A Meta-Analysis on Students' Attitudes toward Statistics

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Introduction

Statistics has been a compulsory course for most of the students enrolled in various undergraduate and graduate programs. Despite the fact that these courses have been widely practiced, research on statistics education has accelerated recently. A small but growing body of evidence showed that attitudes toward statistics contribute to the success in statistics courses (Chiesi & Primi, 2008; Dempster & McCorry, 2009; Limpscomb, Hotard, Shelley, & Baldwin, 2002; Sorge & Schau, 2002). The present study aims to explore the relationship between attitudes toward statistics and statistics achievement through a meta-analysis.

Glass and his colleagues introduced the term "meta-analysis," while referring it to "analysis of analyses." Glass (1976) described meta-analysis as "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p.3). The main difference between a primary study and a meta-analysis is the unit of analysis. The unit of analysis is the subject in a primary study whereas the unit of analysis is the study in a meta-analysis. The meta-analysis is performed by defining an effect size measure that represents the overall result of the each study. The two main families of effect sizes in meta-analysis are the standardized mean difference and the Pearson correlation coefficient (Rosenthal, 1995). The steps of the meta-analysis can be summarized as the following: (1) defining the variables of interest, (2) collecting the studies in a systematic way, (3) examining the variability among the obtained effect sizes, (4) examining the statistical significance and magnitude of the estimated effect size found in meta-analysis. In the field of statistics education, a meta-analysis has been conducted to clarify the relationship between statistics anxiety and achievement. The study showed that the overall estimate of the relationship between statistics anxiety and statistics achievement is negative and small (Fitzgerald, 1997). Such synthesis has not been done to examine the relationship between attitudes toward statistics and statistics achievement.

Attitudes are "dispositions to respond favorably or unfavorably to an object, person, institution or an event" (Ajzen, 2005, p. 3). Attitudes have been studied for many years in education and psychology. In those studies, the relationship between attitudes and behavior has become the core issue. The relationship between attitudes and behavior reported as statistically significant and moderate (r=.30 and r=.41) in two meta-analysis studies (Kraus, 1995; Wallace, Paulson, Lord, & Bond Jr., 2005).

In the current study, students' attitudes toward statistics refer to a multidimensional construct that stand for students' learned predispositions to respond positively or negatively with regard to statistics. Numerous scales have been developed to measure students' attitudes toward statistics; however, they are inconsistent in terms of the number and content of the components that comprise students' attitudes toward statistics (Auzmendi, 1991; Roberts & Bilderback, 1980; Sutarso, 1992; Wise, 1985). The most commonly used early

statistics instruments assumed that statistics attitude is a uni-dimenional (Roberts & Bilderback, 1980) or two-dimensional composing of attitudes toward the field of statistics and attitudes toward the statistics course (Wise, 1985).

In the early 90s, The Survey of Attitudes Toward Statistics© (SATS©) was developed (Schau et al., 1995). The SATS© is the most current and one of the widely used statistics attitudes instruments (i.e., Chiesi & Primi, 2008; Coetzee & van der Merwe, 2010). Being based on a theoretical background, the SATS© assumes the multidimensional structure of attitudes toward statistics. It was developed with four-component structure including affect, cognitive competence, value, and difficulty (Schau et al., 1995). Later, Schau (2003) revised the scale by adding two components: effort and interest.

In the current meta-analysis study, we adopted the multi-dimensional notion of attitudes toward statistics. In the current literature, the most widely investigated components are cognitive competence, affect, value, and difficulty. Therefore, four separate meta-analyses were conducted in which the correlations between statistics achievement and students' affect toward statistics, valuing of statistics, cognitive competence in statistics, and perceptions about the difficulty of statistics were investigated.

Research Questions

The current meta-analysis study addressed following research questions:

1. What is the relationship between statistics achievement and students' affect toward statistics?
2. What is the relationship between statistics achievement and students' valuing of statistics?
3. What is the relationship between statistics achievement and students' cognitive competence in statistics?
4. What is the relationship between statistics achievement and students' perceptions about the difficulty of statistics?

Method

The following selection criteria are applied to choose studies to be included in meta-analysis: First, the study should report the Pearson correlation coefficient between the attitudes toward statistics (cognitive competence, affect, value, and difficulty) and statistics achievement. Second, the sample of study should include students from higher education (undergraduate and/or graduate). If studies report both pre and post attitudes toward statistics, only the correlation coefficients between students' post-attitudes toward statistics and statistics achievement are included in the analysis, as most of the studies report post-attitudes.

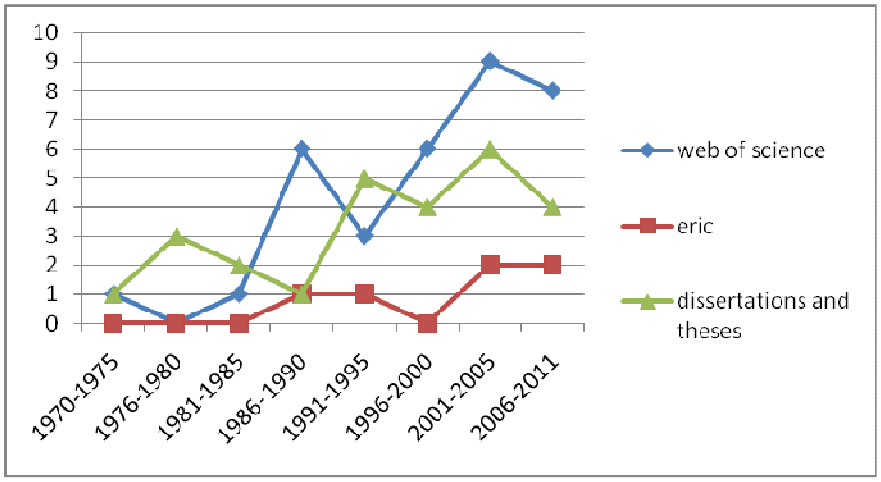
In this meta-analysis, the unit of analysis is each selected study. The effect size measure used in the meta-analysis is the Pearson's correlation coefficient. When more than one correlation coefficient is reported in a study (some studies used multiple measures for assessing statistics achievement; thus, they reported multiple values), the average of correlation coefficients was obtained and used.

In the current study, computer searches were conducted using several databases (i.e., Google scholar, ERIC, Web of Science, Dissertations and Theses). The search was done by using "Statistics attitudes OR attitudes toward statistics" phrases in study "titles." In April 2011, search of Web of Science database resulted with 36 studies, ERIC resulted with 25 studies, Dissertations & Theses resulted with 11 studies, and Google scholar resulted with 183 documents.

Figure 1 demonstrates the distribution of studies in Eric, Web of Science, and in Dissertations & Theses databases with regard to the publication years. As seen in figure, although small in number, the publications refering to students' attitudes toward statistics have increased since 2000s.

Figure 1

Distribution of Studies in terms of the Publication Year



Results

According to the selection criteria explained above, studies to be included into the meta-analysis were determined. The four meta-analyses were conducted by using Comprehensive-Meta-Analysis program in order to investigate the four research questions. Hedges and Olkin's *Q* statistic was applied to test the homogeneity of the correlations analyzed in the study. For each meta-analysis, Hedges and Olkin's *Q* statistic revealed heterogeneity indicating the presence of both within and between studies variability (Huedo-Medina, Sanchez-Meca, Marin-Martinez, & Botella, 2006). Rejecting the homogeneity assumption, random effect model was applied to generalize the study results to the study sample rather than to a larger population (Hedges & Vevea, 1998).

In order to investigate the relationship between statistics achievement and students' affect toward statistics, a meta-analysis of 14 studies was utilized. These studies involved 4781 participants, in total. The studies were conducted in seven different countries. All but one (Bude et al., 2007) study used SATS© to measure students' attitudes toward statistics. Of the 14 studies, eight studies used students' statistics grades, five studies used statistics achievement tests, and one study used course exams (quiz, midterm and final exams) to measure students' statistics achievement. Hedges and Olkin's *Q* statistic revealed statistically significant result that the correlations were heterogeneous. The results of the meta-analysis showed a medium relationship. The average effect size for the random effects model was .34 with a 95% confidence interval of .28 to .39, and statistically significant.

In the second meta-analysis, a medium and statistically significant relationship was found between statistics achievement and students' cognitive competence in statistics. This meta-analysis utilized 16 studies, including 6136 participants from six countries. Thirteen of the studies used SATS©, whereas three studies measured students' cognitive competence by their expected statistics grade. To measure statistics achievement, nine studies used students' statistics grades, five studies used statistics achievement tests, and two studies used course exams (such as quiz, midterm and final exams). Hedges and Olkin's *Q* statistic revealed that the correlations analyzed in the current study were heterogeneous. The average effect size for the random effects model was .36 with a 95% confidence interval of .31 to .41, and statistically significant.

In order to investigate the relationship between statistics achievement and students' valuing of statistics, a meta-analysis of 13 studies was conducted. These studies involved 5357 participants from six different countries. All studies used the SATS© to measure students' attitudes toward statistics. Of the 13 studies, eight studies used students' statistics grades, four studies used statistics achievement tests, and one

study used course exams (quiz, midterm and final exams) to measure students' statistics achievement. Hedges and Olkin's *Q* statistic revealed that the correlations were heterogeneous. The findings showed a low relationship. The average effect size for the random effects model was .23 with a 95% confidence interval of .19 to .28, and statistically significant.

The last meta-analysis included 12 studies with 5283 participants from seven countries. The relationship between statistics achievement and students' perceptions about the difficulty of statistics was found to be low. All of the studies used SATS© to measure students' perceptions about the difficulty of statistics. From these 12 studies, seven of them used students' statistics grades, four used statistics achievement tests, and one study used course exams to measure students' statistics achievement. Hedges and Olkin's *Q* statistic revealed that the correlations analyzed in the current study were heterogeneous. The average effect size for the random effects model was .20 with a 95% confidence interval of .14 to .26, and statistically significant.

The study characteristics and correlations coefficients included in the meta-analyses are presented in Table 1.

Table 1

Study Characteristics and Correlations between Attitudes toward Statistics and Statistics Achievement

Variable	*Study*	*Country*	*Achievement measure*	*Attitudes measure*	*n*	*r*
Affect	Schutz et al., 1998	U.S.A.	grade	SATS©	94	.21
	Cashin & Elmore, 2005	U.S.A.	grade	SATS©	342	.45
	Nasser, 2004	Israel	test	SATS©	162	.18
	Bude et al., 2007	Netherlands	test	MSQ	94	.43
	Estrada & Batanero,2008	Spain	test	SATS©	367	.20
	Chiesi & Primi, 2009	Italy	test	SATS©	232	.29
	Chiesi & Primi, 2010	Italy	grade	SATS©	487	.27
	Demspter & McCorry, 2009	U.K.	test	SATS©	82	.23
	Finney & Schaw, 2003	U.S.A.	grade	SATS©	103	.60
	Schau, 2003	U.S.A.	grade	SATS©	268	.35
	Sorge & Schau, 2002	U.S.A.	exams	SATS©	264	.35
	Emmioglu, 2011	Turkey	grade	SATS©	214	.34
	Emmioglu et al., 2010	Turkey	grade	SATS©	49	.45
	Schau, 2010	U.S.A.	grade	SATS©	2715	.40
Cognitive Competence	Feinberg & Halperin, 1978	USA	exams	Exp.	278	.33
	Schutz et al., 1998	U.S.A.	grade	SATS©	94	.48
	Bessant, 2000	Canada	grade	Exp.	358	.51
	Sorge & Schau, 2002	U.S.A.	exams	SATS©	264	.27
	Finney & Schaw, 2003	U.S.A.	grade	SATS©	103	.64
	Onwuegbuzie, 2003	U.S.A.	test	Exp.	130	.25
	Schau, 2003	U.S.A.	grade	SATS©	268	.36
	Nasser 2004	Israel	test	SATS©	162	.28
	Cashin & Elmore 2005	U.S.A.	grade	SATS©	342	.43
	Estrada & Batanero,2008	Spain	test	SATS©	367	.26
	Chiesi & Primi 2009	Italy	test	SATS©	232	.29
	Demspter & McCorry 2009	U.K.	test	SATS©	82	.31
	Chiesi & Primi, 2010	Italy	grade	SATS©	487	.26
	Emmioglu et al., 2010	Turkey	grade	SATS©	49	.26
	Schau, 2010	U.S.A.	grade	SATS©	2706	.40
	Emmioglu, 2011	Turkey	grade	SATS©	214	.36

Note. MSQ:Motivation toward Statistics Questionnaire (Bude et al., 2007), Exp: Expected final grade

Table 1 continues

Study Characteristics and Correlations between Attitudes toward Statistics and Statistics Achievement

Variable	*Study*	*Country*	*Achievement measure*	*Attitudes measure*	*n*	*r*
Value	Schutz et al., 1998	U.S.A.	grade	SATS©	94	.16
	Nasser 2004	Israel	test	SATS©	162	.15
	Cashin & Elmore 2005	U.S.A.	grade	SATS©	342	.32
	Estrada & Batanero 2008	Spain	test	SATS©	367	.22
	Chiesi & Primi, 2009	Italy	test	SATS©	232	.20
	Chiesi & Primi, 2010	Italy	grade	SATS©	487	.19
	Demspter & McCorry 2009	U.K.	test	SATS©	82	.23
	Finney & Schaw, 2003	U.S.A.	grade	SATS©	103	.42
	Schau, 2003	U.S.A.	grade	SATS©	268	.30
	Sorge & Schau, 2002	U.S.A.	exams	SATS©	264	.09
	Emmioglu, 2011	Turkey	grade	SATS©	214	.16
	Emmioglu et al., 2010	Turkey	grade	SATS©	49	.33
	Schau, 2010	U.S.A.	grade	SATS©	2693	.28
Difficulty	Nasser 2004	Israel	test	SATS©	162	.11
	Cashin & Elmore 2005	U.S.A.	grade	SATS©	342	.30
	Estrada & Batanero 2008	Spain	test	SATS©	367	.09
	Chiesi & Primi 2009	Italy	test	SATS©	232	.17
	Chiesi & Primi, 2010	Italy	grade	SATS©	487	.20
	Demspter & McCorry 2009	U.K.	test	SATS©	82	-.05
	Finney & Schaw, 2003	U.S.A.	grade	SATS©	103	.51
	Schau, 2003	U.S.A.	grade	SATS©	268	.17
	Sorge & Schau, 2002	U.S.A.	exams	SATS©	264	.22
	Emmioglu, 2011	Turkey	grade	SATS©	214	.08
	Emmioglu et al., 2010	Turkey	grade	SATS©	49	.31
	Schau, 2010	U.S.A.	grade	SATS©	2712	.26

Conclusion

The current study demonstrated that students' attitudes toward statistics are important for explaining students' statistics achievement. The results of the meta-analyses revealed that students' cognitive competence in statistics ($r = .36$, $p < .05$) and affect toward statistics ($r = .34$, $p < .05$) has medium and statistically significant relationship with statistics achievement. Students' attitudes toward the value of statistics ($r = .23$, $p < .05$) and difficulty of statistics ($r = .20$, $p < .05$) have small but statistically significant relationship with statistics achievement.

The results of this study demonstrated the importance of students' attitudes toward statistics for succeeding in statistics. Accordingly, we suggest statistics educators to be aware of their students' attitudes toward statistics and adapt appropriate instructional methods in order to encourage their students' positive attitudes toward statistics. We also suggest further studies to examine the relationship between attitudes toward statistics and statistics achievement in different contexts and conduct further meta-analyses as new studies are added to the literature.

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