ATTITUDES TOWARD RESEARCH AS A SOURCE FOR NEGATIVE STATISTICS ATTITUDES

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Many Studies find negative attitudes towards statistics among undergraduates. Literature argues that these attitudes are based on negative experiences during math classes in school and a transfer of attitudes towards maths to the field of statistics. This study argues that attitudes towards research are a second source of negative attitudes towards statistics. Since statistics can be seen as a language in science and research undergraduates differ in their motivation to learn this language depending on the value and attitudes they attribute to research. Data from an introductory statistics course for social scientists (N = 505) support an influence from concepts of the Attitudes towards Research (ATR) questionnaire on the concepts of the Survey of Attitudes Towards Statistics (SATS). In addition, data on the validity of German versions of the two instruments are given.

THEORETICAL BACKGROUND

The role of attitudes in statistics education

Non-cognitive factors, such as attitudes and beliefs, are considered as important elements in the learning process in many fields of education. Gal, Ginsburg and Schau (1997), for example, argue that non-cognitive factors have three major effects that are relevant in education: Firstly, effects on learning behavior within the course are to be assumed. Furthermore, it can be expected that non-cognitive factors influence decisions on the further course of studies, especially in the choice or non-choice of non-obligatory follow-up courses. Thirdly, it can be assumed that non-cognitive factors have an influence on how (strongly) learned contents find their way into professional and everyday life.

In the area of statistics education, research has mainly focused on statistics attitudes. As found empirically in several studies statistics attitudes have an influence on achievement in statistics courses. Although studies show that the nature and extent of this influence can vary, depending for example on language, culture or course format, the general impact of such influences seems to be replicable (Emmioglu & Capa-Aydin, 2012; Vanhoof et al., 2006). Ramirez, Schau and Emmioglu (2012) provide the theoretical embedding of this finding with their expectancy-value theory-based model SATS-M. This model maps attitudes between personality parameters, experiences and processes over time, so that attitudes are a building block in the judgment of both expectation and value.

On the basis of this high importance of attitudes in the sense of the three dimensions after Gal, Ginsburg and Schau and the empirical findings on their relationship to achievement, it can be assumed, for example with Sturm and Eichler (2015), that statistical attitudes are an integral part of a comprehensive understanding of statistics literacy.

Measuring statistics attitudes

Looking for an instrument to measure statistics attitudes provides three main surveys used in several studies. The older ones are the Statistcs Attitude Survey (SAS) by Roberts and Bilderback (1980) and the Attitudes Toward Statistics (ATS) survey by Wise (1985). Both understand statistics attitudes as a one-dimensional construct and provide a measurement of a latent variable of this construct. Schau, Stevens, Dauphinee, and Vecchio (1995) were the first to provide an instrument for measuring more than one dimension of statistics attitudes. They propose four dimensions: Affect, cognitive competence, value, and difficulty. Later, Schau (2003) developed the instrument further and added effort and interest. This instrument, the SATS-36, at least together with its first version SATS-28, became the most widely used measurement instrument for statistics attitudes.

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Studies by various authors, conducted in different languages and course types, tested SATS, in particular its internal reliability. The results must be regarded as roughly identical, but with different subtleties. Schau herself (2003) and also Coetzee and Merwe (2010) and Tempelaar, van der Loeff, and Gijselaers (2007) find the instrument to fit well. They identify and replicate the 6-dimensional structure of the survey and make use of it. Other authors confirm the general suitability of SATS, but have doubts about its 6-dimensionality. Cashin and Elmore (2005), Vonhoof., Kuppens, Castro Sotos, Verschaffel, and Onghena. (2011) and also Homik and Luik (2017) fail to find huge differences between the dimensions affect, cognitive competence and difficulty. Because the resulting 4-dimensional structure fits as good as or better than the 6-dimensional one and explains nearly as much variation they argue for this adjustment.

After a review of all studies on the reliability of the instrument to be found at that time Nolan, Beran, and Hecker (2012) advice their readers to use the original instrument, as it is more common in research and has good fit values, although they acknowledge the tendency for high correlations between the three dimensions mentioned.

Statistics as a language of research

Measuring statistics attitudes and assuming relevance of these attitudes poses the question of their changeability and their origin. For changeability, for example Gundlach, Richards, Nelson, and Levesque-Bristol (2015) or DeVaney (2010) have demonstrated that this is possible by changing methods and focus in statistics courses.

The question of the origin of (bad) attitudes is much older. Gal and Ginsburg already 1994 suspected a connection to the attitudes to mathematics, which could be explained by the closeness to the subject. Nasser (2004), Dempster and McCorry (2009), and also Paul and Cunnington (2017) find empirical proof for this hypothesis. Hood, Creed, and Neumann, (2012) are able to add a second origin of statstics attitudes to the till than monocausal discussion. They argue that statistics is mostly related to an overview-like training in empirical methodology. Experience gained by students in this methodological training can then be reflected in the attitudes to statistics as well as those from mathematics.

This connection between statistics education and training in research methodology can be perfectly associated with an old idea of Lalonde and Gardner (1993). The two transfer ideas about second language learning from Gardner to statistics education arguing that learning statistics just as learning languages requires a lot of knowledge about terms. Taking the idea of statistics as a language serious raises the question of where this language should be applied. One of the main answer for this, especially for university students, may be that statistics is a language of research.

Following this logic and an expectancy-value approach leads to the hypothesis that those who consider statistics useful as a language of research have positive attitudes toward statistics.

Attitudes toward research

Coming from the idea of statistics as the language of research just described, attitudes to research emerge as a new source of statistical attitudes to be discussed. Papanastasiou (2005) was the first and to the author's knowledge the only one to develop an instrument for measuring attitudes toward research. In her Attitudes toward Research (ATR) scale she describes a 5-dimensional structure of attitudes toward research with the factors usefulness of research, anxiety, affect, relevance of research in daily lives, and difficulty of research. Her fit indices are acceptable to good and the instrument shows to provide an interesting insight on students' thoughts about research.

HYPOTHESIS & METHOD

As a consequence of the theoretical discussion two main hypothesis for this study arise:

(1) Attitudes toward research can be seen as an origin of attitudes toward statistics. Therefore, students' attitudes measured by the ATR scale can explain variation in students' attitudes toward statistics.

(2) Corresponding constructs, such as affect toward research and affect toward statistics, are relatively strongly connected, as the transfer of experience is closest there.

Investigated sample

The data of this study are taken from an introductory course on statistics for social scientists at the University of Goettingen. Participants in this course come from nine different subjects in the area social science subjects, most frequently political science or sociology. Bevor their statistics course students already had a course on qualitative and quantitative empirical methods in social sciences of 14 weeks with eight hours per week. Data collection took place just at the beginning of the first session of the course. Of 528 students present in the first lecture n=505 agreed to take the survey. About 60% of the participating students report to be in their second semester of university studies, the average for all is 3.25. 59% of respondents report being female.

Used Instruments

To measure attitudes toward research the ATR scale developed and published by Papanastasiou (2005) was used. Since the items of the factor of difficulty of research were to close to difficulty of statistics and for example contained arithmetic skills this factor was dropped from the survey. The attitudes toward statistics were measured by SATS-36 as published by Schau (2003).

To create a German version of the original surveys they were given to German native speakers with experience in translating from English to German and at least one long stay in an English speaking country. In case the two translations did not match the author developed a compromise or better fitting variant.

To the authors knowledge, until now there is no testing of internal reliability of the ATR except for the publication by Papanastasiou. Therefore, a first step will be to test the instruments for some fit measures of internal reliability to test their usability for this study. To contribute to the discussion on a 6-dimensional or 4-dimensional structure of SATS-36 this instrument is also tested.

EVALUATION OF THE INSTRUMENTS

Tests on the Attitude toward Research scale

As a first step of testing internal reliability of the ATR scale Cronbach alphas are calculated. They range between 0.72 (relevance) and 0.84 (affect) and can therefore be rated as acceptable to good (usefulness: 0.78; anxiety: 0.80). Performing a confirmatory factor analysis results in a CFI of 0.737, RMSEA of 0.094 and SRMR of 0.096. Summarizing these three indices there seems to be some problem in the fit of the model. For this reason, a series of explorative factor analyses were performed to determine an own factor structure, which was calculated using maximum likelihood estimation and promax rotation.

Scree plots as well as the eigenvalue criterion indicate a 5-dimensional structure of the data. Implemented in an explorative factor analysis, already three cycles result in a stable and interpretable model. The items 6, 17, 22, and 24 are deleted due to not loading on any factor higher than 0.4 or because of loading on two factors with a difference in loading of less than 0.15. Among the remaining 25 items, the factors usefulness, affect, and relevance fit the structure proposed by Papanastasiou. The seven items of anxiety split into two groups. Items 10, 12, and 13 load on one factor and contain terms like scare, nervous, and anxious. This wording seems to fit the factor anxiety about research quiet well. The items 11, 14, 15, and 16 contain phrases like complicated, complex, difficult, and stressful and load on another factor. For the author of this study these items seem to be a good measurement of perceived difficulty of research. Therefore, they will build a new factor of difficulty different from the original one. In a confirmatory factor analysis, the 5-dimensional model described this way achieves a CFI of 0.881, RMSEA of 0.069, and SRMR of 0.061. For this reason, it can be spoken of a model improvement and an overall good model.

Tests on the Survey of Attitudes Toward Statistics (SATS-36)

Testing the original version of SATS-36 results in Cronbach alphas of 0.87 (affect), 0.85 (competence), 0.82 (value), 0.76 (difficulty), 0.85 (interest), and 0.82 (effort). Confirmatory factor analysis calculates a CFI of 0.833, RMSEA of 0.072, and SRMR of 0.076. Although these values are initially indicative of a good model, it should be noted that the applied methods are not sufficiently capable of identifying two factors as actually one-dimensional. For this reason, exploratory factor analyses are also performed here.

Depending on the criterion used to determine the dimensionality and keeping in mind that the criteria require interpretation, models with three, four, or six factors remain possible for the explorative factor analysis. Firstly, looking for a good 6-dimensional structure creates factors reflecting the concepts effort and interest very well. In contrast affect, competence, and parts of difficulty go more or less into one factor while value and the rest of the construct difficulty split. Deleting single items from the analysis is not suitable to solve the problem. It must therefore be noted that although the 6-dimensional structure of the SATS provides a satisfactory good fit, it cannot be replicated directly.

Looking for a 4-dimensional structure does not build up any interpretable solution. As discussed above affect, competence, and difficulty indeed start to build up one factor. However, interest and value also start to be one factor. Only effort loads separately as in the proposed model. The fourth factor, on the contrary, collects individual items without any recognizable connection, which are always recomposed after deletions. However, this structure already shows that three factors could make a meaningful interpretation possible. The execution of this analysis comes to a meaningful model even with few deletions. After dropping items 21, 22, 34, and 36 a factor structure results with affect, competence, and difficulty as a first factor, value and interest as the second one and effort as third factor. For the further discussion the first factor shall be called affect about difficulty, the second one interest about the value. Testing this 3-dimensional factor structure is a confirmatory factor analysis results in a CFI of 0.811, RMSEA of 0.084, and SRMR of 0.090. These fit measures have to be seen as not to much worse than the ones of the original model. For a model with just half the factors this is a quite good result. In the following analyses therefore both models, the original one and the 3-dimensional model, will be used to test the research hypothesis.

ANALYSIS

To test whether attitudes toward research can be seen as an origin of attitudes toward statistics multiple linear regressions are performed for each factor of the original SATS-36 where the five factors build out of the ATR scale form the independent variables. Table 1 shows the six regressions by columns:

Table 1: 6 original factors of SATS-36 explained by 5 dimensions of ATR

Slope (p-value)	Affect	Competence	Value	Difficulty	Interest	Effort
n	492	493	494	492	490	494
R^2	0.229	0.210	0.357	0.203	0.318	0.058
Intercept	4.422	4.695	2.032	3.452	1.404	3.816
usefulness	**-0.007** (0.931)	**0.072** (0.342)	**0.294***** (0.000)	**0.096⁺** (0.070)	**0.255***** (0.001)	**0.235**** (0.003)
anxiety	**-0.151***** (0.001)	**-0.191***** (0.000)	**-0.015** (0.618)	**0.043** (0.139)	**-0.087*** (0.033)	**0.083⁺** (0.057)
affect	**0.242***** (0.000)	**0.138*** (0.020)	**0.126**** (0.004)	**-0.107*** (0.010)	**0.434***** (0.000)	**0.147*** (0.019)
relevance	**0.018** (0.755)	**0.098⁺** (0.072)	**0.236***** (0.000)	**-0.070⁺** (0.070)	**0.117*** (0.032)	**-0.181**** (0.002)
difficulty	**-0.411***** (0.000)	**-0.278***** (0.000)	**-0.081*** (0.039)	**0.321***** (0.000)	**-0.131*** (0.016)	**0.034** (0.555)

As Table 1 shows all six factors of the original SATS-36 model can be predicted at least to some extend by attitudes toward research. In every regression at least two factors of ATR have significant impact and most R^2 range from 0.2 to 0.36, only effort cannot be explained as well as the other constructs. A closer look on the coefficients show that close corresponding constructs always have highly significant weights, each among the highest of the respective regression. For example, the best explained factor, value, is very highly explained by the connected constructs usefulness for professional and relevance for daily life. The bivariate regressions alone explain 24.4 resp. 26.0% of the variation.

More about the influences of the attitudes toward research can be seen in the regressions that map to the newly formed factors of the SATS. Results of the three regressions are shown in Table 2:

Table 2: 3 new build factors of SATS-36 explained by 5 dimensions of ATR

Slope (p-value)	Affect about difficulty	Interest about the value	Effort
n	494	494	494
R^2	0.249	0.394	0.058
Intercept	4.565	1.720	3.816
usefulness	**0.010** (0.878)	**0.314*** ** (0.000)	**0.235** ** (0.003)
anxiety	**-0.142*** ** (0.000)	**-0.020** (0.519)	**0.083**[+] (0.057)
affect	**0.162** ** (0.002)	**0.236*** ** (0.000)	**0.147*** (0.019)
relevance	**0.075** (0.118)	**0.190*** ** (0.000)	**-0.181** ** (0.002)
difficulty	**-0.360*** ** (0.000)	**-0.105*** (0.010)	**0.034** (0.555)

While effort obviously stays the same and cannot be well explained, the other factors form two groups. Anxiety, affect, and perceived difficulty have strong impacts on the affects about the difficulty of statistics. Usefulness, relevance, and again affect can be seen as an origin for interest about the value of statistics. The logic of corresponding constructs becomes very clear here.

CONCLUSION

As argued, statistics can be seen as a language used in research. Desiring to be involved in research or at least wishing to understand results of studies thus requires statistical skills. Therefore, attitudes toward research can be assumed to be an origin of (bad) attitudes toward statistics. More precisely, it can be assumed that certain types of attitudes are transferred to corresponding parallel attitudes about statistics. Data of a sample of n=505 students in social sciences support this hypothesis. Therefore, the investment of some time could be worth it to make students understand the value of research as such in order to increase their motivation for statistics.

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