Do attitudes toward statistics change during an introductory statistics course? A study on Italian Psychology students

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Mixed results have been reported about changes that might occur in students' attitudes as a consequence of attending introductory statistics courses and about male and female students' differences in attitudes. Thus, the aim of the current study was to shed light on attitudes changes in students attending introductory statistics courses taking gender into account. Overall, we observed changes in attitude that resulted in a more positive attitude from the beginning to the middle of the course. Nonetheless, along with a general positive trend, it was possible to highlight that some students get significantly worse attitudes and many of them do not substantially change their initial attitudes. Overall, no significant differences were found between male and female students. Finally, probabilistic competences along with statistics anxiety accounted for individual changes in attitudes toward statistics. Educational implications were discussed.

Keywords: Statistics education, attitudes toward statistics, attitude changes; gender differences

Introduction

Attitude toward statistics is a disposition to respond favourably or unfavourably to objects, situations, or people related to statistics learning (Schau, Stevens, Dauphinee & del Vecchio, 1995). It is commonly described as a multi-dimensional concept that consists of affective (students' positive and negative feelings about statistics), cognitive (beliefs about the ability requested to learn statistics and about the discipline), and behavioral (interest and effort) components, which are deemed to have an effect on achievement. Emmioglu and Capa-Aydin (2012) provided a meta-analysis that addressed this relationship suggesting that there is a significant correlation between students' achievement and statistic-related beliefs, motivation, and feelings. Indeed, whereas the reviewed studies employed different research approaches and included different kinds of samples and courses, more positive attitudes were correlated - with different extent, and directly or indirectly- to a better course performance.

For this reason, a basic question of research refers to the changes that might occur in students' attitudes as a consequence of attending introductory statistics courses. Although some studies reported an increase in attitudes as a result of the courses (e.g., Bond, Perkins, & Ramirez, 2012; Chiesi & Primi, 2010), Schau and Emmioglu (2012) conducted a large-scale investigation reporting that the different attitude dimensions do not substantially change through the courses. Nonetheless, Millar and White (2014) highlighted that the mean changes were around zero but the variability in the individual changes was relatively large, i.e., whereas in some cases the attitudes actually did not changed, positive changes (i.e., shifts to a more positive attitude) and negative changes (i.e., shifts to a more negative attitude) were both observed.

Finally, literature on attitudes toward statistics addressed the issue of gender differences. Presumably due to the different sample and course characteristics (engineering students, economic students, psychology students, pre-service teachers), inconsistent results were reported. Some authors found that men expressed more positive attitudes toward statistics than women (e.g., Chiesi & Primi, 2015; Tempelaar & Nijhuis, 2007), others studies found no gender differences (e.g., Martins, Nascimento & Estrada, 2011), and some others documented more positive attitudes for women (e.g., Rhoads & Hubele, 2000).

These mixed results suggest, in line with the recommendation made by Eichler and Zapata-Cardona (2016), to intensifying research on students' statistics-related attitudes. Thus, the aim of the current study was to shed light on attitudes changes in students attending introductory statistics courses taking into account gender differences. The specific aims can be detailed as follows.

a. To investigate the possible changes in attitudes as result of the course. Based on previous studies conducted on similar samples (e.g., Chiesi & Primi, 2010), we hypothesized that a positive overall change might occur from the beginning to the middle of the course. To take into account possible gender-related difference in attitudes, we observed the differences from pre- to post-test in male and female students separately. We expected that the course had an effect on both genders.

b. To provide a more fine-grained investigation we looked at the individual differences in attitude changes, i.e. if the student shifted to a better attitude, or if she/he got worse attitudes as a result of the course, or if the student's attitudes remained unchanged. In defining these typologies we referred to Schau and Emmioglu (2012) and Millar and White (2014). They suggested that, along with the statistical significance of the change in attitude scores, it is important to ascertain if students' attitudes change consistently, i.e., if there is a substantial increase/decrease in the observed scores. As such, following their indications to determine the relevance of the score change, we investigated individual differences in attitude changes controlling for gender. We expected that positive and negative shifts as well as no changes might be observed in both men and women.

c. Since we expected that students – all attending the same course - might change in positive or negative their attitudes towards statistics or maintain them stable, we explored if some specific factors could accounted for individual differences. In line with previous studies on cognitive and non-cognitive factors related to statistics education (for a recent review see Eichler & Zapata-Cardona, 2016), we looked at mathematical and probabilistic competences along with test anxiety and statistics anxiety.

Method

Participants

Participants were 136 psychology students enrolled in an introductory statistics course at the University of Florence in Italy (mean age = 20.93 years, *SD* = 3.59; 70% female). They were first year students who did not have previous experience with the discipline at the university level but they might have encountered the discipline before in school-related contexts or in their out-of-school lives. All students participated on a voluntary basis after they were given information about the general aim of the investigation (i.e., collecting data for a research project on students' statistics achievement).

Description of the Course

The course was compulsory. It covered the usual introductory topics of descriptive and inferential statistics (including basic concept of probability theory and calculus), and their application in psychological research. It was scheduled to take place over 10 weeks, and takes 6 hours per week (for a total amount of 60 hours). During each class some theoretical issues were introduced followed by exercises using either paper-and-pencil procedure or a computer package (*R-commander*). Students were assigned homework for which they were allowed to work in groups. Consultation hours were also offered for one on one help with exercises. The instructor was one of the authors of the current paper.

Measures

Attitude toward statistics was measured administering the 28-item version of the *Survey of Attitudes toward Statistics* (SATS) (Schau et al., 1995; Italian version: Chiesi & Primi, 2009). The SATS contains Likert-type items using a 7-point scale ranging from *strongly disagree* to *strongly agree*. It assesses four attitudes components: Affect (6 items) measures positive and negative feelings concerning statistics (e.g. "I will feel insecure when I have to do statistics problems" or "I will like statistics"); Cognitive Competence (6 items) measures students' attitudes about their intellectual knowledge and skills when applied to statistics (e.g. "I can learn statistics" or "I will make a lot of math errors in statistics"); Value (9 items) measures attitudes about the usefulness, relevance, and worth of statistics in personal and professional life (e.g. "Statistics is worthless" or "Statistical skills will make me more employable"); Difficulty (7 items) measures students' attitudes about the difficulty of statistics as a subject (e.g. "Statistics formulas are easy to understand" or "Statistics is a complicated subject"). Two versions to use at the beginning (pre-SATS) and during or at the end (post-SATS) of the course were developed. For both the pre- and post- versions of the SATS responses to negatively scored items were reversed. Because the subscales were composed of a different number of items, scores were obtained by dividing each component score by the number of items that assess that component. As such all the scores ranged from 1 to 7 and higher scores indicated a more positive attitude. For Difficulty a positive attitude (i.e., high scores) means that students believe that statistics is easy whereas a negative attitude (i.e., low scores) means that it is harder.

The *Mathematics Prerequisites for Psychometrics* (MPP, Galli, Chiesi & Primi, 2011) was employed to measure the mathematical skills needed by students enrolling in introductory statistics courses. The MPP consists of 30 multiple-choice format questions (one correct out of four alternatives) from which a total score (range 0-30) was calculated. Additionally, the *Probabilistic Reasoning Questionnaire* (PRQ; Primi, Morsanyi & Chiesi, 2014), designed to measure proportional reasoning and basic probabilistic reasoning ability, was administered. The scale consisted of 16 multiple-choice questions from which a total score (range 0-16) was calculated.

The *Test Anxiety Inventory* (TAI; Spielberg, 1980) was administered to measure anxiety associated with test-taking situations. The TAI is self-report instrument consisting of 20 items. Respondents are asked to report how frequently they experience specific symptoms of anxiety from 1 (*almost never*) to 4 (*almost always*). A total score was calculated as the sum of all items, with higher scores corresponding to high test anxiety. Along with this general anxiety indicator, the specific anxiety toward statistics was assessed using the *Statistical Anxiety Scale* (SAS; Vigil-Colet, Lorenzo, & Condon, 2008; Italian version: Chiesi, Primi & Carmona, 2011). The SAS is a self-reported measure consisting of 24 items with a five-point rating scale ranging from 1 (*no anxiety*) to 5 (*very much anxiety*). The SAS includes Examination anxiety (8 items, e.g., "Studying for examination in a

statistics course"), Asking for help anxiety (8 items, e.g., "Asking the teacher how to use a probability table"), and Interpretation anxiety (8 items, e.g., "Trying to understand a mathematical demonstration"). A composite score was calculated with higher scores corresponding to high statistics anxiety.

Procedure

Students were administered the SATS-pre, the MPP, the PRQ, and the TAI at the beginning of the course. At the middle of the course (about four weeks later), the SATS-post was administered along with the SAS. The questionnaires were introduced briefly to the students and instructions for completion were given. Answers were collected in paper-and-pencil format and the time needed to complete them ranged from 20 to 40 minutes.

Results

To ascertain the possible changes in attitudes toward statistics and the gender related differences, we ran a 2×2 mixed ANOVAs with course (pre/post) as a within-subjects factor, and gender as between-subjects factors on each of the four attitude dimensions. It was found a main effect of course - that resulted in an overall increase - on Affect ($F(1, 134) = 17.34$, $p<.001$, $\eta_p^2 = .12$; pre: $M = 3.44$, $SD = 1.08$, post: $M = 3.74$, $SD = 1.25$), Difficulty ($F(1, 134) = 24.17$, $p < .001$, $\eta_p^2 = .15$; pre: $M = 3.23$, $SD = 0.64$, post: $M = 3.51$, $SD = 0.66$), Cognitive Competence ($F(1, 134) = 59.67$, $p < .001$, $\eta_p^2 = .31$; pre: $M = 4.19$, $SD = 1.01$, post: $M = 4.72$, $SD = 1.07$), and Value ($F(1, 134) = 4.89$, $p < .05$, $\eta_p^2 = .04$; pre: $M = 5.03$, $SD = 0.85$, post: $M = 5.20$, $SD = 0.94$). With the exception of Value ($F(1, 134) = 1.91$, $p = .17$), significant between-subject differences were found for the remaining attitude dimensions (Affect: $F(1, 134)=8.36$ $p < .01$, $\eta_p^2 = .06$; Difficulty: $F(1, 134) = 4.82$, $p < .05$, $\eta_p^2 = .04$; Cognitive Competence: $F(1, 134) = 6.17$, $p < .05$, $\eta^2 = .04$) with male holding more positive attitudes. Nonetheless, there were not significant course by gender interactions (Affect: $F(1, 134) = 2.08$, $p = .15$); Difficulty: $F(1, 134) = 0.26$, $p = .61$; Cognitive Competence: $F(1, 134) = 1.99$, $p = .16$; Value: $F(1, 134) = 0.89$, $p = .35$) indicating that attitudes improved regardless gender differences in the attitude degrees. In Figure 1 the descriptives by gender are reported for each attitude dimension.
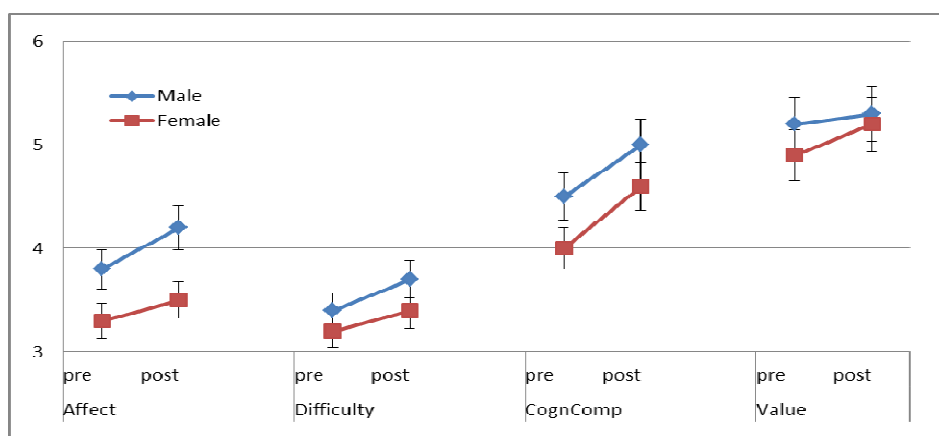
Figure 1. Mean scores of the four components of the *Survey of Attitudes toward Statistics* (SATS) at the beginning and at the middle of the course in male and female students.

Because the rating scale ranged from 1 to 7 and 4 is the midpoint, mean values revealed that male students were around the midpoint at the beginning of the course and later tended to be above it. Female students, whereas they get better across time, remained below it. On average, even taking into account the positive shift from the beginning to the middle of the course, both men and women were below the midpoint for Difficulty, whereas scores over it were observed for Cognitive Competence and Value.

To look at the individual differences, i.e. if students get better, worse, or unchanged attitudes, we referred to Schau and Emmioglu (2012) and Millar and White (2014) to weigh the relevance of the change. Thus, we considered differences of about .5 point or more in absolute value as important. This means that students' scores would change consistently if they changed, for example, their Likert scale responses by 1 point on half of the items in the component. In the current study, to take into account the direction of change, we classified the score as follows: a negative difference of .5 point or less indicated a substantive decrease, a positive difference of .5 point or more indicated a substantive increase, all the other values indicated no substantive changes To take into account possible gender-related difference in attitudes, we observed the kind of pre-/post-test differences separately in male and female students (Figure 2).
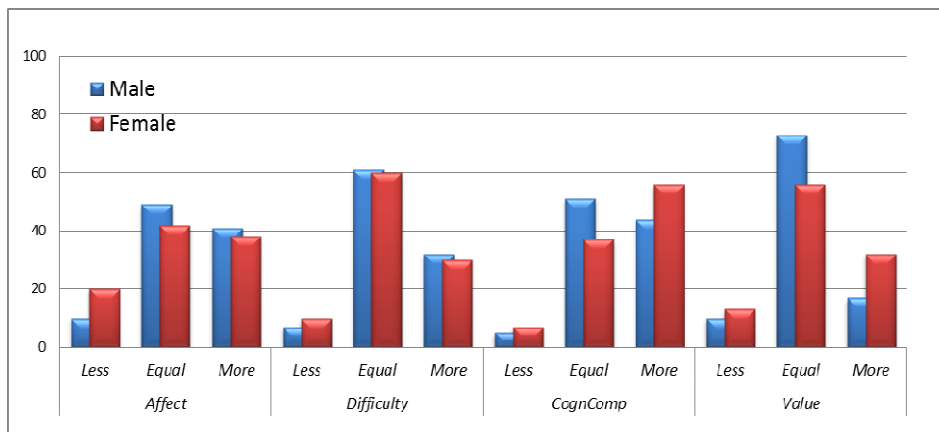
Figure 2. Percentages of negative, stable and positive pre-post difference scores of the four components of the *Survey of Attitudes toward Statistics* (SATS) in male and female students.

Chi-square tests indicated no significant differences between genders (Affect: $\chi^2(2) = 2.16, p = .34$; Difficulty: $\chi^2(2) = .34$, $p = .84$; Cognitive Competence: $\chi^2(2) = 2.48$, $p = .30$; Value: $\chi^2(2) = 3.83$, $p = .15$). Comparing the four components, the highest percentage of negative shifts (more than 15%) was found for the Affect component. A prevalence of stable scores (60% or more) was observed for the Difficulty and Value dimensions. Finally, we registered the highest percentage of positive shifts (about 50%) for the Cognitive Competence component.

To establish the relative impact of mathematical and probabilistic competences, test anxiety, and statistics anxiety on attitude changes, regression analyses were run (Table 1). In order to capture the variability in the changes occurred from the first to the second assessment, the criterion variable was the difference between the pre- and post-test scores. Given the overall absence of gender differences these analyses were conducted on the total sample. Results showed that none of these factors

explained changes in Cognitive Competence ($F(4,130) = 0.71, p = .59$) and Value ($F(4,130) = 0.76$, $p = .55$). On the contrary, the regression models indicated that probabilistic competences and statistics anxiety contributed in explaining changes in Affect ($F(4,130) = 4.90$, $p < .01$, $R^2 = .13$) and Difficulty ($F(4,130) = 5.02$, $p < .01$, $R^2 = .14$). Specifically, higher competences were associated with higher positive changes, whereas higher anxiety levels were associated with higher negative changes. Finally, test anxiety predicted changes in Difficulty in the same direction observed for statistics anxiety, i.e., the greater the degree of anxiety, the less the attitude increase (Table 1).

Criterion	Predictors	β	t	p
Affect change	*Mathematical competence (MMP)*	.045	0.41	.66
	Probabilistic competence (PRQ)	.29	2.87	.005
	Test anxiety (TAI)	.04	0.45	.65
	Statistics anxiety (SAS)	-.24	-2.33	.02
Difficulty change	*Mathematical competence (MMP)*	.15	1.46	.15
	Probabilistic competence (PRQ)	.25	2.47	.015
	Test anxiety (TAI)	-.20	-2.02	.045
	Statistics anxiety (SAS)	-.36	-3.60	<.001

Table 1. Regression analyses on statistics attitude changes (in brackets the scales employed to measure the predictor variables)

Discussion

The current study aimed at investigating in detail attitude changes in male and female Italian psychology students attending introductory statistics courses. In doing that, we took into account some cognitive and non-cognitive variables that might help in shed light on individual differences in attitude changes. Overall, we observed changes in attitude that resulted in a more positive attitude from the beginning to the middle of the course. Except for the Value component, men held more positive attitudes. However, there were not significant course by gender interactions indicating that attitudes improved in both male and female students. On average, and regardless the positive shift from the beginning to the middle of the course, both men and women believed that statistics was difficult, although they had confidence they would be able to learn it. Finally, all students valued statistics somewhat positively.

To provide a more fine-grained investigation we looked at the individual differences in changes as well as to the relevance of the change. Indeed, along with a general positive trend, it is possible to highlight that, although part of the students shifted markedly to better attitudes, some of them got significantly worse attitudes, and many of them did not substantially change their initial ones. Investigating gender-related difference in attitude changes, we observed no significant differences in male and female students. Thus, looking at the general patterns of change, it emerged that about half of the sample remained substantially stable across the four attitude dimensions (with the higher percentage for the Value component), more than one third of the sample shifted to a more positive

attitude (with the higher percentage for the Cognitive Competence component), and a small percentage showed a negative shift (with the higher percentage for the Affect component).

When looking at the factors influencing the direction of the shift, we observed that probabilistic competences along with statistics anxiety accounted for changes in Affect and Difficulty components. That is, students with stronger competences were more likely to move to positive feelings about the discipline and to consider it less hard. At the same time, more anxious students were more resistant to positive changes, i.e., they persistently dislike statistics and consider it hard.

Given these findings, it is interesting to note that the course *per se* promote positive changes in the students' attitudes. That is, arguably when interacting directly with the topics at an introductory level, some students tend to perceive it in a more favorable way. However, many students do not change or even get worst attitudes. Thus, it becomes important to identify methods for promoting better attitudes, for example arranging activities in which students could reinforce their basic competence in probability and providing them the adequate learning strategies to cope with anxiety. As such, they can perceive the subject easier and reduce negative feelings toward the discipline.

The present study has some limitations that we have to take into account when interpreting the results. First of all, it was conducted with Italian psychology students and this may limit their generalizability. Thus, future investigations should be conducted with different student populations to provide further evidence on the changes in attitudes and their determinants. Second, individual differences in changes of the value and cognitive competence components remain basically unexplained. As such, other factors (i.e., self-efficacy, motivation) should be taken into account to understand why some people do not change while others do. Finally, students valued statistics somewhat positively contradicting to some extent previous results on psychology students (e.g., Dempster & McCorry, 2009). This might be a result of social desirability effect that should be controlled in further studies.

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