

# **Mathematical background and attitudes toward statistics in a sample of undergraduate students.**

José Carmona  
[carmona@uhu.es](mailto:carmona@uhu.es)  
Universidad de Huelva, Spain

Negative affective responses to statistics are common among undergraduate students enrolled in a statistics course. It has been suggested that the formation of this attitude has its origin in the previous experience in the context of learning mathematics (Gal, Ginsburg & Schau, 1997). In Schau, Dauphinee, & Del Vecchio (1992), for example, students were asked to describe their feelings regarding mathematics and statistics courses. They found out that most of their students attributed positive feelings to satisfying past achievement in mathematics and negative feelings to poor teaching coupled with poor mathematics self-concept and achievement. The goal of this paper is to study in depth this question, trying to settle what dimensions of attitudes are more related with the students' mathematical background.

Concretely we explore two factors of the maths background that have been shown to be related to attitudes toward statistics in previous research: (a) the more or less math-oriented secondary education (Gil, 1999); and (b) math grades obtained in secondary education (Sorge & Schau, 2002). Students' attitudes are expected to be more positive the more math-oriented secondary education they attended and the better grades in maths they got.. However, because this pattern partially depends on the dimensions of attitudes toward statistics considered, our purpose is to explore which subscales of the most frequently used instruments to measure attitudes toward statistics have a strong association with maths background.

## **Method**

### *Participants*

A convenience sample of 827 college students from two Spanish Universities was selected from various introductory statistics classes. There were 180 males and 647 females students. Males had an age range of 17 to 37 ( $M=21.11$ ,  $SD=3.18$ ). The ages of the females ranged from 17 to 43 ( $M=20.34$ ,  $SD=2.66$ ).

### *Instruments*

Information about secondary studies and maths grades was obtained by self-report. The participants were classified into three groups: lower, middle and upper levels according to the number and complexity of math courses taken in secondary education. The attitudes toward statistics were measured using three instruments: the Survey of Attitudes Toward Statistics – SATS- (Schau, Stevens, Dauphinee & Del Vecchio, 1995), the Attitudes Toward Statistics scale –ATS- (Wise, 1985) and the Statistics Attitude Survey –SAS- (Roberts & Bilderback, 1980).

The SATS is made up of four subscales: Affect –positive and negative feelings concerning statistics-, Cognitive Competence –attitudes about intellectual knowledge and skills when applied to statistics-, Value –attitudes about the usefulness, relevance and worth of statistics-, and Difficulty –attitudes about the difficulty of statistics as a subject. The subscales are formed by 6, 6, 9 and 7 items, respectively.

The ATS consist of two subscales: attitudes toward the Field of statistics (9 items) and attitudes toward the statistics Course (20 items). The purpose of Field subscale is to measure the student's attitudes toward the usefulness of statistics in their field of study. The Course subscale is intended to measure the student's attitudes toward their statistics course.

The SAS is an instrument consisting of 33 items. The SAS is proposed as a one-dimensional scale, so that "*it was not assumed that the SAS was factorially complex or that there were useful possibilities for identifying subscales for diagnostic purposes*" (Roberts & Reese, 1987).

### *Procedure*

Three forms of the questionnaire were used. Form A contained the SATS items and background questions. Forms B and C were composed of the same items as Form A, but moreover included the ATS items (form B) or the SAS items (form C). The three forms were administered during the second week of the course: form A to the entire sample and forms B and C to subsamples of 88 and 99 students, respectively.

### *Analysis*

To explore the relationships between previous math achievement and dimensions of attitudes toward statistics, we calculated correlations between math grades and all the scales and subscales. To study the differences among students' attitudes, we performed two MANCOVAs using the type of secondary education as between-subject factor and math grades as covariate, one with the SATS subscales as dependent variables and the other with ATS subscales as dependent variables.

## **Results**

The analysis of intercorrelations among math grades and attitudes toward statistics scores (Table 1) shows that ATS and SATS subscales more related to math grades are ATS-Course ( $r = .512, n = 88, p < .01$ ) and SATS-Affect ( $r = .332, n = 827, p < .01$ ). ATS and SATS subscales less related to math grades are ATS-Field ( $r = .164, n = 88, p > .01$ ) and SATS-Value ( $r = .106, n = 827, p < .01$ ). Taking into consideration the total scores on the three scales, ATS is the closest scale to math grades ( $r = .374, n = 88, p < .01$ ).

Prior to the main analyses, assumptions of parametric statistics were tested. The data on the covariate -math grades- were severely positively skewed. Therefore, an inverse transformation was performed on this variable. Scores on this transformed covariate and on the dependent variables were screened for outliers within each of the three groups formed on the basis of the math secondary education levels. One case in the middle group and other in the upper group were considered univariate outliers because of their extremely high  $z$  score on SATS-Difficulty and low  $z$  score on SATS-Value, respectively. With the use of a  $P < 0.001$  criterion for Mahalanobis distance two multivariate outliers were detected. Once the four outliers were removed, the final sample consisted of 240 in the upper, 425 in the middle and 158 in the lower levels on math secondary education. Evaluations of assumptions of homogeneity of variance-covariance and homogeneity of regression for group scores were satisfactory.

Table 1.  
Intercorrelations of the scales, subscales and math grades

	Math Grades	SATS-A	SATS-CC	SATS-V	SATS-D	SATS	ATS-C	ATS-F
SATS-A	.332* <sup>a</sup>							
SATS-CC	.303* <sup>a</sup>	.704* <sup>a</sup>						
SATS-V	.106* <sup>a</sup>	.346* <sup>a</sup>	.292* <sup>a</sup>					
SATS-D	.135* <sup>a</sup>	.503* <sup>a</sup>	.505* <sup>a</sup>	.250* <sup>a</sup>				
SATS	.286* <sup>a</sup>	.841* <sup>a</sup>	.799* <sup>a</sup>	.674* <sup>a</sup>	.709* <sup>a</sup>			
ATS-C	.512* <sup>b</sup>	.891* <sup>b</sup>	.587* <sup>b</sup>	.490* <sup>b</sup>	.458* <sup>b</sup>	.813* <sup>b</sup>		
ATS-F	.164 <sup>b</sup>	.347* <sup>b</sup>	.292* <sup>b</sup>	.823* <sup>b</sup>	.118 <sup>b</sup>	.561* <sup>b</sup>	.375* <sup>b</sup>	
ATS	.374* <sup>b</sup>	.692* <sup>b</sup>	.501* <sup>b</sup>	.818* <sup>b</sup>	.314* <sup>b</sup>	.801* <sup>b</sup>	.767* <sup>b</sup>	.882* <sup>b</sup>
SAS	.264* <sup>c</sup>	.780* <sup>c</sup>	.792* <sup>c</sup>	.643* <sup>c</sup>	.589* <sup>c</sup>	.873* <sup>c</sup>		

\*Pearson product-moment correlation coefficients significant at  $p < .01$

<sup>a</sup> n = 827; <sup>b</sup> n = 88; <sup>c</sup> n = 99

The first one-way between subjects MANCOVA was performed on the four subscales of SATS. With the use of Wilks' criterion, math grades appeared to have a significant covariate effect on the combined dependent variables,  $F(4,816) = 25.04$ ,  $p < .01$ . There was a small association between the combined dependent variables and the covariate ( $\eta^2 = .11$ ). After adjusting for math grades, the effect of secondary education type on the combined dependent variable was also significant,  $F(8,1632) = 4.11$ ,  $p < .01$ , although it only accounted for about 2% of the variability in SATS subscales.

Table 2.  
Roy-Bargman tests of covariate (math grades) and main effect (secondary education) on SATS subscales

Effect	Dependent variables	Stepdown F	df
Covariate (Math grades)	SATS-Affect	84.11*	1/819
	SATS-Cognitive Competente	9.58*	1/818
	SATS-Difficulty	5.12	1/817
	SATS-Value	0.12	1/816
Secondary education	SATS-Affect	12.51*	2/819
	SATS-Cognitive Competente	2.51	2/818
	SATS-Difficulty	0.93	2/817
	SATS-Value	0.57	2/816

\*  $p < .01$

To assess the relative importance of the dependent variables, Roy-Bargman step-down analyses were performed. The order of dependent variables in step-down analysis was based on a pilot study (Carmona, 2002). Results of these analyses are summarized in Table 2. According to these analyses, math grades were significantly related to SATS-Affect and SATS-Cognitive Competence. Step-down analyses also showed that students in lower, middle and upper levels of math secondary education significantly differed in SATS-Affect. With lower scores indicating less positive feelings concerning statistics, the more math-oriented group scored the highest in

SATS-Affect ( $M_{(adj)} = 4.66$ ,  $SE = 0.07$ ), followed by the middle group ( $M_{(adj)} = 4.47$ ,  $SE = 0.06$ ) and the less math-oriented group ( $M_{(adj)} = 4.02$ ,  $SE = 0.09$ ).

The other MANCOVA analysis was performed on the two ATS subscales. A significant multivariate effect of covariate on the ATS subscales (Wilks'  $\lambda = 0.81$ ,  $F(2,82) = 9.46$ ,  $p < .01$ ) was found. The effect of secondary education type after adjustment for math grades was significant at 95% confidence level,  $F(4,164) = 2.94$ ,  $p = .02$ . There was a moderate association between the combined dependent variables and the covariate ( $\eta^2 = .19$ ). The association of secondary education type with ATS subscales ( $\eta^2 = .07$ ) was also higher than that of SATS subscales. Given the correlation between the dependent measures ( $r = .37$ ), a Roy-Bargman step-down analysis was done (Table 3). Based on the pilot study, ATS-Course was given the highest priority. The results of step-down analyses showed that math grades were significantly related to ATS-Course. Roy-Bargman analysis revealed also a statistically significant difference among the three groups on this subscale. The estimated means, adjusted for math grades, of the upper, middle and lower group on ATS-Course were 4.79 ( $SE = 0.19$ ), 5.00 ( $SE = 0.21$ ) and 4.06 ( $SE = 0.22$ ), respectively.

Table 3.  
Roy-Bargman tests of covariate (math grades) and main effect (secondary education) on ATS subscales

Effect	Dependent variables	Stepdown F	df
Covariate (Math grades)	ATS-Course	18.88*	1/83
	ATS-Field	0.22	1/82
Secondary education	ATS-Course	5.15*	2/83
	ATS-Field	0.89	2/82

\*  $p < .01$

## Discussion

In the literature about statistics education, it is generally agreed that one important source of attitudes towards statistics is the previous experience in mathematics. Assuming the influence of mathematical background, the remaining question would be which dimensions of attitudes toward statistics are more related to this background. As we expected, the obtained results show more positive attitudes among students with better math grades and more math-oriented secondary education. However, this pattern was not homogeneous across the dimensions of attitudes toward statistics.

We found out that math background, and especially math grades obtained in secondary education, were associated with SATS-Affect and SATS-Cognitive Competence, but not with SATS-Difficulty or SATS-Value. Furthermore they were related to ATS-Course, but not to ATS-Field. These findings are similar to those obtained by Kottke (2001) and Schutz, Drogosz, White & Distefano (1998), although these authors used measures of actual math knowledge instead of the indicators of math background used in this paper.

These results suggested that mathematical background has a strong association with the affective responses to statistics, especially the attitudes toward the statistics course, rather than with the valuing of statistics. We think that previous experience in mathematics is a source of evaluations concerning self-perception in relation to statistics, but not of the more general assessments of statistics. In our opinion this is the reason which explains the significant relations of math background with SATS-Cognitive Competence but not with SATS-Difficulty. Although both subscales assess the students' perception of the difficulty of statistics, SATS-Cognitive

Competence subscale measures attitudes about their own intellectual knowledge and skills when applied to statistics, as long as SATS-Difficulty purpose is to evaluate the attitudes about the difficulty of statistics as a subject. Likewise, ATS-Course was designed to measure attitudes toward the statistics course in which the student is enrolled, while ATS-Field was elaborated to assess the usefulness of statistics.

An interesting finding is the weak relationship between math background and the attitudes about usefulness of statistics (SATS-Value and ATS-Field). In other studies it was also found that these subscales are not related with statistics course performance (Carmona, 2002; Schutz et al., 1998; Wise, 1985). In this point we are in agreement with Gal & Ginsburg (1994) when they states that “a student's responses to items assessing usefulness-of-statistics issues might have little to do with feelings or attitudes towards statistics as a subject; instead, they may only reflect the student's vocational development (Osipow 1973) or knowledge about requirements or content of certain jobs” (par. 25). Further research is needed in order to determine if similar results would be obtained for graduate students and professionals.

### References

- Carmona, J. (2002). *La teoría de facetas y el escalamiento multidimensional en la elaboración y validación de cuestionarios de actitudes: Una aplicación al dominio de las actitudes hacia la estadística*. Unpublished doctoral thesis, Universidad de Sevilla.
- Gal, I., Ginsburg, L., & Schau, C. (1997). Monitoring attitudes and beliefs in statistics education. In I. Gal y J.B. Garfield (Eds.) *The assessment challenge in statistics education* (pp. 37-51). Netherlands: IOS Press.
- Gil, J. (1999). Actitudes hacia la estadística. Incidencia de las variables sexo y formación previa. *Revista Española de Pedagogía*, 214, 567-590.
- Kottke, J.L. (2000). Mathematical proficiency, statistics knowledge, attitudes toward statistics, and measurement course performance. *College Student Journal*, 34(3), 334-347.
- Roberts, D.M. & Bilderback, E.W. (1980). Reliability and validity of a statistics attitude survey. *Educational and Psychological Measurement*, 40, 235-238.
- Roberts, D.M. & Reese, C.M. (1987). A comparison of two scales measuring attitudes toward statistics. *Educational and Psychological Measurement*, 47, 759-764.
- Schau, C. G., Dauphinee, T., & Del Vecchio, A. (1992, April). *The development of the Survey of Attitudes Toward Statistics*. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.
- Schau, C., Stevens, J, Dauphinee, T.L., & Del Vecchio, A. (1995). The development and validation of the Survey of Attitudes Toward Statistics. *Educational and Psychological Measurement*, 55, 868-875.
- Schutz, P.A., Drogosz, L.M., White, V.E., & Distefano, C. (1998). Prior knowledge, attitude, and strategy use in an introduction to statistics course. *Learning and Individual Differences*, 10(4), 291-308.
- Sorge, C. & Schau, C. (2002, april). *Impact of engineering students' attitudes on achievement in statistics: A structural model*. Paper presented at the Annual Meeting of the American Educational Research Association, Nueva Orleans. Retrieved June 14, 2003, from <http://www.unm.edu/~cschau/AERA2002.pdf>
- Wise, S.L. (1985). The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement*, 45, 401-405.