Structural Equation Models Relating Attitudes About and Achievement in Introductory statistics Courses: A Comparison of Results from the U.S. and Israel

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1. Introduction

The difficulties that many students, particularly those in the social and behavioral sciences, encounter while taking an introductory statistics course have been widely reported in many parts of the world. Factors that have been purported as relating to performance in introductory statistics include a variety of cognitive and affective variables (Feinberg & Halperin, 1978). Cognitive factors, such as mathematics ability and background, certainly play a major role in performance in an introductory statistics course; however, affective variables are also important. Gal and Ginsburg (1994) reported that "The body of research on students' attitudes, beliefs, and affect related directly to statistics education is very small and problematic." They further state that concerns for studying non-cognitive aspects of statistics education should not only be motivated by outcome (performance) but also by process considerations.

A major issue concerns the influence of attitudes on achievement. McLeod (1992) suggested that neither attitude nor achievement is dependent on the other, but they "interact with each other in complex and unpredictable ways. (p. 582)" The prospect of the reciprocal relationship of attitude and achievement has been proposed by others (Kulm, 1980) and negates the possibility of isolating the cognitive and affective domains. A number of studies have investigated the relationship between attitudes toward statistics and performance in an introductory course using a variety of correlational and regression techniques. Results generally indicate a small to moderate positive relationship. This relationship appears to be fairly consistent regardless of the instrument

used, the time of administration of either the attitude or performance measure, or the level of the student.

Longitudinal studies of math attitudes and performance (Pajares & Miller, 1994; Meece, Wigfield, & Eccles, 1990; Eccles & Jacobs, 1986) have provided path analyses of the relationship of these variables. In a study of undergraduates, Pajares and Miller (1994) determined that mathematics self-efficacy was highly related to mathematics performance with mathematics self-concept and high school mathematics experience making a small, but significant contribution. Perceived usefulness was not a contributor to mathematics performance. Eccles and Jacobs' (1986) path analysis indicated that mathematics grades were influenced by the students' self-concept of math ability and math anxiety, but were not influenced by the student's perception of the task difficulty or the perceived value of mathematics. Meece, Wigfield, and Eccles' (1990) path analysis found that students' prior grades and expectancies were predictors of grades, while importance and anxiety were not. In several other papers, the first two of the current authors have developed a model suggesting that some aspects of statistics attitude at the beginning of a course affect test performance during the course and that end of course attitudes were both directly and indirectly influenced by performance during the course. The research reported here extends that line of inquiry looking at data from English and Arabic speaking samples available in the U.S. and Israel.

2. Method

The data from Arabic speaking students (n=111) and English speaking students (n=136) were collected at a teacher training college in Israel and at a small public college in the United States. The Arabic speaking students were enrolled in a teacher training program for elementary and middle schools, were mostly female (91%), and were of traditional college age (mean=20.0). The English speaking students were primarily enrolled in education and nursing programs, were mostly female (80%), and were slightly older.

Information about prior achievement in math was drawn from student records or obtained by self-report. Attitudes toward math and anxiety related to learning math were assessed with separate instruments. The Survey of Attitudes Toward Statistics (SATS) by Schau, Stevens, Dauphinee, & Del Vecchio (1995) was used as a measure of students' attitudes about statistics. SATS subscales included Affect (positive and negative feelings concerning statistics), Cognitive Competence (attitudes about students' intellectual knowledge and skills when applied to statistics), Value (attitudes about the usefulness, relevance, and worth of statistics in personal and professional life), and Difficulty (views on the degree of difficulty of statistics as a subject). Finally, students' overall performance in their course was obtained from instructors and expressed on a percentage scale.

Attention was focused on structural equation models involving observed variables using LISREL 8 (Joreskog & Sorbom, 1996). Working from earlier fragmentary analyses exploring differences between the English and Arabic speaking students reported at the ISI meeting in Finland (Wisenbaker, Scott & Nasser; 1999), a full model was estimated constraining some coefficients to be the same and allowing others to vary between the two groups.

3. Results

The overall model resulting from the LISREL analyses applied to the data from the English and Arabic speaking graduate students yielded a good level of fit to the variance-covariance matrices from the two groups. The final chi-square statistic had a value of 95.07 with 97 degrees of freedom (p=0.54). The value for the goodness of fit index (GFI) was 0.94.

The coefficients in the common metric standardized solution are presented in Table 1. The leftmost column of estimates pertains to those coefficients that were not statistically significantly different for the two groups; the one to its right contains those values unique to the Arabic speaking group; the rightmost column those unique to the English speaking group. The 'paths' involving statistically significant coefficients are set forth in Figure 1.

The coefficients associated with many of the components in the model were essentially the same for both English and Arabic speaking students. This was the case for initial assessments of Cognitive Competence, Value and Difficulty and for terminal assessments of Affect and Difficulty. For initial Affect the only difference noted was the need to include Math Attitude (with a positive value) for the English speaking students. Course Performance was equally affected by prior Math Achievement for both the English and Arabic speaking students while negatively affected by Math Learning Anxiety for the Arabic speaking students.

This leaves the terminal assessments of Cognitive Competence and Value as the variables most strikingly different. The terminal assessment of Cognitive Competence was predicted to be higher for those with a higher initial value for Cognitive Competence and for those with initially higher values for Difficulty (meaning they anticipated the course would be easier). Course Performance had positive coefficients for both groups although clearly higher for the English speaking students than for the Arabic speaking students (standardized coefficients of .47 and .11, respectively). For Arabic speaking students, Math Attitude had a positive effect while, for English speaking students, initial Affect had a positive effect.

The terminal assessment of Value proved to have the sharpest differences between the two groups of students. While the initial assessment of Value played a role for both

groups, the degree of effect was considerably larger for the English speaking students. The terminal assessment of Cognitive Competence also played a role for both; however, a much stronger one for Arabic speaking students. Finally, Math Achievement had an effect for Arabic speaking students while initial Difficulty had an effect for the English group.

4. Conclusions and Discussion

Overall, the results presented here reinforce our confidence in the applicability of the Schau, et al (1995) instruments in the contexts of their translation to Arabic based on our earlier work (Wisenbaker, Scott and Nasser; 1999). The remarkable similarity of the groups in terms of the interrelationships among prior Math Achievement, Math Attitude, Math Learning Anxiety and the Cognitive Competence, Value, Affect and Difficulty scales is clearly consistent with the view that the instruments have an adequate degree of reliability and validity. Furthermore, these results reinforce our view that the processes leading to initial attitudes about introductory statistics courses are reasonably similar across very different educational settings.

The results suggest that previously formed attitudes about mathematics and, to a lesser extent, anxiety about learning mathematics have impacts on students' initial sense of competence to learn statistics. As might be expected, more positive attitudes about math and lower levels of anxiety about learning math are suggestive of higher levels of students' efficacy for learning statistics. Initial levels of Cognitive Competence are also very important from the standpoint of initial measures of Value, Affect and Difficulty. Higher levels of Cognitive Competence were associated with a greater value for statistics, more positive feelings about the subject, and a sense that learning statistics would be easy. Interestingly, the value for the standardized coefficients linking Cognitive Competence to each of the other three attitude scales was nearly the same ranging from .43 to .45. This would seem to support an interpretation that the other three initial measures are, to some extent, derivative from students' sense of Cognitive Competence. At variance with the often voiced opinion that students' initial negative attitudes about statistics can have long term consequences in terms of course performance, only prior math achievement (in a positive sense) and, for Arabic speaking students, math learning anxiety (in a negative sense) seemed predictive of ultimate course performance here. Taking these variables into account, there is no evidence for initial attitudes about statistics uniquely influencing how well students learned the material.

Even more interesting are the differences between the Arabic and English speaking students with respect to Cognitive Competence as assessed at the end of the courses. The role of course performance for the English speaking students here was more than four times that for the Arabic speaking students. This would seem to suggest that the

English and Arabic speaking students had somewhat different experiences as they progress through their introductory courses. Certainly, this was so in terms of examinations given to the two groups (with the English speaking students given many more examinations during their course than were the Arabic speaking students). This differential level of feedback seemed to have left the Arabic speaking students basing much more of their end of course sense of Cognitive Competence on their initial attitude about math.

Value as assessed at the end of the courses was more highly affected by initial Value for the English speaking students than was the case for the Arabic speaking students. Likewise, end of course Cognitive Competence was more important for the Arabic speaking students. Here again these facts may be indicative of differences in the course experiences of the two groups. Perhaps the instruction offered to the Arabic speaking students had a greater focus on the value of statistics than was the case for the English speaking group. It would thus seem important to seriously consider the task and situational demands of individual courses in trying to formulate any overall model relating end of course attitudes toward statistics with student background and achievement. Differences in the quantity and detail of feedback to students about their progress in mastering the material and differences in course focus seem plausibly important in understanding relationships among pre-course attitudes, achievement, and post-course attitudes. In any event, much more work needs to be done exploring these issues in the context of different instructors and different cultural circumstances. It may well be the case that the inherent challenges to students posed by a beginning course in statistics and differences among instructors in how they lead students to rise to those challenges are vastly more relevant than the broader cultural context in which a student lives. In fact, it may be that the very nature of the subject matter and the unique perspective necessary for successfully learning about it creates its own microculture with common features experienced by most students learning about statistics.

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Table 1 - Standardized Coefficients in Model

Predicted Variable in Model	In Common	Arabic	English
Cognitive Competence$_1$	Math Learning Anxiety (-0.19) Math Attitude (0.40)		
Value$_1$	Cog. Comp.$_1$ (0.45)		
Affect$_1$	Cog. Comp.$_1$ (0.23) Value$_1$ (0.16) Difficulty$_1$ (0.23)		Math Attitude (0.35)
Difficulty$_1$	Cog. Comp.$_1$ (0.43)		
Course Performance	Math Achievement (0.27)	Math Learning Anxiety (-0.38)	
Cognitive Competence$_2$	Cog. Comp.$_1$ (0.27) Difficulty$_1$ (-0.21)	Course Perf. (0.11) Math Attitude (0.31)	Course Perf. (0.47) Affect$_1$ (0.34)
Value$_2$	Value$_1$ (0.22) Cog. Comp$_2$ (0.22) Math Achievement (0.22)		Value$_1$ (0.56) Cog. Comp$_2$ (0.13) Difficulty$_1$ (-0.26)
Affect$_2$	Cog. Comp.$_1$ (-0.16) Affect$_1$ (0.25) Course Performance (0.10) Cog. Comp.$_2$ (0.73)		
Difficulty$_2$	Difficulty$_1$ (0.39) Cog. Comp.$_1$ (-0.23) Cog. Comp.$_2$ (0.49)		

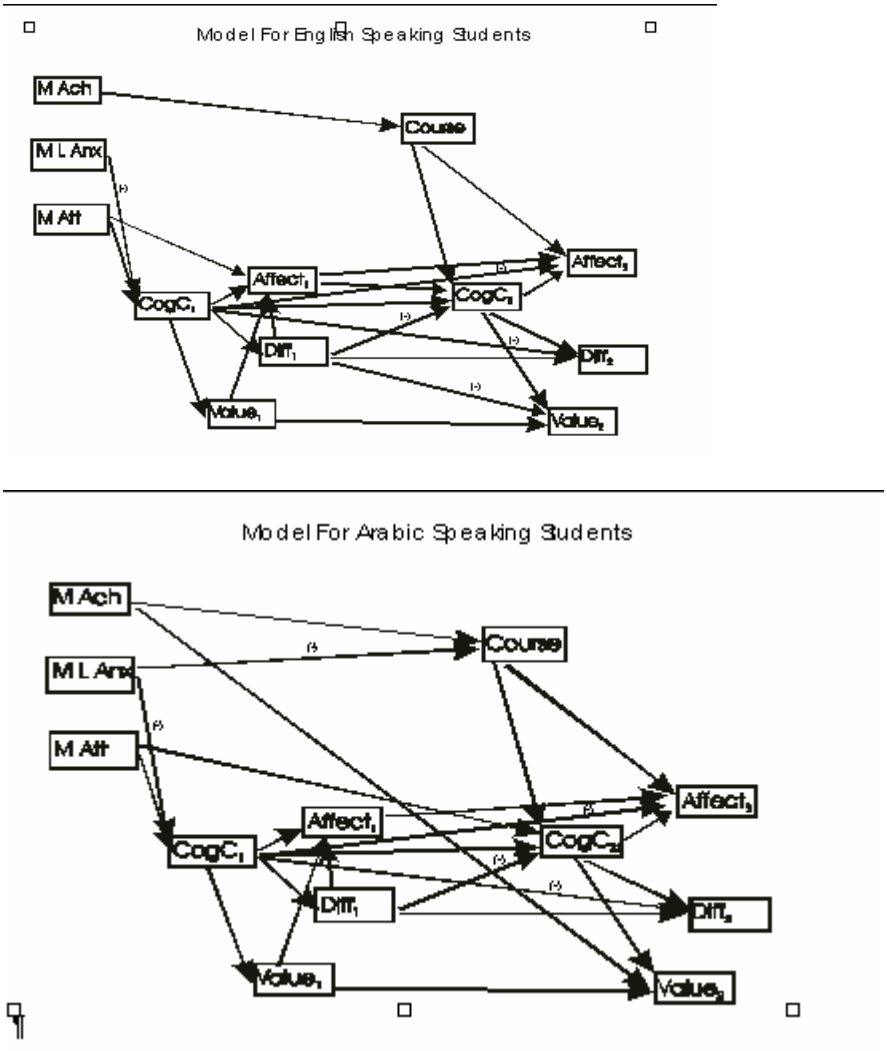

Figure 1 - Models for Arabic and English Speaking Students