Stijn Vanhoof, Statistics attitudes in university students: Structure, stability and relationship with achievement
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Both in scientific research and in everyday life we are increasingly faced with statistical facts, reasoning and figures. However, research in the area of learning and teaching statistics has shown that reasoning in situations involving variability and uncertainty is frequently not in agreement with formal theory. Even after following one or several statistics courses, many students continue to show misconceptions. When investigating students' correct and incorrect reasoning in the area of statistics, attitudes and other non-cognitive factors are increasingly considered important, especially since the reform movement in statistics education. Students are supposed to be active learners able to solve non-routine problems in a social environment, and they will develop positive or negative statistics attitudes as they encounter similar experiences with statistics repeatedly. It is believed that such attitudes may increase or decrease engagement and ability to solve statistics problems. Negative statistics attitudes are often considered to be related to poor learning or low course grades. Positive attitudes are believed to go together with chances of students in developing useful statistical reasoning skills.

Because in earlier studies statistics attitudes and their relationship with statistics achievement were almost exclusively investigated before and after following one introductory statistics course, little was known about the evolution of statistics attitudes during students' whole curriculum. Therefore, the main objective of the present doctoral dissertation was to address this lacuna in the research: Statistics attitudes of 785 students Educational Sciences, and Speech Pathology and Audiology of the Katholieke Universiteit Leuven were assessed five times during the first three years of their curriculum. In the present doctoral dissertation, four manuscripts are presented in which three major aspects with regard to statistics attitudes were investigated: Structure, stability and relationship with statistics achievement. In an introductory chapter (Chapter 1), these aspects are situated within the context of the reform movement in statistics education.

In the study reported in the first manuscript (Chapter 2), a Dutch translation of the Attitudes Toward Statistics scale (ATS; Wise 1985) was used to investigate the relationship between statistics attitudes and short- and long-term statistics exam results. The data for this study were pilot-data coming from another cohort than the participants of the other studies and it is the only study making use of the ATS scale. The findings extended the knowledge regarding the connection between statistics attitudes and statistics achievement to a longitudinal context. Moreover, attitude measures at the beginning of the curriculum appeared equally predictive for long-term achievement as cognitive measures.

The second manuscript (Chapter 3) focused on several unsolved questions with regard to the structure and item functioning of our translated Survey of Attitudes Toward Statistics (SATS-36; Schau et al.,1995). Because earlier studies used the technique of item parceling to analyse the factor structure of this instrument, individual item functioning had not been evaluated before. Based on confirmatory factor analysis using individual items, the results suggested that the SATS-36 can be improved by taking some error covariances into account and by removing poorly functioning items. Furthermore, it was suggested that depending on the goals of a specific study either six subscales could be used or three of them (Affect, Cognitive Competence, and Difficulty) can be combined into one subscale without losing much information.

To examine whether the SATS-36 has appropriate properties for longitudinal comparison and to investigate the stability of statistics attitudes, the third manuscript (Chapter 4) focused on longitudinal measurement invariance of the SATS-36. Increasingly restrictive invariance tests (invariance of factor configuration, factor loadings, indicator intercepts, error variances, factor variances and factor means) were performed. Evidence of weak invariance and partial strong invariance was found for all SATS-36 subscales except Effort, providing support for the SATS-36 as a useful instrument for comparing statistics attitudes across time. Latent attitude means about the statistics domain remained stable over time, while latent mean differences emerged for students' attitudes about themselves as learners of statistics.

The goal of the study presented in the fourth and final manuscript (Chapter 5) was to investigate the directionality of the relationship between statistics attitudes and statistics achievement. Previously, not supported by appropriate empirical data, many researchers assumed a unidirectional effect from statistics attitudes to statistics achievement. In this study, structural equation modeling was used to provide empirical evidence on the directionality of effects. A comparison of alternative plausible models showed results that were opposite from the common view: A unidirectional model with effects from statistics achievement to statistics attitudes was found for students' attitudes about themselves as learners of statistics. Regarding attitudes about the domain of statistics, no effects over and above the stability effect of attitudes and achievement were present during the progress of the students' curriculum. Based on these results, it was suggested that rather than fostering positive attitudes because of their effect on achievement, improving students' achievement in statistics is a strategy for eliciting positive statistics attitudes about themselves as learners.

Finally, in Chapter 6 the main results that emerged from this doctoral dissertation are summarized and discussed and recommendations for further research and for statistics education practice are presented, such as taking suggested modifications to the SATS-36 into account, analyzing both individual items and item parcels to profit from advantages of both approaches, including attitude assessments before and after exams and students' knowing their exam results, and establishing measurement invariance before investigating attitude change.