau et al. (1992) reported similar relationships between course grade and pre-and post-course attitude scores on *affect*, *cognitive competence*, and *value* scales of the SATS. Del Vecchio (1994) showed a relationship between the *cognitive competence* scale of the SATS and persistence: students who reported more confidence in their abilities to do statistics were more likely to complete their course with a passing grade.

We expect attitude and belief issues in statistics to become increasingly important as more students at all educational levels experience statistical education. For K-12, the NCTM *Standards* (1989) recommend the inclusion of projects and novel problems that take extended time commitments and that may have multiple correct answers. As McLeod (1992) and others (e.g., Meece, Wigfield, and Eccles, 1990) have suggested, these kinds of learning situations are more likely to cause affective responses than the traditional restricted problems types that many students have learned to expect.

With the above in mind, three challenges face the statistics education community regarding the domains of statistics attitudes and beliefs. First, the existing measures of attitudes in statistics are only partially suited to assess all the variables of interest. This chapter has presented various methods to extend existing instruments, based mostly on elicitation of information through open-ended items. The development of assessment instruments capable of providing information relevant for instructional purposes at both the college and precollege levels involves many challenges, both conceptual and methodological. Continued efforts to improve and systematize alternative item formats and examine their reliability and validity are needed to improve the quality and conceptual coverage of the measures currently available.

Second, there is almost no research on the nature of statistics attitudes and beliefs, on their relationship with achievement and persistence, and on attitude patterns in different types of learners (e.g., group differences among males and females or minority and non-minority students). Most designs used by researchers studying attitudes towards statistics show little sophistication, and statistical analyses and presentation of results are often ill-suited to the research questions asked. Research based on longitudinal and other appropriate designs, and employing relevant measures, is needed if we want to better understand how attitudes and beliefs about statistics develop and change throughout encounters with statistics instruction. Such research is needed if we want to develop causal models and be able to plan and test the efficacy of corrective interventions.

Lastly, in order to make the learning of statistics less frustrating, less fearful, and more effective, especially among college students but also at earlier stages, further attention by statistics educators should be focused on the attitudes and beliefs students bring into statistics education experiences, how they develop and change during their educational experiences, and the impact they have on students' achievement, persistence, and eventual application of their new

knowledge and skills. This chapter has presented several approaches, both formal and informal, that educators at all levels can use to monitor where their students stand on several facets of beliefs and attitudes towards statistics, its learning, and its use. The use of such methods is paramount if we want to achieve the vision of statistical literacy for all.

Appendix A

This appendix includes the "post" version of the SATS questionnaire, intended for assessing students' attitudes and beliefs towards statistics during or after a statistics class. A "pre" version also exists, for administration before the onset of instruction. The "pre" version includes the same items as the "post" version, with minor wording changes where necessary. It is not reproduced here due to space limits, but sample items are listed later to illustrate the wording changes. Interested readers can contact Candace Schau at the address below, for more information or for the full forms of both versions of the SATS.

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Survey of Attitudes Toward Statistics (SATS) Post version

DIRECTIONS: The questions below are designed to identify your attitudes about statistics. The item scale has 7 possible responses, ranging from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). Please read each question. From the 7 point scale, carefully mark the one response that most clearly represents your agreement with that statement. Use the entire 7 point scale to indicate your degree of agreement or disagreement with our items. Try not to think too deeply about each response. Record your answer and move quickly to the next item.

(Note to the reader: Each of the 28 items below should be followed by a 7-point response scale as described above).

1. I like statistics.
2. I feel insecure when I have to do statistics problems.
3. I have trouble understanding statistics because of how I think.
4. Statistics formulas are easy to understand.
5. Statistics is worthless.
6. Statistics is a complicated subject.
7. Statistics should be a required part of my professional training.
8. Statistical skills will make me more employable.
9. I have no idea of what's going on in statistics.
10. Statistics is not useful to the typical professional.
11. I get frustrated going over statistics tests in class.
12. Statistical thinking is not applicable in my life outside my job.
13. I use statistics in my everyday life.
14. I am under stress during statistics class.
15. I enjoy taking statistics courses.
16. Statistics conclusions are rarely presented in everyday life.
17. Statistics is a subject quickly learned by most people.
18. Learning statistics requires a great deal of discipline.
19. I will have no application for statistics in my profession.
20. I make a lot of math errors in statistics.

21. I am scared by statistics.
22. Statistics involves massive computations.
23. I can learn statistics.
24. I understand statistics equations.
25. Statistics is irrelevant in my life.
26. Statistics is highly technical.
27. I find it difficult to understand statistics concepts.
28. Most people have to learn a new way of thinking to do statistics.

Scoring: Subscale scores are formed by summing the items listed below for each subscale. The scoring for the starred (*) items should be reversed (1 becomes 7, 2 becomes 6, etc.). Higher total scale scores will then correspond to more positive attitudes.

Affect:
1 2* 11* 14* 15 21*

Cognitive Competence:
3* 9* 20* 23 24 27*

Value:
5* 7 8 10* 12* 13 16* 19* 25*

Difficulty:
4 6* 17 18* 22* 26* 28*

Extensions: Depending on the reason for using the SATS, i.e., for instructional or research purposes, additional information can be collected. It may include the respondent's age, ethnicity, degree type, degree status, number of years of high school mathematics taken, number of college mathematics and/or statistics courses completed, computer background, etc. Examples for other attitude related items (note label changes in the scales) that can be used for research purposes in addition to the 28 SATS items include:

How confident are you that you can master introductory statistics material? (A 7-point scale from "Not at all confident" to "Very confident")

How well did you do in your high school mathematics courses? (A 7-point scale from "Very poorly" to "Very well")

How good at mathematics are you? (A 7-point scale from "Very Poor" to "Very Good")

How much experience with statistics (e.g., courses, research studies) did you have before taking this course? (A 7-point scale from "None" to "Great deal")

In the field in which you hope to be employed when you finish school [college], how much will you use statistics? (A 7-point scale from "Not at all" to "Great deal")

Appendix B

SCAS Instrument

The ten items below have been used as part of evaluations of college-level statistics courses. These items do not comprise a scale, i.e., each item is looked at separately. This instrument demonstrates how attitude and belief items can become part of a simple tool for assessing attitudes and beliefs as well for collecting a student's self-appraisal of his or her understanding of statistical issues. Items 5 and 6 directly assess attitudes and beliefs of the kind addressed by the SATS (see Appendix A). However, responses to several other items may also be influenced by students' beliefs.

	1	2	3	4	5
Scale:	Strongly Disagree	Disagree	Neither Agree, nor Disagree	Agree	Strongly Agree

1. I often use statistical information in forming my opinions or making decisions.
2. To be an intelligent consumer, it is necessary to know something about statistics.
3. Because it is easy to lie with statistics, I don't trust them at all.
4. Understanding probability and statistics is becoming increasingly important in our society, and may become as essential as being able to add and subtract.
5. Given the chance, I would like to learn more about probability and statistics.
6. You must be good at mathematics to understand basic statistical concepts.
7. When buying a new car, asking a few friends about problems they have had with their cars is preferable to consulting an owner satisfaction survey in a consumer magazine.
8. Statements about probability (such as what the odds are of winning a lottery) seem very clear to me.
9. I can understand almost all of the statistical terms that I encounter in newspapers or on television.
10. I could easily explain how an opinion poll works.

PART II: ASSESSING CONCEPTUAL UNDERSTANDING OF STATISTICAL IDEAS