WHAT HAPPENS WHEN ATTITUDES TOWARD STATISTICS CHANGE (INCREASE *VS* DESCREASE) DURING THE COURSE?

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Positive attitudes toward statistics are related - with different extent, and directly or indirectly- to a better achievement. What educators do during their courses might help students in improving their attitudes, but it is also possible that it produces no change or even a negative change. Investigating changes in attitudes that occur attending an introductory statistics course, we aimed to highlight their relationships with the exam performance and the learning strategy adopted by students. Results attested that a decrease in the affective component of attitudes toward statistics was more likely to be associated to ineffective learning strategies, poor performances, and exam failures. These findings confirm the importance of implementing pedagogical techniques that help in improving students' positive attitudes.

INTRODUCTION

Statistics education research has investigated the interactions between cognitive and non-cognitive factors in learning statistics (e.g., Chiesi & Primi, 2010; Hood et al., 2012; Primi, Donati & Chiesi, 2017; Tempelaar, van Der Loeff & Gijselaers, 2007) and particular attention has been paid to the relationship between attitudes toward statistics and achievement in statistics (for a meta-analysis, see Emmioglu & Capa-Aydin, 2012). Although different research approaches, samples, and courses, literature provides evidence that more positive attitudes correlate - with different extent, and directly or indirectly- with better course performances. As possible explanations it was suggested that students with positive attitudes are more likely to be more confident and less anxious (e.g., Onwuegbuzie, 2003), to engage in fruitful learning behaviors (e.g., Chiesi & Primi, 2015, 2017a), and to be interested in statistics for their future academic and professional activities (e.g., Ramirez, Schau & Emmioglu, 2012).

Attitude toward statistics is a disposition to respond favourably or unfavourably to objects, situations, or people related to statistics learning. It is commonly described as a multi-dimensional construct that consists of affective (feelings about statistics), cognitive (beliefs about the ability requested to learn statistics), and judgmental (views about the value and difficulty of the discipline) components (Schau, Stevens, Dauphinee & del Vecchio, 1995). What educators do during their courses might help in improving students' feelings, beliefs, and judgments about the discipline but it is also possible that it might result in negative changes, or, alternatively, it might not produce any change. Thus, changes in attitudes that occur during the course have been investigated measuring the attitudes at the beginning of the course and then in different moments during the course (e.g., at the midterm, at the end). Looking at the mean differences, some studies reported an increase in attitudes from the beginning to the end of the course (e.g., Chiesi & Primi, 2010; Swanson VanderStoep & Tintle, 2014), while other ones (e.g., Bond, Perkins & Ramirez, 2012; Schau & Emmioglu, 2012) showed that none of the different attitude dimensions significantly changed through the courses. Nonetheless, Millar and White (2014) suggested to investigate changes at the individual level and not the general trends, i.e., to look at the individual increases and decreases as well as the magnitudes of the pre-post changes.

In line with the Eichler and Zapata-Cardona's (2016) suggestion to intensifying research on students' statistics-related attitudes, the aim of the current study was to investigate changes in attitudes in a sample of students attending introductory statistics courses, and to highlight the effect of a change on both achievement and learning approach. Specific aims can be detailed as follows.

- First of all, we aimed to describe *individual differences in attitude changes* that might occur during the course, i.e., if students shifted to a better/worse attitude, or if they simply do not change their attitudes. To define these differences and their relevance, we referred to Schau and Emmioglu (2012) and Millar and White (2014): we considered as noteworthy a difference of about 0.5 point or more. By and large, this means that students' attitudes are deemed to change consistently if their ratings change at least on half of the items used to measure each

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attitude dimension. In line with a previous study conducted on a similar sample and focused on the predictors of changes in attitudes (e.g., Chiesi & Primi, 2017b), we expected to find individual differences in attitude changes.

- Second, we investigated the effect of a *change in attitudes on achievement* comparing students who get better and worse attitudes. Having in mind that more positive attitudes are related to a better exam performance (Emmioglu & Capa-Aydin, 2012), we hypothesized that a negative change might result in a lower grade and even in an exam failure.
- Finally, we explored the effect of changes in attitudes on students' approach to learning (e.g., Entwistle, 1991; Marton & Saljo, 1976a, 1976b). From previous studies (Chiesi & Primi, 2015; 2017a) we know that attitudes toward statistics have an effect on learning approaches, which in turn impact on achievement. Specifically, we found that attitudes toward statistics affected the way in which students move towards the discipline. If students perceive statistics as difficult and worthless, have negative feelings, and are not self-confident in their ability to deal with, they are more likely to adopt a *surface* approach in learning. That is, they focus on rote-learning, study the topics in an unrelated manner, and misunderstand important concepts. As a consequence, they get poor learning outcomes. Starting from this premise, we focused our attention on the *surface* approach and we investigated in which way a positive or negative changes in attitudes toward statistics might be related to this kind of approach to learn.

METHOD

Participants

Data were collected from 130 psychology students (N = 130; 71% female; mean age = 20.94, *SD* = 3.65) enrolled in an undergraduate introductory statistics course at the University of Florence in Italy. The course was compulsory for psychology students. The course was scheduled to take place over 10 weeks, at 6 hours per week (for a total amount of 60 hours). It covered the usual introductory topics of descriptive and inferential statistics, and their application in psychological research. During each class some theoretical issues were introduced followed by practical examples and exercises. Students were requested to solve exercises by paper-and-pencil procedure, and and computer package (*R-commander*). The course was organized presenting the students some seminal articles in which sound methodology and statistical analyses were employed inside the research in psychology. The instructor aimed at fostering a positive attitude toward the discipline showing the importance for the formative pathway and the future professional life of a psychologist. All students participated on a voluntary basis after they were given information about the general aim of the investigation (i.e., collecting information in order to improve students' statistics achievement).

Measures

The 28-item version of the *Survey of Attitudes toward Statistics* (SATS-28; Schau et al., 1995; Italian version: Chiesi & Primi, 2009) was used to assess attitudes. The SATS-28 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 am scared by statistics" or "I 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", "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", "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", "Statistics is a complicated subject"). Two versions to use at the beginning (pre-SATS) and at the end (post-SATS) of the course were developed. For both the pre- and post- versions the SATS responses to negatively scored items were reversed, and a score for each attitude component is calculated as the mean response to all items that assess that component, i.e., because each factor was composed of a different number of items, scores were obtained by dividing each component score by the number of items. Higher scores indicated a more positive attitude. The meaning of positive attitudes is clear for all components, except for

Difficulty. Higher scores on the Difficulty component indicate that students believe that statistics is easier whereas lower scores mean that they think it is harder.

The Surface scale of the *Approaches and Study Skills Inventory for Students* (ASSIST; Tait et al., 1998) developed by Chiesi et al. (2015) was administered. The scale measures a learning approach characterized by a lack of personal engagement in the learning process. It contains 12 statements, and respondents indicate the degree of their agreement with each statement using a five-point Likert scale where 1 = disagree and 5 = agree. The statements are combined into three subscales of four statements each: Lack of Purpose (e.g., "I'm not really interested in this course, but I have to take it for other reasons", "Often I find myself wondering whether the work I'm doing here is really worthwhile"), Unrelated Memorizing(e.g. "Much of what I'm studying makes little sense: it's like unrelated bit and pieces", "I often have trouble in making sense of the things I have to remember"), Syllabus-Boundness (e.g., "I tend to read very little beyond what is actually required to pass", "I concentrate to learning just those bits of information I have to know to pass"). A total score is calculated as the mean response to all items that assess the approach.

Finally, achievement was assessed considering students' midterm grades. The grade was assigned through a written task, which consisted of a multiple-choice and open-ended questions constructed by instructors. All the items pertained to contents covered in class (e.g., students were asked to read frequency distributions, two-way tables, and graphs, to define central tendency, spread and association measures, to interpret output of data analyses conducted with *R-Commander*). Grades range from 0-30. From 0 to 17 the grade is considered insufficient in accordance with the Italian University Grading System. Thus, only student who obtain 18 or higher grades pass the examination.

Procedure

Students were administered the pre-SATS during the first day of class. The Surface scale of the ASSIST was completed during the fourth week of the course along with the post-SATS. 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 10 to 15 minutes. The achievement was assessed at the midpoint (about the fifth week) of the course. The test was timed (1 hour) and it was run under exam conditions. Only students who passed this midterm test were allowed to sit to the second one at the end of the course.

RESULTS

Attitude change: Referring to Schau and Emmioglu (2012) and Millar and White (2014), we computed the difference between the pre-SATS and post-SATS scores for each attitude dimensions and we defined three groups labeled as follows: *Decrease* (the negative score difference was 0.5 point or less), Stable (the score difference was comprised in the range between -.05 and .05), and *Increase* (positive score difference were 0.5 point or more).

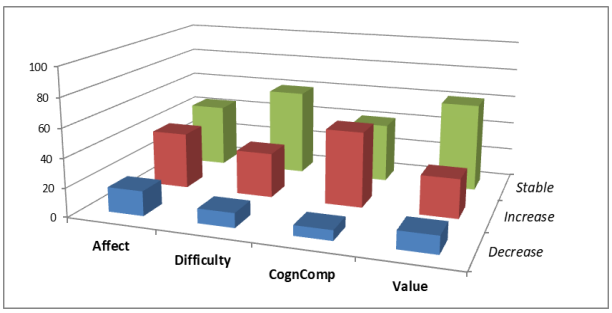

Figure 1. Change in each of the four attitude dimensions as measured by the pre- and post- version of the *Survey of Attitudes toward Statistics* (SATS).

Results are displayed in Figure 1. The highest percentage (more than 15%) of negative shifts was registered for the Affect component. Similar patterns were observed for the Difficulty and Value dimensions: about 10% of reduced scores, 60% of unchanging scores, and 30% of raised

scores. We observed the higher percentage of positive shifts (about half of the sample) in the Cognitive Competence component.

Attitude change and Achievement: Having observed that some students shifted to a higher score (*Increase* group) and some others shifted to a lower one (*Decrease* group) in the different dimensions of the SATS, we compared their grades at the midterm exam to highlight the effect of their attitude change on achievement. We excluded from this analysis students who showed unchanged scores (*Stable* group) because the effects on achievement cannot be clearly interpretable. Thus, comparing positive *vs* negative shifts in the four attitude components, results showed a significant difference in the midterm test grade for the Affect dimension ($t(74)= -3.26$, $p<.01$, $d = 0.80$; $M_{Dec} = 14.91$, $sd = 5.37$, $N = 23$; $M_{Inc}= 19.39$, $sd = 5.54$, $N = 53$). That is, students who showed a decrease in the Affect subscale obtained lower grades at the exam when compared to those ones who showed an increase (Figure 2) and the effect size associated to this difference was large. Indeed, a Cohen's *d* of 0.8 indicates that 79% of the Decrease group is beyond the mean of the Increase group, and there is a 71% chance that a student picked at random from the first group would have a lower grade than a student picked at random from the second group. In particular, remembering that to pass the exam a minimum grade of 18 is needed, students who showed a negative change were more likely to fail ($\chi^2(1) = 6.57$, $p = .01$): 65% of them did not pass the exam while the percentage of failures was 33% for those students who showed a positive change (in line with the percentage of failures of the whole sample, which was 37%).

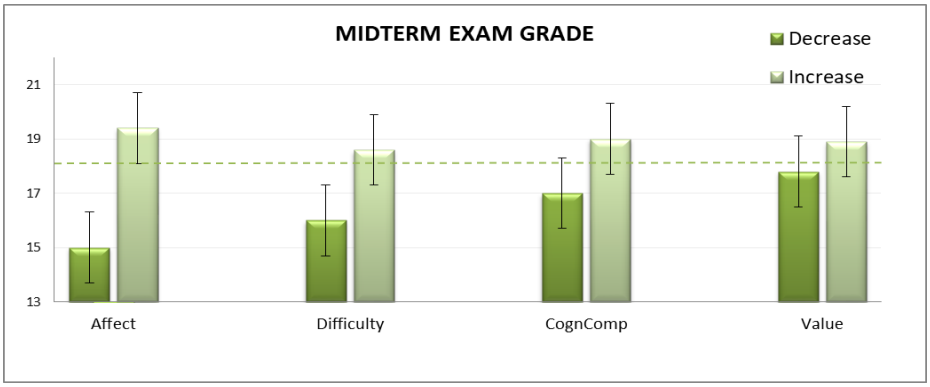

Figure 2. Achievement (mean grade) in students who shifted to a worst (decrease) or to a better (increase) attitude for each dimensions of the *Survey of Attitudes toward Statistics* (SATS).

When comparing the Increase *vs* Decrease groups for the other three dimensions (Figure 2), grade mean differences failed to reach a statistical significance (Difficulty: ($t(53)= -1.36$, $p=.18$, $d = 0.40$; $M_{Dec} = 16.15$, $sd = 6.65$, $N = 13$, $M_{Inc} = 18.57$, $sd = 5.26$, $N = 42$, Cognitive Competence: ($t(78)= -1.15$, $p=.25$, $d = 0.38$, $M_{Dec} = 16.78$, $sd = 6.30$, $N = 9$; $M_{Inc} = 18.97$, $sd = 5.28$, $N = 71$, Value: ($t(51)= -0.71$, $p=.48$, $d = 0.21$; $M_{Dec} = 17.81$, $sd = 4.80$, $N = 16$, $M_{Inc} = 18.89$, $sd = 5.22$, $N = 37$). Nonetheless, the *Decrease* groups were very small in size ($N \leq 16$) and these small samples might preclude achieving significance. Indeed, when looking at the effect size we found a Cohen's *d* of about 0.4 for the Difficulty and Cognitive Competence dimensions, i.e., about the 65% of the Decrease group are beyond the mean of the Increase group, and there is about the 60% chance that a student picked at random from the first group would have a lower grade than a person picked at random from the second group.

Attitude change and Learning approach: As a preliminary step, we confirmed that a Surface approach score was negatively correlated with achievement ($r(N=130) = -.22$, $p<.001$). Then, looking at the relationship between changes in attitudes and this learning approach, a significant difference was observed when comparing students who changed in the Affect dimension ($t(73)= -2.60$, $p<.05$, $d = 0.62$, $M_{Dec} = 2.30$, $sd = 0.42$, $N = 23$; $M_{Inc} = 2.61$, $sd = 0.57$, $N = 52$). Specifically, students who showed a decrease in the affective component of attitudes toward statistics were more prone to adopt a surface approach than those ones who showed an increase. The effect size associated to this difference was of 0.62 indicating that 73% of the Decrease group

are above the mean of the Increase group, and there is a 66% chance that a "negative shift" student would be more prone to adopt a surface approach than a "positive shift" student.

For all the other dimensions, mean differences in the Surface score failed to reach a statistical significance (Difficulty: $t(53)= -0.22$, $p=.83$, $d = 0.09$; $M_{Dec} = 2.37$, $sd = 0.37$, $N = 13$, $M_{Inc} = 2.41$, $sd = 0.49$, $N = 42$; Cognitive Competence: $t(78)= -0.98$, $p=.33$, $d = 0.36$, $M_{Dec} = 2.58$, $sd = 0.50$, $N = 9$; $M_{Inc} = 2.39$, $sd = 0.46$, $N = 71$; Value: $t(51)= -0.73$, $p=.48$, $d = 0.55$; $M_{Dec} = 2.38$, $sd = 0.40$, $N = 16$, $M_{Inc} = 2.15$, $sd = 0.44$, $N = 37$). Nonetheless, when we look at the Cohen's *d* for the Cognitive Competence and Value dimensions, we observe a medium effect size indicating again that negative shifts were more likely to be associated with higher surface approach score than positive shifts.

CONCLUSION

To provide new insights on the impact of non-cognitive factors on statistics achievement in higher education, the aim of the current study was to shed light on attitudes changes in students attending introductory statistics courses. Thus, we investigated changes that occurred during the course but, in particular, we focused on individual differences. That is, we described what happened to students' attitudes during the course, identifying no changes as well as positive and negative shifts. Specifically, results showed that more than the half of the sample did not change their initial attitudes, i.e., self-confidence, positive or negative feelings, value and difficulty ascribed to statistics. However, about one third of the student showed a positive shift in these components and, in particular, they get more confident about their ability to cope with the discipline. Finally, we observed some negative shifts, especially in the affect component, since some students get more scared and disliked statistics more.

Then, to understand the effect of a shift to better/worst attitudes on achievement, we compared the exam performance of these two groups. Results suggested that a negative change was related to negative outcomes. Indeed, these students get lower grades and were more likely to fail at the exam. To identify a possible reason of these poor outcomes, we looked at the learning approach and we found that if a student gets worse attitudes, she/he tends to adopt a surface approach in studying.

Overall, these findings suggest that intervention strategies in statistics education should support positive changes in attitudes toward the discipline and, in particular, they should contrast negative ones. Indeed, students who hold negative attitudes toward statistics aren't willing to put in the effort needed to learn statistics (Schau, Miller & Petocz, 2012). As such, the course attendance should enhance students' attitude by the implementation of pedagogical techniques that are effective in reducing students' negative feelings, improving their perceived competence, catching the utility of the discipline for their future professional lives.

Finally, some limitations of the present study need to be acknowledged and amended in future investigations. Indeed, the current results are limited by the specific sample characteristics (i.e., Italian Psychology students) and by the limited size of some sub-samples. Although these limitations, the current study offers new insights on the interplay between cognitive and non-cognitive factors in statistics achievement.

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