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PREDICTING STUDENT PERFORMANCE IN A STATISTICS COURSE USING THE MATHEMATICS AND STATISTICS PERCEPTION SCALE (MPSP)

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ABSTRACT

Students tend to have higher apprehension for a statistics class than for other psychology classes. Because anxiety can impair the performance in a class, and ultimately the mastery of the subject matter, the Mathematics and Statistic Perception Scale (MSPS) was designed to assess students' perceptions of anxiety and attitudes toward statistics as well as provide a tool that could be used in classroom settings. The 22-item scale with three subscales (mathematics perceptions, statistics perceptions, and perceptions of relevance) was administered to 154 undergraduates and showed that over the course of a semester, perceptions of mathematics anxiety tended to decrease and perceptions of relevance tended to increase, whereas negative perceptions of statistics remained unchanged. Pre-test scores were predictive of final course grades. Programmatic assessment using the scale is discussed.

† † †

Students tend to have preconceived ideas and anxieties about statistics classes that can either help or hinder their performance in a statistics course. Negative attitudes can be disadvantageous to the learning of statistics whereas positive attitudes can be beneficial (Baloglu 2003, Gal and Ginsburg 1994, Waters et al. 1988, Wise 1985). For example, Ashcraft and Kirk (2001) examined how negative attitudes and/or anxiety for mathematics can affect a student's performance and mastery of the field. The researchers found that students with high mathematics anxiety had decreased working memory capacity. Due to this limited working memory, students were impaired in their problem-solving skills. This inability to solve mathematics problems may lead students to avoid mathematics classes at all costs. The more students avoid a dreaded topic, the more they miss the practice necessary to achieve mastery in it. It is therefore important to examine students' prior attitudes and/or anxieties toward subject areas that might be conducive to higher avoidance by students. The purpose of the present study was (a) to develop a brief scale that would measure undergraduate students' perceptions of anxiety toward statistics, (b) to identify which students may be at risk of failing a statistics class because of their perceived higher anxiety for the subject area, and (c) whether the implementation of innovative instructional methods has a positive impact on reducing initial anxiety levels. The scale was designed to include important factors that may influence perceptions of anxiety and performance in a statistics class such as perceptions of mathematics anxiety, affect toward statistics, and the relevance of statistics to a future profession. A further aim of the project was to ensure this scale could be utilized by classroom instructors to improve teaching and student learning within a course.

Statistics anxiety occurs as a result of exposure to statistics in any form (Onwuegbuzie et al. 1997). Onwuegbuzie et al. (2000) reported that between 75% and 80% of graduate students tend to develop uncomfortable levels of statistics anxiety. As a result, students fear failing the course and delay enrolling in statistics courses. The lack of self-efficacy and higher anxiety in statistics may keep students away from pursuing research opportunities or certain academic careers. This anxiety is not necessarily due to a lack of training or insufficient skills, but may be due to the misperception about statistics and its relevance, as well as negative experiences in a statistical class (Pan and Tang 2004). Evaluating the anxiety level of students in statistics courses allows for course-specific assessment and modification. Onwuegbuzie and Leech (2003) articulated a model for teaching and learning statistics that incorporates teaching context, pedagogical style, course content, and student learning. At the heart of this paradigm is the teaching context that is impacted by the presence and level of student anxiety. An instructor teaching a class of highly anxious students can optimize learning and performance by adjusting his/her pedagogical style. A brief assessment at the beginning of the semester allows the instructor to directly address student anxiety and create opportunities to provide sensitive contexts and appropriate curriculum adjustments for anxious students.

Several scales measuring attitudes toward statistics have been developed. The majority of the studies have focused primarily on measurement of and factors contributing to statistics anxiety. For example, Roberts and Bilderback (1980) developed the Statistics Attitude Survey (SAS) and Wise (1985) developed and validated the Attitude Toward Statistics (ATS) scale. The ATS scale was developed to offset problems found with the SAS. Wise (1985) noted that a large portion of the SAS was not measuring attitudes toward statistics, but rather it was measuring achievement. The ATS consists of two subscales: attitudes toward a statistics course and attitudes toward the use of statistics in the students' field of study. Factor analyses confirmed that these two subscales measured also separate stable factors (Waters et al. 1988, Wise 1985). A third scale, the Survey of Attitudes Toward Statistics (SATS) was developed by Schau et al. (1995). A confirmatory factor analysis on the SATS identified four distinct factors of students' attitudes toward statistics: (a) affect (feelings concerning statistics), (b) cognitive competence (attitudes toward intellect and skills applied to statistics), (c) value (attitudes toward the usefulness and relevance of statistics), and (d) difficulty (attitudes toward the difficulty of the subject matter). Because the SATS was developed relatively recently, few studies have investigated its validity. However, Schau et al. (1995) found that the SATS has concurrent validity in that it is highly correlated with the ATS (Wise 1985). Cruise et al. (1985) later developed the Statistical Anxiety Rating Scale (STARS). The 51-item scale is divided into two parts, one measuring statistics anxiety and one measuring dealings with statistics. Using this scale, Baloglu (2003) found that young students do not experience as much statistics anxiety as older students and that previous mathematics experience significantly affected undergraduate students' levels of statistics anxiety. However, unlike other studies that had found gender differences in statistics anxiety (Onwuegbuzie 1995, Zeidner 1991), with women suffering from higher levels of anxiety than men, this scale did not reveal any gender differences. While such scales have been useful for initial examinations of anxiety for statistics, their length and complexity have made their classroom utility and applicability less possible.

In sum, several scales have attempted to identify components of statistical anxiety. In general, the scales were found to have concurrent validity and to have test-retest reliability. The purpose of the present study was to devise a scale that would be quick to administer and that would assist in identifying students at risk for failing a statistics class due to high apprehension and low self-efficacy. Individuals' belief systems affect the level of effort they invest in tasks. Task success is often attributable to their level of self-efficacy (Bandura 1977, 1986). In other words, students' expectations of success or failure can influence their effort and perseverance for the class and predict their performance level. For example, Onwuegbuzie et al. (2000) found that statistics anxiety arising from poor statistics computation self-concept and students' achievement expectations predicts achievement in a research methods class and in statistics classes (Fitzgerald et al. 1996). In addition, Onwuegbuzie (2003) showed that statistics anxiety and expectations mediate the relationship between statistics achievement and other cognitive variables. Furthermore, Onwuegbuzie et al., (1997) found that students with failure anxiety (i.e., study-related, test, and grade anxiety) tended to be preoccupied with past and future statistics evaluations, and Onwuegbuzie (2000, 2003) showed that statistics anxiety and achievement expectations predicted performance in statistics courses. It is therefore important to identify students' prior perceptions of mathematics and statistics self-concept. Negative attitudes would presumably lower students' confidence, self-efficacy, and expectation and may place them at risk of failing in a statistics class.

Because attitudes and expectations can influence performance in a statistics class (Onwuebuzie 2003), we designed a new survey that was intended to be used not only for basic research but also for outcome assessment for statistics instructors. The present Mathematics and Statistics Perception Scale (MSPS) was intended to examine undergraduate students' perceptions of self-efficacy toward statistics and mathematics and their attitudes toward the application of statistics in real-world settings. MSPS also provides information on multiple dimensions of perceptions and applicability in an efficient format that is easy to administer in either group or individual settings.

In summary, the MSPS was hypothesized to identify students who are at risk of poor performance due to statistical and mathematical apprehension and low self-efficacy. In particular, we predicted that, similar to other scales (e.g., Wise 1985) demonstrating changes in mean anxiety scores over the course of a semester, students' (positive) perception scores would increase. We also hypothesized that the MSPS would measure multiple attitudes in students taking a statistics course.

SCALE DESIGN

Methods

Participants

A total of 107 undergraduate students from two mid-sized universities in the Midwest participated in the initial scale design. The scale was administered to three different groups of undergraduate students attending a psychology class. A total of 27 students participated in the first round of this study (9 men and 18 women) (mean age 21.59, *SD* = 2.91). Ninety-two percent of the first sample was Caucasian and half of the students had not yet taken a statistics class.

Nineteen undergraduate students participated in the administration of the second version of the scale (3 men and 16 women; mean age = 22.74, *SD* = 6.18). Eighty-four percent of the students were Caucasian, ten percent were of African-American decent, and five percent of Asian background. Sixty-eight percent of the students had not previously attended a statistics class.

The third group, who completed the 35-item scale, consisted of 61 undergraduate students (17 men and 44 women; mean age = 22.35, *SD* = 4.34). Eighty percent of the participants in this final sample were Caucasian, seven percent were of African-American background, ten percent were Asian-Americans, and three percent were from India. The majority of the students in this sample were psychology majors and forty percent of the participants had not previously attended a statistics class.

The final sample consisted of 154 undergraduate students (32 men). Eighty percent of the participants were Euro-American, seven percent were of African-American background, ten percent were Asian-Americans, and three percent were Indian-American. The majority of the students in this sample were psychology majors and 83% percent of the participants had not previously attended a statistics class. They completed the 22-item scale.

Materials

The initial 65 item-scale included statements assessing mathematics abilities and anxiety, computer competence, affect toward statistics, and the value of statistics in the real-world. The statements (positive and negative) were anchored using a 6-point Likert-type rating (1 = strongly disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = moderately agree, 6 = strongly agree). No neutral point was included in order to get the respondents to voice an opinion. A high score indicated positive attitudes and a low score negative attitudes. Negatively worded items were later reverse coded.

The second version of the MPSP consisted of 44 items and the third version included 35 items. The final version consists of 22 items. The same anchors were used for all versions. For all rounds of the current study, item-analyses and item-total correlations were obtained. The 22-item scale was administered both at the beginning and at the end of the semester. Performance in the course was measured using final course grades for each participant. All participants gave informed consent and some students were given extra credit for their participation. Completion of the scale took about 15 minutes.

RESULTS

Round 1. The results of the 65-item-scale yielded a reliability coefficient for the entire scale of .928. Based on the corrected item-total correlations, items that were either negative or less than .09 were eliminated (n = 8). The second item-analysis of the remaining 57 items resulted in an α of .940. An additional 6 items that had a corrected item-total correlation of less than .18 were eliminated. A third item-analysis of the remaining 51 items yielded an α of .944. The cut-off criterion for elimination was .3 or less (n = 7). The fourth item-analysis conducted on the final 44 items resulted in an α of .946.

Round 2. The second round of data collection was performed with the revised 44 item scale. The item-analysis resulted in a reliability of .964. Items were selected for deletion if the corrected item-total correlation was less than .40. Using this criterion, nine items were eliminated. The reliability coefficient for the remaining 35 items increased to an α of .971.

Round 3. The third and final round of the study involved administering the 35 item scale to undergraduate participants in two universities. The item-analysis on this final version revealed an α of .946.

Principal components analysis

Principal components analysis (PCA) was conducted on the 35-item Mathematics and Statistics Perception Scale (MSPS) in order to validate how many underlying constructs to interpret and allow for further data reduction. The number of eigenvectors or factors to interpret was determined using the scree test (Cattell 1966). There were seven factors with eigenvalues > 1 in this sample. However, a scree plot graph indicated three factors — mathematics perceptions (MP), statistics perceptions (SP), and relevance (A) — should be retained.

There were several empirical considerations for identifying which items characterize each factor. First, factor loadings for an orthogonal (uncorrelated) three

Table 1. Three factor principal components analysis solution from the Mathematics and Statistics Perception Scale (MSPS).

Variables	Factor 1 Mathematics Perception	Factor 2 Statistics Perception	Factor 3 Relevance	$h^{2\,a}$
Confident in mathematics skills	**.76**	.33	.20	.73
Enjoy hand calculations	**.68**	-.07	.07	.48
Like using mathematical formulas	**.79**	.15	-.01	.65
Like algebra	**.80**	.14	.10	.68
Enjoy working with numbers	**.81**	.31	.20	.79
Like college mathematics classes	**.64**	.33	.17	.55
(RC) Mathematics is least favorite subject	**.67**	.39	.28	.68
Always loved mathematics	**.72**	.49	.06	.77
(RC) Dislike working with numbers	**.72**	.29	.25	.67
Mathematics comes easy	**.73**	.47	.11	.76
Liked high school mathematics classes	**.77**	.30	.08	.69
(RC) Dislike algebra	**.77**	.16	.14	.64
Mathematics is favorite subject	**.66**	.50	.08	.69
(RC) Statistics course makes me nervous	.18	**.81**	.19	.73
(RC) Scared of statistics	.25	**.81**	.16	.75
Expect to do well in statistics course	.34	**.68**	.24	.63
Expect statistics to be relatively easy	.43	**.69**	-.05	.66
Understand why mathematics needed in daily life	.05	.21	**.66**	.48
(RC) Unlikely to use statistics in future	.23	-.01	**.77**	.65
(RC) Statistics unimportant for career	.20	-.15	**.74**	.61
Statistics useful skills in everyday life	.06	.23	**.71**	.56
(RC) Mathematics is useless	.03	.21	**.71**	.54
Cronbach's α	.95	.86	.78	

[a]Communalities (h^2) represent the percent of variance in an item accounted for by the total underlying MSPS construct.

factor solution were examined (see Table 1). Bryant and Yarnold (1995) suggest loading criteria be sensitive to sample size by requiring item loadings being statistically significant for inclusion in a factor. According to this guideline, critical values of .32 or higher for our sample could be classified as part of a factor ($r = .32$, $p < .001$). To further adjust for possible error, we decided to interpret items with factor loadings two times the critical value ($2 \times .32 = .64$) (F. Bryant, personal communication, January 15, 2000). Items that did not load onto any of the three factors were eliminated until all remaining questions loaded onto at least one factor. The remaining 22 items (see Appendix A) all exceeded the .64 critical value. These items all loaded onto only one factor, the variables all correlated at least .66 with an eigenvector, and all of the items also had communalities (h^2) above .48.

As expected, the three factor groupings identified represented students' perceptions about statistics, perceptions about mathematics, and their attitudes toward the application of statistics in real-world settings. A mean summary score was created for each factor in order to use a common 6-point rating scale for each dimension. Cronbach's α coefficients were computed for each of the three factors to assess the internal reliabil-

Table 2. Percentage of participants who had a score of 3 or below (negative perception) for each of the pre- and posttest subscales.

Subscale	Test	Men	Women	Total Participants
Mathematics				
	Pretest	23%	24%	24%
	Posttest	18%	13%	13%
Statistics				
	Pretest	40%	17%	35%
	Posttest	28%	11%	23%
Relevance				
	Pretest	4%	0%	3%
	Posttest	4%	3%	4%

ity of these questions. As presented at the bottom of Table 1, α levels were high for each factor ranging from .78 to .95.

Does student anxiety change over the course of a semester?

Pre-Test Scores. In order to examine potential individual differences, mean summary scores were computed for each of the three sub-scales which ranged from 1 (negative perception) to 6 (positive perception). At the start of the semester mean perception scores were moderate: M = 3.78 for mathematics (SD = 1.12), M = 3.76 for statistics (SD = 1.11), M = 4.75 for relevance (SD = .75). See Table 2 for the percentage of participants who reported scores of 3 or below.

Post-Test Scores. At the end of the semester mean perception scores were still moderate: M = 3.91 for mathematics (SD = 1.04), M = 3.91 for statistics (SD = 1.11), M = 4.56 for relevance (SD = .83) (see Table 2 for percentage scores). The wordings for items 18 and 21 were amended for the post-test to reflect that students had completed the semester (see Appendix A).

In order to examine the change between pre- and post-semester perception scores, a repeated measures analysis of variance with perception sub-variable as within-subjects variable was computed for each subscale. Results indicated that there was a statistical trend for initially negative mathematics perceptions to be reduced over the course of semester, $F(1, 134) = 3.52$, p = .06. Statistics perceptions fell over the course of the semester but not significantly, $F(1, 134) = .70$, $p = ns$. Finally, as expected, participants' perceptions of the relevance of statistics increased over the course of the semester, $F(1, 134) = 7.47$, $p < 01$.

Does prior exposure reduce negative perceptions of statistics?

In order to examine whether individuals differ in their perceptions toward statistics if they have successfully completed a statistics class at a previous time, a multivariate ANOVA with the initial MSPS sub-scale scores as the dependent variable and statistics background (taken vs. not taken) as the independent variable revealed no overall difference in perceptions based on previous experience with statistics, $F(3,146) = .40$, $p = ns$.

Do students with negative perceptions perform worse?

To examine whether students with negative perceptions were more likely to perform worse than those with positive perceptions, Pearson correlations between pretest scores for mathematics, statistics, and relevance perceptions and final grades were performed. There were significant positive correlations between grades and mathematics perceptions ($r(153) = .27$, $p < .001$) and statistics perceptions (r (153) = .28., $p < .001$). The lower the mathematics and statistics perceptions, the lower the students' final grades were. Regression analyses with grade as the criterion and the three pre-test factors as the predictors were also performed. The regression of grades on the pre-test scores was significant, $F(3,138) = 4.61$, $p = .004$.

DISCUSSION

The results of the present study provide initial evidence that the 22-item Mathematics and Statistics Perception Scale (MSPS) is a reliable scale for measuring perceptions toward mathematics and statistics perceptions in undergraduate students. Principal component analysis identified three factors—mathematics perception (MP), statistics perception (SP), and perceptions of relevance (R). In general, students' perception levels were moderate, and they tended to change in a positive way over the course of a semester. Analyses on change scores showed that students' MP tended to increase, SP levels remained stable, while R increased significantly. In other words, there was a trend toward an increase in positive perceptions about mathematics self-efficacy, while perceptions of statistics remained unchanged and the understanding that statistics can be useful to the students' career increased. Interestingly, the findings also showed that prior exposure to statistics did not change students' perceptions.

The findings of the current study indicate that the MSPS can be a useful tool for statistics professors. Similar to previous scales demonstrating that statistical anxiety scores were positively correlated with final statistics course grades (Wise 1985), the MSPS provides statistics instructors with a tool to identify students who may be at risk of performing poorly in the course due to their attitude and perceptions toward statistics. For many students, statistics is one of the most anxiety-inducing courses (Zeidner 1991). The anxiety level can be so great that students come to regard the class as a difficult class. Administering the scale at the beginning of a semester and modifying the course content accordingly could positively impact individuals' performance. As Onwuegbuzie (2003) showed, students' low expectations of statistics ability can lead to underachievement. Students with low attitudes and low self-efficacy could be monitored more closely. Improving their self-perception of their ability to learn statistics may have a direct positive effect on statistics performance.

How to reduce anxiety in learning statistics

Relatively few studies demonstrate how to reduce the anxiety in learning statistics in the social sciences. For example, incorporating humorous cartoon examples has been perceived to be helpful in statistics anxiety reduction (Schacht and Stewart 1990). Smith et al. (1992) suggest that journal writing is an effective tool in reducing levels of anxiety. However, these studies did not find statistically significant decrease in anxiety levels. Others have proposed that instructors could consider administering statistics examinations in an untimed fashion and with supporting material (i.e., review sheet or formulae). Onwuegbuzie (2000) found that students feel less anxious and stressed when they are allowed to use course-related materials and are not under time pressures to finish the exams. Information regarding students' understanding and knowledge of statistics can also be collected using flexible time frames, open-ended formats, and collaborative learning techniques. Students' levels of performance can be improved by providing them with clear scoring criteria for the evaluation task, prior to their attempting the task, by specifying the standards of acceptable performances, and by encouraging students to assess their own performances. "At risk" students could be paired with students with high self-perception to work on solving statistical problems together. Avoiding the use of statistical terminology and complex statistical formulae could also prove helpful. Cherney (2003) found that actively engaging students with technology is also a successful tool to increase students' involvement in a statistics class. For example, she had students create vignettes that would depict the use of statistical tests. Students then presented those case studies in class and subsequently completed a narrated slideshow of their presentation. The completed slideshow was then uploaded on the instructor's website. These clips provided students with real-world applications of statistical analyses that could be viewed at all times and that were presented by fellow students.

Students tend to learn for tests. That is, they will study the material that they believe will be on the exams (Crooks 1988). If tests are designed to measure what students understand rather than what they can regurgitate or calculate, they will be more likely to internalize the information and learn the material. The MSPS is one of multiple tools that can be utilized to assess students' progress toward achieving learning goals. Thus, the context, content, pedagogical style and assessment become an "interactive, iterative, and recursive process" (Onwuegbuzie and Leech 2003, p. 124) in each statistical class. Assessment instruments like the MSPS could thus serve as a means of improving teaching and learning.

Future studies should consider collecting post-test data to ascertain whether students believe their levels of anxiety have changed. Furthermore, the present sample consisted of predominantly female, European-American undergraduate students. A more representative sample is needed to generalize the results.

Programmatic assessment using the MSPS

In addition to incorporating the MSPS into course context that will impact both pedagogy and curriculum, the MSPS can become a part of a programmatic assessment effort. According to Palomba and Banta (1999), successful assessment strategies should involve multiple components including developing goals and objectives, developing a rationale and plan with contributions from involved parties, selecting methodologies consistent with targeted outcome areas, using results, and assessing the assessment plan. The MSPS can be incorporated into these essential components in multiple ways. First, utilizing the MSPS in statistics and methods courses will provide information from student participants as well as faculty planners. Data from multiple, involved parties will provide useful information about the approach context for core courses. Second, if MSPS results indicate a need for classroom activities geared to decrease negative perceptions, this goal can and should become part of the departmental or discipline targeted outcome area. Using the MSPS at the end of a course will provide post-test data on the targeted outcome area and may contribute to the departmental assessment plan. For example, Palomba and Banta (1999) examined the importance of listening to students' voices and modifying context and pedagogical style accordingly because "...students are often in the best position to evaluate whether what educators are doing is working" (p. 181) to meet their needs. Student-centered contextual information is critical for determining the utility of pedagogical approaches as well as student learning. The MSPS can become a departmental tool to identify the need to include additional resources to address student perceptions regarding the relevance of the course material as well as their perceptions toward the content areas in statistics and mathematics.

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LITERATURE CITED

Ashcraft, M. H., and E. P. Kirk. 2001. The relationship among working memory, mathematics anxiety, and performance. *Journal of Experimental Psychology: General* 130: 224–237.

Baloglu, M. 2003. Individual differences in statistics anxiety among college students. *Personality and Individual Differences* 34: 855–865.

Bandura, A. 1977. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review* 84: 191–215.

———. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, New Jersey, Prentice Hall: 617 pp.

Bryant, F. B., and P. R. Yarnold. 1995. Principal-components analysis and exploratory and confirmatory factor analysis. *In* L. G. Grimm and P. R. Yarnold (eds.), *Reading And Understanding Multivariate Statistics.* Washington DC, American Psychological Association: 69–136.

Cattell, R. B. 1966. The meaning and strategic use of factor analysis. *In* R. B. Cattell (ed.), *Handbook of multivariate experimental psychology*. Chicago, Illinois, Rand McNally: 174–243.

Cherney, I. D. 2003. The use of technology in psychology: Examples from an introductory psychology and statistics class. *In* C. Spirou (ed.) *Technology in Teaching and Learning in Higher Education*. Chicago, National-Louis University Press: 31–35.

Crooks, T. J. 1988. The impact of classroom evaluation practices on students. *Review of Educational Research* 58: 431–481.

Cruise, R. J., R. W. Cash, and D. L. Bolton. 1985. Development and validation of an instrument to measure statistics anxiety. *Proceedings of the Statistical Education Section of the American Statistical Association*: 1985: 92–98.

Fitzgerald, S. M., S. Jurs, and L. M. Hudson. 1996. A model predicting statistics achievement among graduate students. *College Student Journal* 30: 361–366.

Gal, I., and L. Ginsburg. 1994. The role of beliefs and attitudes in learning statistics: toward an assessment framework. *Journal of Statistics Education* 2: 1–54.

Onwuegbuzie, A. J. 1995. Statistics test anxiety and women students. *Psychology of Women Quarterly* 19: 413–418.

———. 2000. Attitudes toward statistics assessments. *Assessment and Evaluation in Higher Education* 25: 321–339.

———. 2003. Modeling statistics achievement among graduate students. *Educational and Psychological Measurement* 63: 1020–1038.

———, D. DaRos, and J. Ryan. 1997. The components of statistics anxiety: a phenomenological study. *Focus on Learning Problems in Mathematics* 19: 11–35.

———, and N. L. Leech. 2003. Assessment in statistics courses: more than a tool for evaluation. *Assessment and Evaluation in Higher Education* 28: 115–127.

———, J. Slate, F. Paterson, M. Watson, and R. Schwartz. 2000. Factors associated with under-achievement in educational research courses. *Research in the Schools* 7: 53–65.

Palomba, C. A., and T. W. Banta. 1999. *Assessment Essentials: Planning, Implementing, and Improving Assessment in Higher Education.* San Francisco, California, Jossey-Bass.

Pan, W., and M. Tang. 2004. Examining the effectiveness of innovative instructional methods on reducing statistics anxiety for graduate students in the social sciences. *Journal of Instructional Psychology* 31: 149–159.

Roberts, D. M., and E. W. Bilderback. 1980. Reliability and validity of a statistical attitude survey. *Educational and Psychological Measurement* 40: 235–238.

Schacht, S., and B. J. Stewart. 1990. What's funny about statistics? A technique for reducing student anxiety. *Teaching Sociology* 18: 52–56.

Schau, C., J. Stevens, T. L. Duaphinee, and A. Del Vecchio. 1995. The development and validation of the survey of attitudes toward statistics. *Educational and Psychological Measurement* 55: 868–875.

Smith, C. H., D. M. Miller, and A. M. Robertson. 1992. Using writing assignments in teaching statistics: An empirical study. *Mathematics and Computer Education* 26: 21–34.

Waters, L. K., T. A. Martelli, T. Zakrajsek, and P. M. Popovich. 1988. Factor analyses of two measures of attitudes toward statistics. *Educational and Psychological Measurement* 48: 1037–1041.

Wise, S. L. 1985. The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement* 45: 401–405.

Zeidner, M. 1991. Statistics and mathematics anxiety in social science students—some interesting parallels. *British Journal of Educational Psychology* 61: 319–328.

APPENDIX A

MATHEMATICS AND STATISTICS PERCEPTION SCALE (MSPS)
CHERNEY, I. D. (2003)

Instructions: For each of the following statements please indicate your agreement or disagreement. You should do this by circling the number that most clearly represents your opinion about that statement using the scale below:

1 = strongly disagree	4 = somewhat agree
2 = moderately disagree	5 = moderately agree
3 = somewhat disagree	6 = strongly agree

1.	*I am confident in my mathematics skills.*	1	2	3	4	5	6
2.	*I enjoy doing hand calculations.*	1	2	3	4	5	6
3.	*I like using mathematical formulas.*	1	2	3	4	5	6
4.	*I understand why we need mathematics in everyday life.*	1	2	3	4	5	6
5.	*I like algebra.*	1	2	3	4	5	6
6.	*Statistics make me nervous.*	1	2	3	4	5	6
7.	*I enjoy working with numbers.*	1	2	3	4	5	6
8.	*I like college mathematics classes.*	1	2	3	4	5	6
9.	*It is unlikely that I will use statistics in my future job*	1	2	3	4	5	6
10.	*Mathematics is my least favorite subject.*	1	2	3	4	5	6
11.	*I have always loved mathematics.*	1	2	3	4	5	6
12.	*I dislike working with numbers*	1	2	3	4	5	6
13.	*Statistics are unimportant for my career*	1	2	3	4	5	6
14.	*Mathematics comes easy to me.*	1	2	3	4	5	6
15.	*I liked high school mathematics classes*	1	2	3	4	5	6
16.	*I am scared of statistics.*	1	2	3	4	5	6
17.	*I dislike algebra.*	1	2	3	4	5	6
18.	*I expect to do well in a statistics course.*	1	2	3	4	5	6
19.	*Statistics is a useful skill in everyday life.*	1	2	3	4	5	6
20.	*Mathematics is useless.*	1	2	3	4	5	6
21.	*I expect statistics to be relatively easy.*	1	2	3	4	5	6
22.	*Mathematics is my favorite subject.*	1	2	3	4	5	6