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AUTHOR Watson, Freda S.; Lang, Thomas R.; Kromrey, Jeffrey D.; Ferron, John M.; Hess, Melinda R.; Hogarty, Kristine Y.

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ABSTRACT

EncStat (Encouraged about Statistics) is a multimedia program being developed to identify and assist students with statistics anxiety or negative attitudes about statistics. This study explored the validity of the assessment instruments included in EncStat with respect to their diagnostic value for statistics anxiety and negative attitudes about statistics and conducted a pilot study of a weekly attitude change tracking instrument. Data from 69 graduate students supported the psychometric integrity of the Survey of Attitudes towards Statistics (SATS; Schau, Stevens, Dauphinee, and Del Vecchio, 1995) and the Statistical Anxiety Rating Scale (STARS; R. Cruise, R. Cash, and D. Bolton, 1985) and their revised, combined version. The Study Skills assessment and the Past Math History assessment developed for the EncStat program were also evaluated and supported. The Statistics Anxiety Weekly Affect Check, which evaluated 23 emotions in 7 areas related to statistics, was analyzed through 998 affect responses over a semester. Exploratory factor analysis identified the factor structure of the scale, and internal consistency estimates were acceptable. Findings also supported the mathematics diagnostic scale developed for use at the beginning of statistics courses. Findings suggest the statistics anxiety surveys targeted for EncStat will support reliable decisions in the program without undue burdens on students. The affect check is attached. (Contains 11 tables and 6 references.) (SLD)

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Freda S. Watson

Thomas R. Lang

Jeffrey D. Kromrey

John M. Ferron

Melinda R. Hess

Kristine Y. Hogarty

University of South Florida

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Paper presented at the annual meeting of the American Educational Research Association, April 21-25, 2003, Chicago, Illinois.

Rationale and Background -

In his introduction to The Assessment Challenge in Statistics Education, Gal (1997) observes, "Statistics has gained recognition as an important component of the precollege mathematics and science curriculum" (p. 1). New instructional materials are being developed, and more attention is being devoted to statistics education, at all levels. However, as Garfield and Ahlgren (1988) note "Extensive research shows that statistics and probability concepts are difficult to teach and often poorly understood" (p. 210.) A major cause of that difficulty is statistics anxiety. Some researchers estimate the percentage of graduate students who are uncomfortably anxious about statistics to be as high as between 66% and 80%. As Onwuegbuzie and Wilson (in press) note:

> Statistics anxiety has been found to be extremely prevalent among women and minorities, and some researchers believe statistics anxiety may, in part, prevent some graduate students . . . from completing their degree programs. Most of the recent increase in research activity concerning statistics anxiety has been directed towards undergraduate students. More investigations are needed, especially with respect to graduate students and interventions. (in press)

Concerning attitudes, Gal, Ginsburg, and Schau (1997) stress that:

> "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. . . 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." (p. 37)

EncStat is a multimedia program designed to identify students with statistics anxiety or negative attitudes toward statistics. Major elements of EncStat include identification of students with statistics anxiety, amelioration of that anxiety using cognitive behavior therapy techniques, and assisting students to achieve more positive attitudes about statistics. Two of the scales most frequently used in measuring statistics anxiety and attitudes, the SATS and the STARS, were deemed appropriate for EncStat. Because student attitude, as well as anxiety, plays a crucial role in statistics achievement and frequency and quality of statistics use by alumni, information provided by both scales was considered essential. In the computerized pilot version of EncStat (the preliminary version was paper/pencil), this information was used to tailor the intervention for each student, an accommodation that would be impossible without

information provided by the SATS and STARS subscales. For example, if the STARS and SATs results show a student highly values statistics but has poor study skills and a previous history of negative experiences with math, the EncStat program for that student would include only brief statements on the worth of statistics but significant detail about improving study habits and overcoming the effects of a negative past history with math. Feinberg and Halperin suggest ". . . individual diagnostic profiles . . .may be useful in establishing prescriptive treatments specifically designed to help students who are likely to experience difficulty in statistics" (p. 11) Because some subscales were believed to tap the same domain, it was decided to combine both instruments, along with a measure of study skills and past math history (the STARS and SATS Pilot) and administer the pilot to a small sample. After deletion of overlapping items, psychometric properties of the subscales would be examined.

It was also believed that information about particular factors, in addition to that provided by responses to Likert type scales, would be helpful in remediating statistics anxiety. Gal and Ginsburg assert, "A key deficiency [in previous research] . . . is that responses to Likert-type scales reveal little about the causes for answers. . . it appears that Likert-type scales have very limited usefulness for identifying what individual students are anxious about, their beliefs about learning statistics that might be counter-productive, and what types of support or educational experiences might be useful for students." (p. 9)

To provide information about attitude change, a revised version of the attitude change monitoring method suggested by Gal and Ginsburg (1994) was used, whereby students mark one of 12 to 15 faces, or alternatively, emotion words, as a rough measure of attitude periodically throughout a class. In this study, students were also requested to give an intensity rating and to add one or two explanatory phrases or sentences. It was posited that this fine-grained detection might have particular pedagogical applicability for instructors of statistics anxious students.

Because literature review consistently referenced the finding that a significant portion of statistics anxiety is caused by the student's perception that statistics is heavily mathematical, it was posited that a short quiz on basic mathematics skills would assist in identifying students with statistics anxiety as well initially explore the connection between actual versus perceived math skill deficits and statistics course achievement.

Purpose

The purpose of this study was to explore the validity of the assessment instruments included in EncStat (Encouraged About Statistics) with respect to their diagnostic value for statistics anxiety and negative attitudes toward statistics (Strand I); to evaluate the potential

and utility of broadening the assessment base for EncStat through conducting a pilot of a weekly attitude change tracking instrument (Strand II) and a mathematics skills diagnostics test (Strand III).

Data Sources and Method

The first data source consisted of survey responses from 69 graduate students enrolled in three sections of statistics courses: one section of Statistical Analysis for Educational Research I (Statistics I) and two sections of Statistical Analysis for Educational Research II (Statistics II). An additional 22 students in a section of Statistical Analysis for Educational Research I (Statistics I) were added the subsequent semester. Subsets of these students constituted the sub-samples depicted in the Data Map (Table 1) and completed the weekly affect check pilot, and the math diagnostic pilot.. Students were attending a Research I urban university in the southeast. The majority were doctoral students, for whom Statistics I and II were required components of their program of study. The students represented a variety of educational disciplines, such as early childhood education, educational leadership, and secondary education. Participation was voluntary, informed consent was obtained, and extra credit points were given to some sections.

Table 1

Data Map

Semester	STARS & SATS – Original	STARS & SATS – Revised	Affect Check	Math Diagnostic
Spring 02, Stats I & II	X			
Fall 02		X	X	X
Stats I			X	
Stats II				
Spring 03		X		X

Strand I: STARS and SATS (Original and Revised) -- Results and Discussion

The original STARS and SATS instruments were combined, along with nine questions regarding study skills and past experiences with mathematics, and results of administration to an initial sample of students were analyzed. The original STARS and SATS instruments were revised, as explicated below, and subsequently administered to another sample of students, In

the remainder of this discussion, "original instrument" refers to the original instruments; "revised" refers to the instrument as revised, subsequent to data analysis, for use in EncStat.

Psychometric Properties of STARS -

Each participant completed the STARS and the SATS as well as five questions each on study skills and past experiences with math. Two forms were used, with order of administration for the STARS and SATS counterbalanced, to control for order effects. When none were found, the STARS was administered first in the revised instrument, so that the demographic questions (on the SATS) could be positioned at the end.

Demographic information on the participants suggests that the average student was just under 40 years of age (M = 39, SD = 9.21, range = 24 to 63 years). The number of graduate credit hours earned at the time of the statistics course ranged from 0 to 84 with a mean of 29.75 and a SD of 21.70. Grade Point Average (GPA) was high, as expected with doctoral courses, with a mean of 3.83 and a SD of 0.23. GPA values ranged from 0 to 4.0. Years of high school mathematics ranged 1 to 6 years (grades 7 –12^{th}) with a mean of 3.40 and a SD of 0.93, and the number of college math or statistics courses (CC) ranged from 0 to 12 with a mean of 3.8 and a SD of 0.93.

The STARS (Cruise, Cash and Bolton, 1985) consists of six subscales. The 51 items in this instrument all use a 5-point response scale. Values range from "No Anxiety" (1) to "Very Much Anxiety" (5) for Part One of the instrument. Part Two also uses a five point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). The STARS was developed to measure statistics anxiety, which the authors define as "feelings of anxiety encountered when taking a statistics course or doing statistical analysis."(Cruise, et al. p.92) A high score on the STARS indicates either a high level of anxiety and/or a negative attitude towards statistics. Cronbach's alpha for this original instrument when administered in combination with the SATS was estimated to be .94. After revision and deletion of 15 items, the revised instrument's 36 items were estimated to have a Cronbach's alpha of .95.

Worth of Statistics (Worth). This subscale is comprised of 16 items that address the student's perceived importance of statistics. Higher scores reflect a lower level of personal importance placed on statistics by the individual. Cronbach's alpha was estimated to be .94. The revised subscale contains six items. Five of the items are unrevised from the original instrument; one was a revised item. Cronbach's alpha for the revised subscale was estimated to be .87.

Interpretation Anxiety (Interp). This set of 11 items was designed to measure anxiety as a result of interpreting or making a decision utilizing statistical data. A high score on this

subscale indicates an inability to effectively use statistical procedures and strategies in the course of daily life. Cronbach's alpha was estimated to be .89. The revised subscale contains ten items, nine of the original items and one revised item. The Cronbach's alpha was estimated to be .90.

Test and Class Anxiety (Tstclss). The eight items comprising this subscale focus on anxiety exhibited as a result of class or test participation. As with the two previous subscales, a high score is synonymous with increased levels of anxiety. Cronbach's alpha was estimated to be .90. The revised subscale also consists of eight items, of which five are unchanged, two are revised, and one is a new item. The Cronbach's alpha was estimated to be .93.

Computational Self-Concept (Compute). This subscale contains seven items focusing on anxiety related to one's perceived knowledge and ability to use statistics and to complete computations of mathematical procedures. Cronbach's alpha was estimated to be .88. A high score reflects a greater level of anxiety related to performing mathematical computations within statistical procedures as opposed to statistics itself. The revised subscale was revised with four items, two of which are revised, and one of which one is new . The Cronbach's alpha was estimated to be .80.

Fear of Asking for Help (Fearhlp). The four items comprising this subscale address anxiety related to asking for help. High scores reflect greater amounts of anxiety perceived by the individual as a result of asking either teachers or fellow students for help in understanding materials of a statistical nature. Cronbach's alpha was estimated to be .83. There were no changes to this subscale, and the Cronbach's alpha remains .83.

Fear of Statistical Teachers (Feartch). This set of five items was developed to address an individual's perception of the statistics teacher. The Cronbach's alpha was estimated to be .64. High scores reflect an individual's perception that the instructor lacks sufficient understanding to relate to the individual's predicament and as a result the instructor should be feared. The revised subscale consists of four items, two of which were revised from the originals and one new item. The Cronbach's alpha was estimated to be .74.

Psychometric Properties of SATS

The SATS was developed by Schau, Stevens, Dauphinee and Del Vecchio (1995) and consists of 4 sub-sections containing a total of 28 items. The items utilize a seven point Likert scale. While a high score on the SATS reflects a positive attitude or view towards statistics in our previous studies, the revised instrument has all positive items reflected in scoring so that a higher score reflects a more negative view or attitude towards statistics. Based on the pilot

results three items were deleted, two new items were added, and six items were revised for a total of 27 items in the current study. The original instrument's Cronbach's alpha was estimated to be .92, in the pilot and .93 in the current study.

Affect (Affect). The original subscale contains six items and its focus is on feelings towards statistics. A low score reflects a positive view of statistics. Cronbach's alpha was estimated to be .88. In this study three items were revised and an item was dropped, for a total of 5, and the alpha decreased to .87.

Cognitive Competence (CogComp). The six items in this subscale evaluate an individual's attitudes and intellectual knowledge relating to statistics. A low score reflects a positive attitude and knowledge level. Cronbach's alpha was estimated to be .83. In the revised instrument, three items were revised and an additional two items were added to this subscale (n=8) and the alpha increased to .86.

Value (Value). The original subscale reflects attitudes regarding the relevance and usefulness of statistics. This subscale contains nine items. Cronbach's alpha was estimated to be .82. Two items were dropped from the original subscale and the corresponding alpha for the resulting seven items was .80.

Difficulty (Diff). The seven items in this subscale address perceived difficulty of statistics materials. Lower scores reflect a more positive attitude towards the field of statistics. Cronbach's alpha was estimated to be .75. There were no changes to this subscale, and again the alpha was estimated to be .75.

Psychometric Properties of Additional Scales

The authors developed two additional scales in an attempt to learn more about participants' study skills and past math history. Both of these instruments use a 5-point Likert response scale.

Study Skills (Study). This subscale consists of 5 items that focus on the individual's study habits. A high score reflects better study habits as reported by the individual. Cronbach's alpha was estimated to be .63. The revised subscale contains eight items. One of the original items was identified as a double-barreled item and was divided into two items and two new items were added to the subscale. The Cronbach's alpha was estimated to be .70.

Past Math History (MathPH). The four items making up this subscale evaluate the individual's perceptions of their past experiences with mathematics. A high score indicates a positive history with the field of mathematics. Cronbach's alpha was estimated to be .86. There

were no changes to this subscale, and the Cronbach's alpha was estimated to be .88 in this analysis.

Relationships Between Scales

Relationships between subscale and total instrument scores for the STARS and SATS were examined first, to investigate the extent of commonality between the instruments. The correlation matrices for the instrument and subscales, original and revised, are presented in Tables 2 and 3 respectively. The large negative correlation (r = -.89) between the two total instrument scores on the original scales is expected because a high score on the SATS reflects a positive attitude towards statistics while a high score on the STARS reflects a negative attitude towards statistics. The correlation (r=.80) between the revised STARS and SATS scales reflects the flipping of positively stated items so both instruments reflect higher scores equating to negative attitudes or higher levels of anxiety. The moderate to large correlations within and between the two instrument's subscales provide evidence of convergent validity. Similarly, the moderate negative correlation (r = -.66), in the original and (r= -.41) in the revised instrument, between MathPH and Compute was expected because a high score on MathPH reflects a positive experience in the past with mathematics and a high score on Compute measures anxiety experienced when working math problems as well as perceived ability to understand and calculate statistics. The moderate correlation between MathPH and Compute supports theoretical expectations.

With the exception of the small correlations and between Study Skills and CogComp (r = .29) and Study Skills and Affect (r = .22), the remainder of the correlations for Study Skills were in essence zero. In the revised instrument there was a small correlation between Study Skills and the STARS (r=.16) the remaining correlations were essentially zero. The subscale Affect in general correlates highly with the STARS subscales, which address feelings related to statistics as opposed to Feartch and Fearhlp which reflect specific components of anxiety related to fear.

Table 2

Correlations Between Instrument Subscales.- Original STARS and SATS

	STARS	SATS	Affect	Cog Comp	Value	Diff	Study	Math PH	Worth	Interp	Tstclss	Compte	Fearhlp	Feartch
(STARS)	1.00													
(SATS)	-0.89	1.00												
(Affect)	-0.82	0.87	1.00											
(CogComp)	-0.77	0.82	0.78	1.00										
(Value)	-0.63	0.77	0.44	0.40	1.00									
(Diff)	-0.68	0.81	0.63	0.56	0.52	1.00								
(Study)	-0.09	0.16	0.22	0.29	-0.02	0.04	1.00							
(MathPH)	-0.51	0.49	0.51	0.59	0.24	0.29	0.09	1.00						
(Worth)	0.90	-0.87	-0.72	-0.67	-0.77	-0.63	-0.09	-0.40	1.00					
(Interp)	0.81	-0.64	-0.67	-0.59	-0.34	-0.52	-0.05	-0.36	0.56	1.00				
(Tstclss)	0.85	-0.75	-0.76	-0.62	-0.46	-0.64	0.06	-0.42	0.66	0.73	1.00			
(Compute)	0.82	-0.77	-0.72	-0.77	-0.49	-0.55	-0.20	-0.66	0.77	0.55	0.63	1.00		
(Fearhlp)	0.61	-0.38	-0.36	-0.42	-0.17	-0.34	-0.05	-0.34	0.36	0.60	0.52	0.40	1.00	
(Feartch)	0.60	-0.58	-0.49	-0.48	-0.46	-0.45	-0.13	-0.21	0.59	0.32	0.40	0.37	0.31	1.00
Mean	2.34	4.24	4.01	4.68	4.99	3.09	3.66	3.92	2.15	2.47	3.25	2.09	2.11	1.94
S D	0.70	1.01	1.57	1.25	1.20	1.04	0.74	1.07	0.88	0.77	1.03	0.99	0.96	0.69

Table 3

Correlations Between Instrument Subscales. – Revised STARS and SATS

	STARS	SATS	Affect	Cog Comp	Value	Diff	Study	Math PH	Worth	Interp	Tstclss	Compte	Fearhlp	Feartch	Math Pretest
(STARS)	1.00														
(SATS)	0.80	1.00													
(Affect)	0.82	0.92	1.00												
(CogComp)	0.79	0.93	0.85	1.00											
(Value)	0.33	0.63	0.50	0.41	1.00										
(Diff)	0.70	0.84	0.74	0.80	0.26	1.00									
(Study)	0.16	-0.00	0.09	0.01	-0.10	-0.01	1.00								
(MathPH)	-0.54	-0.36	-0.37	-0.45	-.05	-0.39	-0.27	1.00							
(Worth)	0.60	0.72	0.64	0.58	0.75	0.49	-0.03	-0.14	1.00						
(Interp)	0.87	0.57	0.64	0.61	0.09	0.53	0.10	-0.49	0.29	1.00					
(Tstclss)	0.90	0.67	0.74	0.69	0.21	0.58	0.28	-0.52	0.37	0.77	1.00				
(Compute)	0.72	0.76	0.69	0.74	0.51	0.59	0.09	-0.41	0.72	0.46	0.53	1.00			
(Fearhlp)	0.74	0.46	0.51	0.48	0.05	0.43	0.19	-0.57	0.25	0.67	0.70	0.39	1.00		
(Feartch)	0.55	0.53	0.44	0.51	0.24	0.59	-0.07	-0.22	0.49	0.32	0.36	0.40	0.21	1.00	
Math Pretest	-0.31	-0.37	-0.40	-0.33	-0.37	-0.17	-0.14	0.16	-0.33	-0.11	-0.34	-0.41	-0.14	-0.14	1.00
Mean	2.48	2.74	2.90	2.79	2.17	3.28	3.50	3.75	2.00	2.37	3.12	2.23	2.17	2.54	9.01
S D	0.65	0.62	0.96	0.79	0.63	0.70	0.70	1.16	0.70	0.74	0.99	0.82	0.85	0.83	1.57

Correlation analysis also provides some evidence of possible areas to explore in an attempt to reduce the number of items. Specifically, correlations between Value and Worth and between CogComp and Compute were both 0.77; it seems likely one of each pair could be eliminated. As a result of these findings the correlation between Value and Worth on the revised instrument was 0.75 and reflects the deletion of 12 items when compared to the original instrument. The correlation between CogComp and Compute was 0.74 with the omission of 5 items from the revised instrument.

Relationships with Demographic Variables

Correlations used to explore the relationship between responses on the instruments, new and revised, and demographic factors, are presented in Tables 4 and 5 . Moderately positive relationships were observed for the subscales Study with age (r = .43) and MathPH with CC of (r = .47). These suggest that as one matures their study habits improve and as students take more courses in statistics and math they have a more positive outlook on past courses.

Finally, correlations between the subscales and students' final grades were used to explore relationships between classroom performance and instrument scores. The correlation matrix for achievement and subscales is presented in Tables 6 and 7. A small negative relationship(r = -.29) was observed between Study Skills and students' Achievement, but correlations with the total instrument scores were essentially zero. The revised instrument also showed a small negative relationship(r= -.25) between Study Skills and students' Achievement. Additionally, small negative correlations were found between Achievement and the STARS(r= -.23) and SATS(r= -.28). These correlations could be interpreted as students with higher grades being less likely to report having poor attitudes or high levels of anxiety towards statistics

In addition to completing the attitude scales, students were asked to predict the grade they would receive in their current statistics course (options were letter grades A through F). Because only three participants selected a grade of C or less, the responses were collapsed into two groups, those expecting an A (57% of the sample) and those expecting less than an A (43% of the participants). To investigate differences between these two groups of students on the SATS, STARS, Study Skills and Path Math History, t –tests were conducted, using a Bonferroni approach to maintain familywise alpha at .05 (i.e., each test was conducted at the alpha value of 0.0125). For the revised instrument the percentage of students reporting an expected a grade of A was 57% and 43% expecting a grade less than an A.

Table 4

Correlations Between Subscales (original STARS and SATS) and Demographic Variables.

	STARS	SATS	Study	MathPH	Expected Grade	Age	Hours	GPA	Years math	College Courses
Statistical Anxiety Rating Scale (STARS)*	1.00									
Survey of Attitudes Toward Statistics (SATS)**	-0.89	1.00								
Study Skill (Study)*	-0.09	0.13	1.00							
Past Math History (MathPH)*	-0.51	0.54	0.09	1.00						
Expected Course Grade (Xgrade)	-0.52	0.45	0.31	0.28	1.00					
Age	0.21	-0.21	0.43	-0.13	-0.08	1.00				
Earned Credit Hours (Hours)	0.19	-0.14	-0.26	-0.06	-0.09	0.04	1.00			
GPA	0.14	-0.16	0.27	-0.07	0.16	0.21	0.14	1.00		
Years of High School Mathematics (Yearsmath)	0.14	0.19	0.16	0.22	-0.01	0.01	0.01	0.06	1.00	
Number of College Math/Stats Courses (CC)	-0.11	0.37	0.18	0.47	0.31	0.04	-0.03	-0.08	0.21	1.00
Mean	2.34	4.16	3.66	3.92	4.53	39.1	29.25	3.83	3.40	3.81
SD	0.70	0.94	0.74	1.07	0.60	9.21	21.70	0.23	0.93	2.64

* Scales with a 5 point Likert Scale
** Scales with a 7 point Likert Scale

Table 5

Correlations Between Subscales (revised STARS and SATS) and Demographic Variables.

	STARS	SATS	Study	MathPH	Expected Grade	Age	Hours	GPA	Years math	College Courses
Statistical Anxiety Rating Scale (STARS)*	1.00									
Survey of Attitudes Toward Statistics (SATS)**	0.80	1.00								
Study Skill (Study)*	0.16	-0.00	1.00							
Past Math History (MathPH)*	-0.54	-0.36	-0.27	1.00						
Expected Course Grade (Xgrade)	-0.39	-0.37	-0.16	0.22	1.00					
Age	-0.03	-0.00	0.39	0.00	-0.16	1.00				
Earned Credit Hours (Hours)	0.14	0.10	0.31	-0.17	-0.15	0.29	1.00			
GPA	-0.08	0.02	0.26	0.00	-0.00	0.06	0.12	1.00		
Years of High School Mathematics (Yearsmath)	-0.49	-0.39	-0.28	0.69	0.48	-0.14	-0.17	0.19	1.00	
Number of College Math/Stats Courses (CC)	-0.26	-0.22	0.03	0.25	-0.09	0.09	-0.08	-0.06	-0.04	1.00
Mean	2.48	2.74	3.50	3.75	4.51	36.84	11.83	3.80	2.99	4.24
SD	0.65	0.62	0.67	1.16	0.61	9.42	15.55	0.50	0.90	7.03

* Scales with a 5 point Likert Scale
** Scales with a 7 point Likert Scale

Table 6

Correlations Between Subscales and Achievement.

	STARS	SATS	Study	MathPH	Final Grade
Statistical Anxiety Rating Scale (STARS)*	1.00				
Survey of Attitudes Toward Statistics (SATS)**	-0.89	1.00			
Study Skill (Study)*	-0.09	0.26	1.00		
Past Math History (MathPH)*	-0.51	0.49	0.09	1.00	
Achievement (Final Grade)	-0.07	0.13	-0.29	0.19	1.00
Mean	2.34	4.24	3.66	3.92	58.44
SD	0.70	1.01	0.74	1.07	33.38

* Scales with a 5 point Likert Scale
** Scales with a 7 point Likert Scale

Table 7

Correlations Between Subscales and Achievement.

	STARS	SATS	Study	MathPH	Final Grade
Statistical Anxiety Rating Scale (STARS)*	1.00				
Survey of Attitudes Toward Statistics (SATS)**	0.80	1.00			
Study Skill (Study)*	0.16	-0.00	1.00		
Past Math History (MathPH)*	-0.54	-0.36	-0.27	1.00	
Achievement (Final Grade)	-0.23	-0.28	-0.25	0.15	1.00
Mean	2.48	2.74	3.50	3.75	83.77
SD	0.65	0.62	0.67	1.16	10.90

* Scales with a 5 point Likert Scale
** Scales with a 7 point Likert Scale

The original results suggested a statistically significant difference between the two groups on the SATS (t(67)= -4.76), p<.01). Participants who anticipated a grade of A had a significantly higher mean score on the SATS than those who anticipated a grade less than A. For the 'A group', $\bar{X}$ =4.67, SD =0.95; for the 'less than A' group, $\bar{X}$ = 3.64, SD=0.78. The 'A' students mean of 4.67 suggest that they reported slightly positive attitude towards statistics and the 'less then A' group reported slightly negative attitudes towards statistics. A mean of 4 on this scale could be interpreted as a neutral value.

Like the original study the results of the revised instrument provided a statistically significant difference between Expected Grade and the SATS (t(86)=4.19), p<.0001. For the A group, $\bar{X}$ =2.53, SD =0.61; for the less than A group, $\bar{X}$ = 3.04, SD=0.50. Even though the less than A group has a higher mean it is important to remember that items were flipped so that a lower value suggests that they reported slightly more positive attitude towards statistics than the 'less than A' group reported.

Similarly, a statistically significant difference was obtained between the two groups on the STARS (t(67)= 5.15), p<.01). This suggests that participants who anticipated a grade of A had a significantly lower mean score on the STARS than those who anticipated a grade less than A. For the A group, $\bar{X}$ =2.02, SD =0.59; for the less than A group, $\bar{X}$ = 2.77, SD=0.61. These scores would suggest that participants who selected the grade of A are reporting low levels of anxiety while those who selected a 'grade less then A' are reporting higher levels of anxiety than the 'A' students.

Again the revised instrument results mirror those of the original study as a statistically significant difference was obtained between the two groups on the STARS (t(86)= 4.33), p<.0001). For the A group, $\bar{X}$ =2.25, SD =0.65; for the less than A group, $\bar{X}$ = 2.81, SD=0.52.

Despite differences between the two groups on STARS and SATS scores, on the original instrument, no statistically significant difference was obtained on Study Skills (t(66)= -2.26), p<.03). For the 'A' group, $\bar{X}$ =3.83, SD =0.77; for the 'less than A' group, $\bar{X}$ = 3.43, SD=0.64. Both groups are reporting above average (3) study skills with the 'A' group having a higher score then the 'less than A' group.

Like the original instrument there were no statistically significant differences found between Study skills and expected grade (t(86)=1.34), p=.1830).). For the 'A' group, $\bar{X}$ =3.42, SD =0.73; for the 'less than A' group, $\bar{X}$ = 3.61, SD=0.57.

Similarly, no differences were obtained on past math history (t(65)= -2.50, p= .015). For the 'A' group, $\bar{X}$ =4.22, SD =0.84; for the 'less than A' group, $\bar{X}$ = 3.62, SD=1.14. The 'A' group

approached the maximum value (5) while the 'less than A' group reported values above neutral and positive.

The revised instrument provided no statistically significant difference between math past history and expected grade (t(86)= -1.98), P=0.0508). For the 'A' group, $\bar{X}$ =3.96, SD =1.17; for the 'less than A' group, $\bar{X}$ = 3.47, SD=1.17.

Gender differences were also investigated using independent-means t-tests. As with the Expected Grade variable, the comparisonwise alpha was set at 0.0125 to keep the experimentwise alpha at 0.05. The sample contained 36% males and 64% females. The sample for the revised instrument was comprised of 27% males and 73% females.

No statistically significant difference between males and females was obtained on the SATS (t(67)= 0.82), p<.41). For Males, $\bar{X}$ =4.37, SD =0.99; for Females, $\bar{X}$ = 4.16, SD=1.03. Similarly, no difference was obtained on the STARS (t(67)= -0.27), p<.79). For Male, $\bar{X}$ =2.31, SD =0.72; for Females, $\bar{X}$ = 2.36, SD=0.70.

Like the original study there were no statistically significant differences obtained between females and males on the SAT (t(82)=0.28, p=.78) for the revised instrument. For females, $\bar{X}$ =2.73,SD=0.64; for males $\bar{X}$ =2.77, SD=0.62. Additionally, no difference was found on the STARS (t(82)=1.05, p=.46). For males $\bar{X}$ =2.59,SD=0.67; for females $\bar{X}$ =2.43, SD=0.63.

Further, the male and female students showed no significant differences on study skills (t(65)= -2.20), p<.03). For Male, $\bar{X}$ =3.44, SD =0.70; for Females, $\bar{X}$ = 3.82, SD=0.67. Finally, no gender differences were obtained on past math history (t(66)= -0.31), p= .76. For Males, $\bar{X}$ =3.86, SD =1.02; for Females, $\bar{X}$ = 3.94, SD=1.11.

Similarly no differences were found on study skills for the revised instrument (t(82)=0.74, p=.46). For males, $\bar{X}$ =3.49, SD=0.67; for females, $\bar{X}$ =3.49, SD=0.68). Additionally no gender differences were found on past math history (t(82)=-0.53, p=0.60). For females, $\bar{X}$ =3.77, SD=1.21; for males, $\bar{X}$ =3.62, SD=1.08.

Differences among racial/ethnic groups were also investigated. This item originally asked participants to select from White, Native, Hispanic, Asian or Other American and Foreign Student. Due to the small numbers in the various minority categories this item was collapsed into three categories: White, Non-White and Foreign Students. These categories had sample sizes of 47, 13, and 9 respectively. One factor ANOVAs were conducted for these 3 groups. For the revised instrument race was collapsed into two categories White(n=63) and Non-White(n=21).

The analysis of the SATS instrument revealed a statistically significant difference between the racial/ethnic group ($F(2,61) = 10.83$; $p < .0001$). Pairwise contrasts with a Bonferroni adjustment were used to determine differences between the groups and keep the familywise alpha at .05. Contrasts showed that white students scored significantly lower on the SATS than either foreign students ($p = .001$) or non-white students ($p = .004$). White $\overline{X} = 3.83$, SD = .78; Non-white $\overline{X} = 4.62$, SD = .64; Foreign student $\overline{X} = 5.07$, SD = 1.16. This suggests that foreign students and non-white students evidence a more positive attitude towards statistics than white students.

The results of the revised instrument found no statistically significant difference between White and Non-white ($F(1,82)=0.16$;$p= .6769$) on the SAT. White $\overline{X} = 2.72$, SD = .60; Non-white $\overline{X} = 2.78$, SD = .73.

The analysis of the STARS instrument revealed no statistically significant difference among the racial/ethnic groups ($F(2,66) = 3.05$; $p=.054$). White $\overline{X} = 2.48$, SD = .67; Non-white $\overline{X} = 2.07$, SD = .63; Foreign $\overline{X} = 2.01$, SD = .78. These values would suggest that the groups reported neutral to slightly positive attitudes towards statistics.

The revised instrument's results produced no statistically significant difference between White and Non-white ($F(1,82)=0.17$;$p= .6769$) on the STARS. White $\overline{X} = 2.46$, SD = .64; Non-white $\overline{X} = 2.52$, SD = .65.

Similarly, no significant differences were obtained between racial/ethnic groups on the self-reported study skills ($F(2,65) = 1.85$; $p=.1659$). The means and standard deviation are as follows: White $\overline{X} = 3.73$, SD = .74; Non-white $\overline{X} = 3.31$, SD = .65; Foreign $\overline{X} = 3.78$, SD = .77. Finally, no significant differences were obtained for past history in mathematics ($F(2,65) = 1.85$, $p= .1652$). White $\overline{X} = 3.76$, SD = 1.08; Non-white $\overline{X} = 4.37$, SD = .58; Foreign $\overline{X} = 4.11$, SD = 1.41.

For the revised instrument, statistically significant differences were found between racial/ethnic groups and self-reported study skills ($F(1,82)=7.28$, $p=0.0085$). White $\overline{X} = 3.63$, SD = .66; Non-white $\overline{X} = 3.19$, SD = .62. These results suggest that White's are reporting better study skills than Non-whites. Significant differences were also reported between Math Past History and race ($F(1,82)=6.73$, $p=.0112$). The means and standard deviations are as follows: White $\overline{X} = 3.54$, SD = 1.24; Non-white $\overline{X} = 4.29$, SD = .70. The data suggests that Non-whites are more likely to report favorable views of prior math courses than Whites.

STARS and SATS (Original and Revised) - Discussion

In general, the data obtained in this investigation support the psychometric integrity of both the STARS and SATS as well as the revised instruments. Both original and revised STARS and SATS instruments evidenced excellent internal consistency reliability both in their total scores and in their subscale scores. Further, the correlations between subscales both within and across instruments support the anticipated multidimensional structure of statistics anxiety and suggest that the instruments sample overlapping domains.

Many relationships with variables external to the two scales are in the theoretically anticipated direction and are of sufficient magnitude to provide initial evidence supporting the validity of scores on these instruments. For example, individuals' perceptions of past math history were found to be inversely related to STARS scores and directly related to SATS scores, students who reported higher levels of statistics anxiety evidenced lower achievement *expectations* (but, interesting, did not evidence lower performance in statistics), and statistics anxiety scores were not appreciably related to either study skills or overall GPA in graduate work.

Demographically, statistics anxiety scores were not related to student gender, but were related to student racial/ethnic classification. Interestingly, white students reported statistically significantly higher levels of anxiety than either non-white or foreign students. Although previous research suggests higher anxiety scores should be anticipated for minority students, such research was based on samples of undergraduate students. Research on statistics anxiety among doctoral students is just beginning and the generalizability of results from undergraduate samples has yet to be determined.

Strand II: Statistics Anxiety Affect Checklist Pilot --Results and Discussion

The Statistics Anxiety Weekly Affect Check was created after review of the literature about statistics anxiety, with careful attention paid to noting the emotions most often described as associated with students' feelings about and attitudes toward statistics. It was deemed appropriate to use the five general emotion families (as identified by Eckman, 1992): happy, angry, sad, fearful, and indifferent. Two other emotion families were added, dumb and confused, to account for other feelings students were believed to commonly experience, based on literature review, in statistics classes. A list of 23 emotions was written to measure affect in these seven areas. A copy of the Affect Check is provided in Appendix A.

Sixty-six students of Statistics I and 41 students in Statistics II voluntarily completed the affect check. Students were given the opportunity to complete the Affect Check halfway through each of their weekly classes in the Fall 2002 semester. A total of 685 were collected from Statistics I students and 313 from Statistics II students. A total of 998 responses were collected, entered and analyzed. Results of the analyses follow.

Exploratory Factor Analysis of Affect Check Data

An exploratory factor analysis was conducted using principal factors extraction with squared multiple correlations as the initial communality estimates via PROC FACTOR in SAS. This analysis was based on 950 completed affect checks, which were collected weekly during one semester in two sections of the introductory statistics course and one section of the second statistics course. The initial communality estimates ranged widely, from a low of .36 for the item indifferent, to a high of .86 for the item confused. Seventeen of the twenty-three items had initial communality estimates of .70 or higher.

The decision of how many factors to extract was based on the theory underlying the development of the items, interpretability of the solution, and consideration of the eigenvalues. The average eigenvalue was .71 and the first 8 eigenvalues were 10.43, 2.61, 1.58, 0.86, 0.69, 0.54, 0.44, and 0.07, respectively. Visual analysis of the scree plot revealed that the last notable drop was between the 7^{th} and 8^{th} eigenvalue, while a comparison of each eigenvalue to the average suggests only four values greater than the average. Based on the eigenvalues we could argue for extracting between four and seven factors. Since the theory behind the instrument had seven factors (the original five plus the two added that were presumed to be associated with statistics anxiety) and the seven-factor solution was easily interpreted with respect to this theory, the decision was made to extract seven factors.

After extraction, the factors were rotated to improve interpretability. This was accomplished using the promax procedure, which allows the factors to correlate. Both the factor pattern matrix and the structure matrix for the rotated factors were examined. The pattern matrix, which is provided in Table 8, was easier to interpret and showed better simple structure. This was anticipated because of the expected correlation among factors. Perusal of Table 8 suggests seven factors that match the seven constructs used in developing the scale. The first factor, "Confused", had large positive pattern coefficients for the items confused, puzzled, and lost. The next factor, "Happy", had large positive coefficients for the items excited, proud, happy, and interested. The next factor, "Dumb", had large positive coefficients for the items stupid, dumb, and foolish. The fourth factor, "Angry" included the items of irritated, mad, disgusted, and frustrated. The fifth factor, "Sad" had high coefficients for the items depressed,

sad, and miserable. The sixth factor, "Fearful", had high positive coefficients for worried, anxious, and afraid. Finally, the last factor, "Indifferent", had high positive coefficients for bored and indifferent.

Table 8
Rotated Factor Pattern Matrix

	Factor						
	Confused	Happy	Dumb	Angry	Sad	Fearful	Indifferent
Item							
Confused	**0.96**	-0.01	0.01	-0.03	0.00	0.00	0.01
Puzzled	**0.91**	0.08	-0.01	-0.03	-0.01	0.03	0.05
Lost	**0.81**	-0.02	0.08	0.01	0.08	0.00	0.01
Excited	0.00	**0.87**	0.02	0.02	0.00	0.00	-0.01
Proud	-0.02	**0.86**	0.04	0.07	-0.04	0.00	0.04
Happy	-0.04	**0.78**	-0.04	-0.05	0.01	-0.03	0.08
Interested	0.10	**0.73**	-0.04	-0.05	0.03	0.04	-0.15
Stupid	0.02	0.00	**0.91**	0.00	-0.01	0.01	-0.02
Dumb	0.13	0.00	**0.83**	-0.02	0.00	0.04	-0.03
Foolish	-0.02	-0.01	**0.69**	0.08	0.15	0.00	0.05
Irritated	0.07	-0.03	-0.04	**0.84**	0.00	0.00	0.01
Mad	-0.09	0.06	0.08	**0.75**	0.13	0.03	0.03
Disgusted	0.11	0.01	0.04	**0.58**	0.23	-0.04	0.05
Frustrated	0.42	-0.04	0.05	**0.51**	-0.11	0.13	-0.07
Depressed	0.06	-0.01	0.04	0.02	**0.85**	0.01	-0.06
Sad	-0.03	0.02	0.08	0.08	**0.79**	-0.04	0.08
Miserable	0.07	-0.02	0.02	0.13	**0.59**	0.13	-0.04
Discouraged	0.36	-0.04	0.04	0.16	**0.31**	0.18	-0.01
Worried	0.23	-0.01	-0.03	-0.02	-0.01	**0.81**	0.00
Anxious	0.15	-0.01	-0.01	0.05	-0.03	**0.80**	-0.03
Afraid	-0.01	0.05	0.13	0.00	0.13	**0.71**	0.07
Bored	0.03	-0.02	-0.01	-0.01	0.03	0.05	**0.70**
Indifferent	0.04	-0.01	0.00	0.04	-0.05	-0.02	**0.67**

Three items should be noted more particularly. The disgusted item was originally intended to load on the indifferent factor, but it clearly emerged on the angry factor, which seemed to make sense upon reflection. Thus it was included on the angry scale that was used in later analyses. While the discouraged item had no large coefficients, it did have small coefficients with both the confused factor and the sad factor. Since the item was originally developed to index a sad factor we included it on the sad scale that was used for later analyses.

The frustrated item also cross-loaded, showing moderate coefficients for both the angry factor and the confused factor. Since it was originally intended to be part of the angry scale, it was included on that scale for later analyses.

The correlations among the factors are provided in Table 9. The relationships among factors tend to be positive, except for the happy factor, which tended to have small negative correlations with the other factors. The largest correlations were between the confused factor and the fearful factor (r=.68), between the angry factor and the sad factor (r=.67), and between the dumb factor and the sad factor (r=.64). About half of the correlations were moderate (10 of the 21 correlations exceeded .50) while the others were smaller.

Table 9
Inter-factor Correlation Matrix with Cronbach Alpha Indices on the Diagonal

	Confused	Happy	Dumb	Angry	Sad	Fearful	Indifferent
Confused	0.94						
Happy	-0.10	0.89					
Dumb	0.55	-0.08	0.91				
Angry	0.59	-0.10	0.58	0.89			
Sad	0.52	-0.07	0.64	0.67	0.90		
Fearful	0.68	-0.12	0.53	0.56	0.54	0.93	
Indifferent	0.12	-0.06	0.25	0.33	0.38	0.04	0.73

Internal Consistency Estimates

Following the factor analysis, scale scores were constructed for each of the seven factors by averaging the ratings on the items that seemed to go with each scale. The bolded pattern coefficients in Table 8 indicate which items were used to represent each factor. The internal consistency of the ratings on the items within a scale was then estimated using alpha. These estimates are provided in the diagonal of Table 9. Six of the seven scales had estimates exceeding .88, which suggest reasonable levels of internal consistency for the scales of confused, happy, dumb, angry, sad and fearful. The last scale, indifferent, had an internal consistency estimate of .73. Although this is acceptable, the scale only has two items. It may be reasonable to include another indifferent item in future administrations.

Strand III: Math Diagnostic Pilot – Results and Discussion

At the beginning of an Educational Statistics I course, students were administered a short diagnostic mathematics test designed to assess basic and fundamental skills and knowledge. Initially an 11-item test composed of items requiring student knowledge of basic arithmetic operations, the use of order of operations, exponents and square roots, as well as absolute values was administered to two groups of students. The internal consistency of the items was measured using Cronbach's Alpha in order to determine how reliable the scores obtained from the mathematics pre-test might be. The resulting Cronbach's alpha of 0.57 indicates a moderate amount of internal consistency. The overall scores were then examined relative to students' subsequent achievement on the midterm and final exam in the course using the Pearson Product-Moment Correlation index. Descriptive statistics for the three measures as well as correlation indices are provided in Table 10.

Table 10.

Descriptive Statistics and Correlations for the First Mathematics Pre-Test, Midterm Exam, and Final Exam

	Mean (pts/total possible)	Standard Deviation	Correlation with Math Pre-test	Correlation with Midterm Exam Score	Correlation with Final Exam Score
Math Pre-test N = 39	9.19/11	1.6	1.00	0.25	0.15
Midterm N = 39	86.15/100	10.4	0.25	1.00	0.71
Final N = 47	88.23/100	9.6	0.15	0.71	1.00

As might be expected, the correlation between the midterm and final exam scores was fairly strong and was statistically significant ($p < .0001$). However, neither a notable nor significant relationship was found between the mathematics pre-test and neither the midterm nor final exam ($p = .12$ and $p = .27$ respectively). .

The following semester, the mathematics pre-test was revised to better represent calculations common to statistical operations, e.g., the computation of the standard deviation. This 10 item test was administered to one group of Statistics I students at the beginning of the

semester and similar analyses were run (Table 11). An examination of the internal consistency of these items revealed a similar degree of relationship among the items (Cronbach alpha = 0.51) as the previous group of pre-test items. At the time of this report, this group of students had only taken the midterm exam so the findings do not include information about final exam scores.

Table 11.

Descriptive Statistics and Correlations for the Second Mathematics Pre-Test and Midterm Exam

	Mean (pts/total possible)	Standard Deviation	Correlation with Math Pre-test	Correlation with Midterm Exam Score
Math Pre-test N = 22	8.59/10	1.5	1.00	0.57
Midterm N = 22	25.77/30	3.1	0.57	1.00

The findings from this analysis indicate a more likely relationship between performance on the mathematics pre-test and performance on the midterm ($p = .005$). However, based on the size of the sample as well as the limited number of items on the pre-test, both of which contribute to the potential for measurement error, it is not prudent to conclude that this relationship, if indeed it exists, is stable throughout the population. Further examination of this potential relationship is warranted.

Limitations and Implications

The data clearly indicate a need for a program such as EncStat to provide support for graduate students with statistics anxiety. Further, the initial information suggests that the statistics anxiety surveys targeted for EncStat will support reliable decisions within the program without undue burden on students . Review of results indicated that the Statistics Anxiety Affect Check will likely provide useful information on attitude change. Further study will be made of the math diagnostic pilot to elucidate its potential contribution to identification of students for whom a basic math review would be beneficial, with respect to achievement as well as anxiety reduction.

Educational Importance of the Study

Multidimensional constructs, like statistics anxiety and attitudes toward statistics, require multiple measures. Although not its main purpose, the present study contributes to the "...emerging field of the assessment of attitudes in statistics education" (Gal 1994, p. 10) by assessing the validity of existing instrumentation as well as exploring the utility of modifications to those instruments and the second wave of more finely-tuned instruments for which the field is ready. Fortuitously, ascertaining that assessment is adequate for an intervention program provides useful pedagogical and research information as well. The data clearly indicate the need for a program such as EncStat to provide support for graduate students with statistics anxiety and indicate that the assessment strategy planned for EncStat is appropriate.

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Appendix A

Affect Check- Fall 2002 –Statistics I and II **Research ID # _____**

For each word, please circle the number that corresponds to your feelings about statistics at this time.

	Do Not Feel This Way At All						**Feel This Way Intensely**
Mad	1	2	3	4	5	6	7
Irritated	1	2	3	4	5	6	7
Frustrated	1	2	3	4	5	6	7
Anxious	1	2	3	4	5	6	7
Worried	1	2	3	4	5	6	7
Afraid	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Indifferent	1	2	3	4	5	6	7
Bored	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Depressed	1	2	3	4	5	6	7
Discouraged	1	2	3	4	5	6	7
Miserable	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Interested	1	2	3	4	5	6	7
Proud	1	2	3	4	5	6	7
Excited	1	2	3	4	5	6	7
Puzzled	1	2	3	4	5	6	7
Confused	1	2	3	4	5	6	7
Lost	1	2	3	4	5	6	7
Dumb	1	2	3	4	5	6	7
Foolish	1	2	3	4	5	6	7
Stupid	1	2	3	4	5	6	7

Please write a couple of sentences explaining why you feel as you have indicated.

_____

_____

_____

_____

Thank you for helping us learn more about statistics education.

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Organization/Address: University of South Florida, 4202 East Fowler Avenue, EDU 355, Tampa FL 33620-7900	Telephone: 813-974-5739	Fax: 813-974-4495
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