WHO FAILED THE INTRODUCTORY STATISTICS EXAMINATION? A STUDY ON A SAMPLE OF PSYCHOLOGY STUDENTS

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ABSTRACT
The purpose of the present study was to explore factors linked to the difficulties encountered by psychology students in introductory statistics courses. Data were collected over a two-year period and a between-subjects design was conducted in order to stress differences between students who failed one or more times at the final examination and students who did not fail. Differences concerning background in mathematics, math competences, attitudes and anxiety toward statistics, performance in statistics final examination were found. From the present results we obtain indications to identify students who are likely to encounter learning difficulties when enrolled in statistics courses, and suggestions to provide teaching intervention strategies.

INTRODUCTION

Psychology students are required to enrol statistics and quantitative-based research methodology courses inside their degree programs. Teaching statistics to psychology students aim to prepare them to understand and to use statistical data in their field of study. As documented in many educational contexts (Carmona, Matìnez & Sànchez, 2005; Onwegbuzie, 2003), instructors as well as students enrolled in statistics courses often encounter difficulties. Teachers, despite their efforts, fail to adequately prime their students and often they experience frustration in doing their work. Students are troubled in dealing with these disciplines and they often attain low level of performance on examinations. Moreover, they sometimes fail. In this way, these courses delay the completion of the degree program and in some cases they are an obstacle to the attainment of the degree.

Factors related to performance in quantitative discipline and their interrelations have been largely investigated in order to understand the mechanism underlying achievement (Lalonde & Gardner, 1993; Nasser, 2004; Onwuegbuzie, 2003; Sorge & Shau, 2002; Tremblay, Gardner & Heipel, 2000). Most of these studies presented models in which the causal paths among variables related to achievement were explored.

Lalonde and Gardner (1993) hypothesized that statistics learning could be conceptualized as second language learning. In their model achievement was related to mathematical ability, statistics anxiety and attitudes as well as motivational factors. Analyses showed the importance of mathematical ability, which had the main effect on statistics achievement. Tremblay and colleagues (2000), studying the impact of the same variables, supported the hypothesis that mathematical ability contribute to the prediction of achievement in statistics as suggested by other studies (Harlow, Burkholder & Morrow, 2002; Schutz, Drogosz, White & Distefano, 1999); furthermore, they found a relationship between anxiety toward statistics and achievement according to previous studies (Onwuegbuzie,1998; Onwuegbuzie & Seaman, 1995; Zeidner, 1991).

Sorge and Schau (2002) examined possible causal relationships among students' previous academic success (i.e. outcomes from prior learning experiences), their attitudes toward statistics and their achievement in a introductory statistics course; they found that previous success and attitudes toward statistics were positively correlated to statistics achievement according to previous researches which revealed the effects of attitudes on performance (Gal, Ginsburg & Shau, 1997; Wisenbacker, Scott & Nasser, 2000).

Onwuegbuzie (2003) proposed a model to predict statistics achievement by students' educational background, self-efficacy and anxiety. The model stressed that anxiety was negatively correlated with mathematics ability and achievement. Nasser (2004) examined the extent to which anxiety and attitudes toward mathematics and statistics, motivation and mathematical ability could explain the achievement of pre-service teachers enrolled in introductory statistics course. Consistent with previous studies

(Lalonde & Gardner, 1993; Tremblay et al., 2000) it was reported a high positive effect of mathematical ability.

In some studies carried out in Italy, introductory statistics achievement has been related to attitudes toward the discipline at the beginning and at the end of the course, anxiety, and mathematical competence (Chiesi, Primi & Petrucci, 2005; Primi & Chiesi, 2007). In particular, according to previous results (Harlow, et al., 2002; Lalonde & Gardner, 1993; Nasser, 2004; Schutz, et al., 1999; Tremblay, et al., 2000), mathematical background (high school achievement) and maths competence played the major role in performance in introductory statistics course.

Most of the above mentioned studies, by and large, investigated the interrelations among factors related to statistics achievement and their effect on performance using a within-subject experimental design. The present research examined this relations using a between-subjects design in order to identify the characteristics of those students who are likely to encounter learning difficulties when enrolled in statistics courses. In particular, achievement related factor differences between the students who passed the exam at the first attempt and students who failed were investigated.

Taking into account the findings of the above mentioned studies, mathematics background (prior achievement in mathematics), mathematical competence, attitudes toward statistics, and anxiety toward statistics were taken into account. Moreover, the effect of failure on performance was explored.

METHOD

The sample for this study consisted of 442 psychology students (17% males and 83% females) of the University of Florence. Age ranged from 19 to 53, with a mean age of 21.45 (*SD* = 4.32) years. They enrolled introductory statistics course in the first semester of 2005.

Several instruments were administered in order to collect data about variables of interest.

The *Prerequisiti di Matematica per la Psicometria* (PMP) scale (Galli, Chiesi & Primi, 2008) is a 30-problem test developed to assess math basics for introductory statistics courses. Each problem presents a multiple choice question (one correct among four alternatives). The test includes six areas: *Fractions* (e.g. "Which is the result of 2/5 ÷ 3/2?), *Operations* (e.g." In a school there are 125 students; the students who passed an examination are 116. Which is the percentage of the students who failed?); *Equations* (e.g. "Which is the result of the following equation: (5+3)x= 0?); *Relations* (e.g. "The value -.98 is within"); *Probability* ("What is the probability to draw one ace from a pack of 40 cards?"); *Set-theory* ("The set A includes odd numbers within 8 and 20, whereas the set B includes all numbers lower than 10. How many elements the two sets share?"). Moreover students' mathematics background information were collected: high school *final Math Grade* (range 0-10) and *Learning Debts* in math during the three last years of high school (range 0-3). In the Italian high schools debts are attributed to students that have insufficient grade at the end of the year. At the beginning of the following school year the students have to succeed in an examination test in order to prove they have reached the requested level of achievement.

The *Survey of Attitudes Toward Statistics (*SATS) (Schau, Stevens, Dauphinee & Del Vecchio 1995) was administered to measure attitudes toward statistics. It contains 28 Likert-type items using a 7-point scale. It exists in two forms to administer at the beginning of the course (pre-SATS) and at the end of the course (post-SATS). The SATS 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"); *Cognitive Competence* (6 items) measures students' attitudes about their intellectual knowledge and skills when applied to statistics (e.g. "I can learn statistics"); *Value* (9 items) measures attitudes about the usefulness, relevance, and worth of statistics in personal and professional life (e.g. "Statistics is worthless"); *Difficulty* (7 items) measures students' attitudes about the difficulty of statistics as a subject (e.g. " Statistics formulas are easy to understand").

The *Statistical Anxiety Rating Scale* (STARS) (Cruise, Casch & Bolton, 1985) was used to measure statistics anxiety. It is a 51-item (5-point Likert format) instrument organized in two parts. The first part includes 23 items ranging from "No anxiety" to "Very much anxiety", related to different aspects of statistic anxiety ("Studying for the final exam") and the second part includes 28 items

ranging from "Strong disagreement" to "Strong agreement" related to respondent's feeling toward statistics ("Statistics is useless").

Concerning achievement measures, the final examination included a written test (three problem solving questions and six open-ended conceptual questions) and an oral interrogation. The grade derived both from the written and verbal assessment (range 0 - 30) allowed scoring both *Final Grade* (scores equal or greater than 18) and *Failure* (scores less than 18).

The pre-SATS was administered the first day of class. The PMP was presented the second day of the course the STARS was administered about at the half of the course and the post-SATS at the end of the course. Each survey was presented briefly to the students and they were given instructions for compilation. Answers were collected in paper-and pencil form and the time needed to complete them ranged from 15 to 30 min. Each written test was timed (40 min). The final grades and failures were registered from June 2005 to February 2007.

RESULTS

From data emerged that the 22.4% (N = 99) of the students failed once, the 9.5% (N = 42) failed twice, the 5.1% (N = 21) failed at least three times. The *Failure* variable was recoded as dichotomous one defining two categories: *No Failure (NF)* and *Failure (F)*. Thus, it was found that *NF* students (i.e., who passed the exam at the first attempt) were the 63% (N = 280), whereas the *F* students (i.e., who needed several attempts to pass the exam) were the 37% (N = 162).

Concerning the mathematics background, the final maths grade was significantly different between the two groups ($t_{(297)}$= 3.09, $p < .01$) with a medium effect size (d = .37): *NF* students had higher math grade (M = 6.92, SD = 1.13) than *F* students (M = 6.48, SD = 1.25). Moreover a significant relationship between learning debts in math and failures ($\chi^2_{(1,\ n\ =\ 311)}$ = 13.96, $p < .001$) was found; students who had learning debts were more likely to fail the final exam (Figure 1).

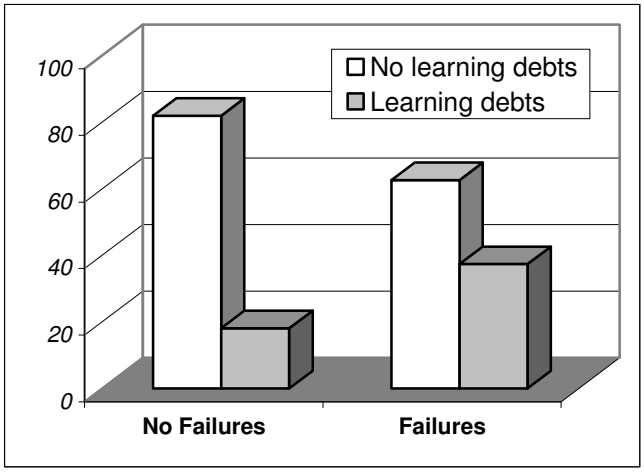

Figure 1. Percentages of students with/without learning debts among who failed or did not fail.

Concerning the student's math competence, *NF* students had an higher math competence (M = 23.71, SD = 4.6) than *F* students (M = 20.48, SD = 5.9). The difference was statistically significant and large in size ($t_{(323)}$= 5.39, $p < .001$, d = .61).

With regard to the others variables investigated, the attitude toward statistics was significatively different with a small to medium effect size at the beginning of the course between the two groups ($t_{(350)}$= 2.96, $p < .01$, d =.33): *NF* students had a more positive attitude (M = 117.40, SD = 17.24) than *F* students (M = 111.83, SD = 16.35). The same difference was found also at the end of the course ($t_{(256)}$= 5.41, $p < .001$) but the effect was larger (d =.77): the first group had a more positive attitude towards statistics (M =128.42, SD = 19.90) than the other group (M = 113.54, SD = 18.57). The pre-course and post-course attitude toward statistics scores of *NF* students were significantly different and medium in

size ($t_{(153)}$= -8.41, p < .001, d = .59), indicating a more positive attitude at the end of the course; whereas the pre-course to post-course attitude toward statistics scores of *F* students were not significantly different ($t_{(54)}$= -1.05, p = .319), indicating that the attitude of the *F* students did not change at the end of the course (Figure 2).

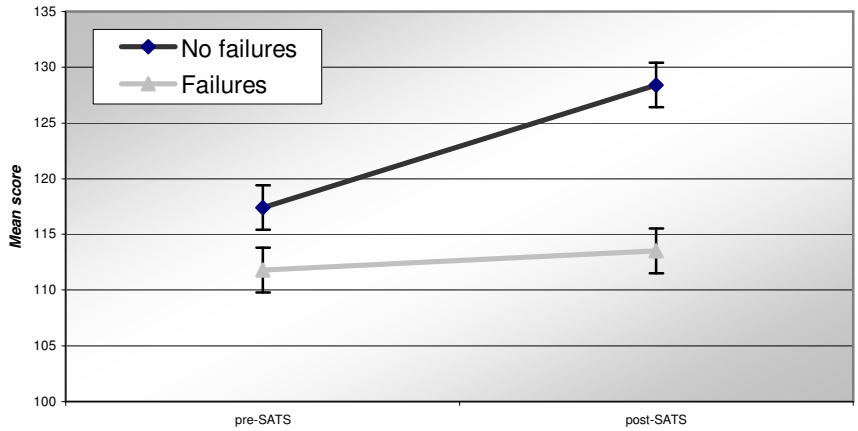

Figure 2. Mean scores of Attitudes toward Statistics at the beginning and at the end of the course for each group.

Concerning the anxiety toward statistics a significant and large difference ($t_{(287)}$= -5.48, p < .001, d = .84) was found: *NF* students had lower level of anxiety (M = 109.15, *SD* = 24.25) than the *F* students (M = 126.32, *SD* = 15.41).

Finally, a significative and large difference in the level of performance at the final exam ($t_{(440)}$= 8.96, p < .001, d = .92) was found: students who passed the exam at first time had a higher grade (M = 24.43, *SD* = 4.06) than who repeated the exam (M = 21.15, *SD* = 2.97).

DISCUSSION AND CONCLUSION

Factors linked to the difficulties encountered by psychology students in introductory statistics courses were investigated using a between-subjects design: two groups of students were formed considering who never failed the final examination and who needed several attempts to pass it, and their characteristics in terms of math background, math competence, attitude and anxiety toward statistics were explored.

Results showed that students who failed had lower grades in math at the last year of high school and they were more likely to have had learning debts in math during the last three years of high school. Accordingly with the above results, when they enrolled the course they do not possess an adequate level of mathematical competence, and they showed more negative attitudes at the beginning as well as at the end of the course. Moreover, the course did not change their attitude, whereas students that did not fail improve their attitude toward the discipline across the course. Remembering that anxiety was measured during the middle of the course and that a higher level of anxiety toward statistics was found among students that are going to fail, it can be stressed that these students showed higher level of apprehension and negative feelings even before they started to collect failure/s.

Finally, concerning the level of performance at the examination, data showed that students who failed reported lower grades. This difference suggest that the failure do not help in improving the performance (i.e., students could not learn from the previous experience concerning the exam). Hence, repetitions lead to a waste of time, and they delay the completion of the degree program, without any positive effect on learning and achievement.

Taken as a whole, the present investigation offers some hints to forecast students who will be likely to encounter difficulties in introductory statistics course. Administering the set of instruments above mentioned students who need an educational support could be identified, and it should be possible to help them from the beginning of the course, before they drop or fail the examination. Specifically, results suggest the need to improve student's mathematical skill and attitudes toward statistics, and to reduce their level of anxiety toward this discipline. This purpose should be attained fostering mathematical skills starting from the assumption that working on mathematical skills should have a positive effect on attitudes toward statistics (Harlow et al. 2002; Lalonde & Gardner, 1993; Schutz et al. 1999) as well as on anxiety toward statistics (Gal et al. 1997; Onwuegbuzie, 2003; Sorge & Schau, 2002). That is, increasing mathematical competence should improve statistics achievement not only directly, but also indirectly, i.e. who has more abilities develops a more positive attitude and experiences less anxiety.

This investigation offers some indications that can be helpful to prevent learning difficulties, to reduce time necessary to pass the examination, and to improve the level of performance.

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