Too Afraid to Learn: Attitudes Towards Statistics as a Barrier to Learning Statistics and to Acquiring Quantitative Skills

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Abstract

Quantitative skills are important to study and understand social reality. Political science students, however, experience difficulties in acquiring and retaining such skills. Anxiety for statistics has often been listed among the major causes for this problem. This study aims at understanding the underlying factors for this anxiety and proposes a potential remedy. More specifically, we advocate the integration of quantitative material in non-methodological courses. After assessing the influence of dispositional, course-related, and person-related factors on the attitudes toward statistics among political science students, we provide insights in the relation between these attitudes on the one hand and the learning and retention of statistics skills on the other. Our results indicate that a curriculum-wide approach to normalize the use quantitative methods, can not only foster interest in statistics but also foster retention of the acquired skills.

Introduction

How can we help political science students in acquiring numeric and statistical skills? In society, numbers are omnipresent. Media, corporations and politicians overwhelm people with quantitative information. Numeric skills are important to avoid deception and to function in society. By consequence, these skills are also important for political science students to grasp and understand social reality (Hulsizer and Woolf 2009). Students, however, tend to avoid quantitative methods and even fear them[1]. If quantitative skills are becoming more important in society and political science, and we wish to help students in acquiring them, we need to understand this statistics anxiety and its impact on statistics learning better. This paper seeks to address two questions: To what extent is statistics anxiety a barrier preventing students from retaining their previously acquired statistical skills? And more importantly, what kind of approach is needed to remove this barrier?

In order to address this problem, we proceed in two steps. First we inquire into the various antecedents of statistical anxiety. On the basis of this discussion, we propose to integrate quantitative methods in substantive courses as a potential remedy. In a second step, we test whether the suggested innovation also fosters retention of the acquired skills. The structure of the paper follows this logic.

On the causes and effects of statistics anxiety

Students perceive statistics as *'the worst course taken in College'* (Wiberg 2009, p. 1) or as *'inherently uninteresting, quite difficult and, like immunization injections they received as children, a necessary but quite unpleasant aspect of growing up'* (Bridges et al. 1998, p. 15). Statistics courses are not only a negative experience, but students are often 'scared to death' by the idea (Bradstreet 1996; Onwuegbuzie and Wilson 2003). Onwuegbuzie and Wilson (2003, p.196) describe statistics anxiety as the '*anxiety that occurs when a student encounters statistics in any form or at any level*'. This anxiety does not necessarily stem from bad training or insufficient skills (Pan and Tang 2004), but from students' misperceptions about both statistics and their (lack of) mathematical skills, from warnings from their peers, or from the 'horror stories' they have heard (Bridges et al. 1998; Hulsizer and Woolf

2009; Onwuegbuzie and Wilson 2003; Pan and Tang 2004). For an extensive review see Onwuegbuzie and Wilson (2003).

Statistical anxiety is not without consequences for the ability of students to acquire statistical skills and, once acquired, to retain them (Elmore et al. 1993; Emmioğlu and Çapa-Aydin 2011; Onwuegbuzie 2003). A meta-analysis conducted by Emmioğlu and Çapa-Aydin (2011) indicates for instance, that a positive relationship exists between students' affect toward statistics and their perception of their cognitive competence on the one hand, and obtained grades in statistics tests on the other hand. Their analysis also shows a positive but small effect of the valuing of statistics and of the perception of difficulty, with all attitudes coded such that a higher score represents a more positive attitude.

There is a vast amount of research on the antecedents of statistics anxiety (Pan and Tang 2004; Papanastasiou and Zembylas 2008). Factors inducing such anxiety are often classified in three categories: dispositional, course-related, and person-related factors (Baloğlu 2003; Onwuegbuzie and Wilson 2003; Pan and Tang 2004). The *'dispositional factors'* (Onwuegbuzie and Wilson 2003; Pan and Tang 2004) refer to the psychological and emotional characteristics of students, such as attitudes, perceptions, and (perceived mathematical) self-concept. Negative scores on these factors are generally related with more statistics anxiety. The course-related elements also referred to as '*situational factors*', immediately result from statistics courses. These can be the nature of the course (Onwuegbuzie and Wilson 2003), prior knowledge, statistical course grades (Papanastasiou and Zembylas 2008), and course and/or teacher evaluation (Baloğlu 2003; Onwuegbuzie and Wilson 2003; Papanastasiou and Zembylas 2008). These course-related factors expand to prior experiences with mathematical courses and grades as well (Onwuegbuzie and Wilson 2003; Zeidner 1991). Negative experiences tend to increase statistics anxieties, particularly when students are confronted with mandatory courses. Finally, the person-related antecedents (also referred to as '*environmental'* factors) are the socio-demographic characteristics, e.g. gender, age, and educational level, of the students. Female students suffer more from statistics anxiety than male students do, and the same holds for younger students as compared with older ones (Baloğlu 2003; Onwuegbuzie and Wilson

2003). It is clear that dispositional or person-related antecedents are largely out of our control. If we wish to remedy statistics anxiety we need to target the course-related elements.

A look at the literature indicates that whenever studies suggest remedies for statistics anxiety and its impact on statistics learning, a strong focus exists on statistics or research methods courses (Elmore et al. 1993; Emmioğlu and Çapa-Aydin 2011; Onwuegbuzie 2003). The implicit underlying assumption seems to be that such courses and their reform should play a prominent role in remedying statistical anxiety and from there on statistical achievement and retention. While there is much credence to such an approach, it can only remedy the problem insofar as the class-context allows for it. Statistics teachers may feel very uncomfortable about reforming their courses. Characteristics of the student group that such teachers meet in their classes (such as the size of the group and variation in mathematical skills among students) may make it even impossible. Our political science program fits into this latter category. First, statistics courses tend to be taught to very large student groups (>300 students) from over thirteen different programs, among which political science students form a minority. Activating students in such a context is extremely difficult as is the provision of appealing examples. Second, mandatory statistical and research methods courses tend to be front-loaded in our programs. In multi-year programs this means that students encounter statistics in the first semesters of their training. After that, they can easily escape from them, which most students do. Only 5% of them opt for an advanced statistics course when exposed to the choice between such a course and one on advanced qualitative research methods in the third year of their training. For the remainder, no statistics courses are on offer. There are however some elective non-methodological courses in which teachers make use of statistical analysis.

In addition, as statistics courses have a bad reputation among many students, enrolment into the mandatory statistics courses is already sufficient to trigger high anxiety levels. Overcoming this effect by reforming these courses may be extremely difficult in the short to medium term, given the negative aura that tends to surround such courses.

A way out of this may then consist of an anxiety reducing approach that transcends the statistics or research methods courses. Building on Markham's (1991) call for introducing quantitative methods in introductory courses, and on the more recent plea of Adeney and Cary (2009; 2011) to contextualise quantitative methods in political science education, we investigate whether using statistics in non-methodological courses can be a remedy for the statistics anxiety problem. In order assess the potential of this approach, we propose an extra course-related factor: the acquisition of statistical skills outside statistics courses. By doing so, we address an important lacuna as until now an explicit measurement of the impact that such an approach can have on students' ability to learn statistics has been absent in the literature.

Data and measures

In light of the *Educational Project on Overcoming Statistics Anxiety (EPOS)* – initiated in the Political Science program of our university – we conducted a survey with all students enrolled in that programme. In our project, we seek to integrate a learning trajectory on quantitative methods in non-methodological courses. This is achieved by the development of learning activities for the various courses involved. The systematic incorporation of such activities results in a gradual and repeated exposure of students to quantitative methods. For more information on the project see http://soc.kuleuven.be/epos. As our paper focuses on the retention of prior acquired statistical skills, analyses are based on the data from our third year (last year of the Bachelor programme; *n*= 41, response rate of 77,36%) and Master programme students (*n*=116, response rate of 63,74%). At the start of the project, we administered a web-survey for both groups. This survey is based the Survey of Attitudes Toward Statistics (SATS-36) (Schau et al. 1995), and contained additional questions about prior experiences with statistics, as well as questions on socio-demographic parameters.

The SATS-36 of Schau et al. (1995) consists of six subcomponents: Affect, Cognitive Capacity, Value, Difficulty, Interest, and Effort. We dropped the Effort subscale because the students in question are not enrolled in a statistics course. A factor analysis on the reduced version of SATS-36 failed to distinguish the 'Affect' subscale from the other factors[2]. The four obtained factors, however, can still be interpreted using the original scoring scheme of Schau (2005). The *Interest* subscales means: *"students' level of individual interest in statistics"* (Cronbach's alpha = 0,87). *Difficulty* can be understood as: *“students’ attitudes about the difficulty of statistics as a subject”* (Cronbach’s alpha = 0,74). The *Value* subscale can be defined as: *“students’ attitudes about the usefulness, relevance, and worth of statistics in personal and professional life”* (Cronbach’s alpha = 0,81). Finally, *Cognitive Competence* means: *“students’ attitudes about their intellectual knowledge and skills when applied to statistics”* (Cronbach’s alpha = 0,82). For each factor we reversed negative statements and constructed a mean scale, with range 1-7, ‘1’ meaning a negative attitude and ‘7’ meaning a positive attitude toward statistics. The four factors were used as dependent variables in our analyses of the antecedents of statistical anxiety (see table 1). The measurement of these antecedents is presented below.

For the dispositional factors we included a measure for mathematics self-concept, i.e. students’ perception about themselves in relation to mathematics, and for the perception of use of statistics in their future career. Regarding the latter, students were asked to answer on a 7-point Likert scale to what extent they think they will use statistics in their future job, with 7 meaning ‘I’ll use statistics frequently in my future job’. For mathematical self-concept, students were asked to evaluate their own statistics skills on a 7-point Likert scale.

The course-related (situational) factors probed the students’ experience with statistics, both in a subjective and an objective sense. For subjective experience, students were asked to state how experienced they are with statistics on a 7-point Likert scale, with 7 meaning very experienced. Objective experience was measured by the amount of statistics courses taken in higher education. Finally, for person-related (environmental) factors, gender, age and year of the programme the students are enrolled in were included in the model.

For our anxiety reducing approach of introducing statistics in non-methodological courses, we used the following measurements: For Quantitative Material in Non-methodological Courses (QMNC), we asked students to self-report their encounters with statistics in non-methodological course on a 5-point Likert scale with 5 meaning frequent encounters. As data gathering took place at the start of the project – before quantitative learning activities were developed and implemented – the variation on this variable results from the students’ selection of electives. In the later years, a number of non-methodological electives already, although not systematically, incorporate quantitative methods. The

EPOS-project seeks to systematize this practice and to spread it to courses where quantitative data are not being used. In our current sample, twenty-five per cent of the students indicated that they regularly encountered quantitative material in their courses whereas twenty per cent almost never shared such experience. The majority or responding students (54%) fell in between both categories, selecting sometimes as the most appropriate response to our question.

In the first set of analyses of this paper, we use the antecedents and the measurement for QMNC as independent variables to explain the variation in statistics anxiety. In the second set of analyses we use both the antecedents and the statistics anxiety measures as independent variables to understand the retention of statistical skills.

Unlike other studies that focus on the effects of statistics anxiety on the learning of statistics deal with the achievements in statistics courses, we focus on the retention of such skills. Given the growing importance of statistics, retention of quantitative skills should be a goal of higher education, as it secures that students are well prepared for their future careers. To measure statistics retention, we constructed a second battery of questions inquiring into students' statistical skills. This happened in close collaboration with educational scientists from our university. The questions were based on exercises from the ARTIST-project (https://app.gen.umn.edu/artist/); the Dutch translation of Garfield's questionnaire 'Statistical reasoning Assessment' (Vanhoof et al. 2009) and the practice book of Moore & McCabe (2007). The topics range from the interpretation of OLS regression results and significance tests to probability theory and histograms. From the responses on these questions a variable was computed which represents the percentage of correct responses relative to the number of answered questions (90% of the students answered 20 questions out of 25). We interpret this variable as 'statistics retention', as almost all of the sampled students were not enrolled for a quantitative methods course in one (third bachelor) or two (masters) years preceding the survey. To our knowledge, we are among the first to study the relation between attitudes toward statistics and the retention of statistical skills in political science.

Results

Table 1 shows the results of the first set of analyses, i.e. the models regressing statistics anxiety on the antecedents. Whereas model 1 includes the full array of explanatory variables, we decided to run an additional set of regressions (only for the 'Value' and 'Cognitive Competence factor) excluding the dispositional factors where the conceptual overlap with the dependent variable became problematic. Where relevant, we only discuss the results from model 2.

[table 1 about here]

Looking at the effect of the dispositional factors, the results show that the perception of statistical skills has a positive effect on 'interest', 'difficulty', and 'value'. Whereas such perceptions promote a larger individual interest in statistics (and a recognition of its value), they also reduce the conviction that statistics is difficult. The perception of the future use of statistics impacts positively on 'interest', 'difficulty', and 'cognitive competence'. The recognition that statistics learning has an added value professionally reduces students' mental barriers with respect to statistics.

With regards to the course-related factors, the results show that subjective experience has a negative effect on 'interest' and 'difficulty'. Students that report more experience with statistics are generally less interested in the subject and generally find it more difficult. The number of statistics courses taken on the other hand, does not have an effect on the attitudes towards statistics except for cognitive competence.

Regarding the person-related factors, we find no impact of age on statistics anxiety. On the other hand, female students tend to be more pessimistic about their 'cognitive competence' and the difficulty of statistics. They also value statistics less than their male colleagues do.

Looking at the effect of our proposed remedy for statistics anxiety (and retention of statistics, see infra), we find that, contrary to the course-related factors, encountering quantitative methods during substantive (non-methodological) courses has a positive effect on both the interest in, and the value attributed to statistics. These findings point at the potential of explicitly introducing statistics in non-methodological course for remedying students' fear for statistics, and potentially for the retention of previously acquired skills.

In our second set of analyses (see table 2), we first regress the retention of statistical skills on the four factors of statistical anxiety, controlling for the antecedents (see model 3, table 2). In the following model (model 4), we add the measure for quantitative material in non-methodological courses (QMNC) to the model. Doing so we can assess the extra explanatory power of QMNC on the retention of statistical skills. Given our interest in improving students' ability to retain statistics skills, the analyses presented in table 2 are most central to our argument. We discuss the results by comparing both models.

[table 2 about here]

In model 3, only three variables prove to be statistically significant: interest, difficulty, and subjective experience with statistics[3]. The results are intuitive and in line with the existing literature. Higher interest in statistics, perceptions of statistics as being less difficult, and more subjective experience with statistics promote retention. The addition of experience with quantitative material in non-methodological courses (QMNC) clearly affects these outcomes, as model 4 indicates. The QMNC factor itself is statistically significant and positively related. Students reporting more encounters with statistics in non-methodological courses score, generally speaking, higher on the statistical retention variable.

Next to the significance of the QMNC variable, we find that including this measure in the model has some important repercussions for the model as well. More specifically, we find QMNC to be a suppressor variable for the perception of statistical skills. By including QMNC in the model, the effect of the perception of statistical skills becomes significant, revealing that students who believe to have good statistical skills score generally lower on the retention variable. Additionally, we find that QMNC is slightly redundant to 'interest'. By including QMNC, the 'interest' variable becomes less significant (from $p < 0{,}05$ to $p < 0{,}10$) and its effect decreases slightly. The encounters with statistics in non-methodological course, thus, account for part of the effect of interest on the retention of statistical skills.

From these results some important observations can be derived. First, it is clear that an approach that includes the use of quantitative material in non-methodological courses promotes the ability to retain statistics skills and strongly so. With an extra explanatory of power of nearly 7% (cf. change in R^2), we conclude that QMNC is an important factor to take into account when working on statistics retention. . At the same time, however, QMNC is not a panacea that solves all problems. 'Difficulty' continues to affect statistics retention directly as much as students' perceptions of their statistical skills do. Taking the effect of both of these factors into account, the results indicate that when addressing students' perceptions of the difficulty of statistics, we need to remain aware that to much confidence in once abilities to do statistics reduces the retention of statistics skills (Keeley et al. 2008).

Conclusion

The aim of this paper was to find out how we can help our political science students in their ability to learn and retain statistics skills. We did so by first exploring the different antecedents of statistics anxiety We then analysed the relation between students' experience with quantitative material in non-methodological courses (QMNC) on students' retention of statistics skills. The results, which are in line with existing findings, show that the dispositional, course-related, and person-related antecedents have their influence on students' attitudes toward statistics. The analyses also show that the number of statistics courses taken has no influence on students' statistics retention; it is the extent to which quantitative material is used in non-methodological (substantive) courses that positively impacts on such retention. This provides an argument not to limit the promotion of statistics learning to reforms of statistics or research methods courses as such, but to do so by intervening in the non-methodological parts of the political science curriculum as well.

The use of quantitative material in non-methodological courses can be a double-edged sword however that requires a fine-tuned use of such material. Although our analyses show that such use has a strong potential to positively impact on students' ability to retain their statistical skills, they may also suggest that badly shaped use of QNMC may definitively turn-off students that already have a complex relationship with statistics, both on the basis of the perception of their own skills and their perception of statistics as a difficult topic. The use of quantitative material in non-methodological courses is therefore, not a panacea. It requires full attention to the kinds of underlying problems that trigger statistics anxiety and low statistics learning.

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Table 1: Results of regressions analyses with the 4 factors of the adapted SATS-36 scale as dependent variables. Statistics: Unstandardized regression coefficients (b), standardized coefficients (B) and coefficient of determination (R^2).

	Model 1				Model 2	
	Interest	**Difficulty**	**Value**	**Cognitive Competence**	**Value**	**Cognitive Competence**
	b (B)	b (B)	b (B)	b (B)	b (B)	b (B)
Experience with quantitative material in non-methodological courses (QMNC)	0,305** (0,181)	-0,020 (-0,013)	0,114 (0,090)	-0,005 (-0,003)	0,169[a] (0,135)	-0,072 (-0,052)
Dispositional factors						
Perception of statistics skills	0,298*** (0,346)	0,442*** (0,571)	0,076 (0,118)	0,461*** (0,646)	0,165** (0,256)	/
Perception of use statistics in future job	0,449*** (0,440)	0,136* (0,148)	0,386*** (0,505)	0,102[a] (0,121)	/	0,223*** (0,263)
Course-related factors						
Subjective experience with statistics	-0,134[a] (-0,151)	-0,167* (-0,220)	0,018 (0,029)	-0,052 (-0,074)	0,093 (0,147)	-0,071 (-0,101)
Number of statistic courses taken	-0,024 (-0,021)	-0,021 (-0,021)	-0,077 (-0,092)	0,023 (0,025)	-0,110 (-0,132)	0,142[a] (0,154)
Person-related factors						
Age	0,030 (0,091)	-0,012 (-0,040)	0,024 (0,099)	0,006 (0,024)	0,033 (0,134)	-0,003 (-0,012)
Women (reference: Men)	-0,022 (-0,009)	-0,258[a] (-0,121)	-0,166 (-0,093)	-0,341** (-0,173)	-0,233[a] (-0,131)	-0,421** (-0,214)
Third Bachelor (reference: Masters programme)	-0,475** (-0,177)	-0,205 (-0,085)	-0,274[a] (-0,136)	-0,244[a] (-0,109)	-0,281[a] (-0,140)	-0,234 (-0,105)
Constant	0,425	2,586***	2,840***	1,969***	3,324 ***	2,593 ***
R^2	0,451***	0,340***	0,367***	0,520***	0,161***	0,210***
N	155				155	

[a] $p < 0,10$; * $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

Table 2: Results of regressions analyses with statistics retention as the dependent variable.
Statistics: Unstandardized regression coefficients (b), standardized coefficients (B) and coefficient of determination (R^2) and adjusted R^2.

	Model 3	Model 4
	b (B)	b (B)
Non-Methodological Courses		
Exp. with quantitative material in non-methodological courses (QMNC)	/	5,817*** (0,290)
Attitudes towards statistics		
Interest	3,483* (0,286)	2,572[a] (0,211)
Cognitive competence	0,650 (0,046)	1,020 (0,072)
Value	0,751 (0,045)	0,508 (0,031)
Difficulty	3,387* (0,261)	3,780** (0,291)
Other Antecedents		
Perception of statistics skills	-1,995 (-0,192)	-2,629* (-0,253)
Perception of use statistics in future job	-0,817 (-0,067)	-0,619 (-0,050)
Subjective experience with statistics	2,147[a] (0,212)	2,095[a] (0,207)
Number of statistics course taken	-0,115 (-0,008)	-0,872 (-0,064)
Age	-0,045 (-0,011)	0,036 (0,009)
Women (reference: Men)	-2,977 (-0,105)	-3,730 (-0,132)
Third Bachelor	0,298 (0,009)	-0,777 (-0,024)
Constant	14,805	1,785
R^2	0,232***	0,300***
R^2 change	/	0,069***
Adjusted R^2	0,164	0,232
n	136	136

[a] $p < 0,10$; * $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

[1] Although we are aware of the differences between statistics and the wider concept of quantitative methods, we use both terms interchangeably.

[2] Results of factor analysis are not shown due to space limitations. Results are available upon request.

[3] Given the small sample, we tolerate the chance of wrongfully rejecting the null-hypothesis (type I error) to be 10% ($\alpha = 0{,}10$).