

WHAT CHANGES STUDENTS' ATTITUDES? A QUALITATIVE PANEL STUDY ON HOW AND WHY ATTITUDES TOWARD AN INTRODUCTORY STATISTICS COURSE CHANGE

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Change in attitudes toward statistics during introductory courses has been shown to have a major impact on learning success. Although attitudes pre- and post-introductory courses have therefore been widely studied, there is a lack of research on how attitudes evolve during the course. Only Kerby and Wroughton (2017) include a measurement at midterm and find some roughly v-shaped progressions of attitudes. The present study shows a different development in a qualitative panel study with six students and four interviews per student. The main reason for changes in attitudes is identified as the current course content, which changes how mathematical, difficult, interesting, and valuable statistics is currently perceived to be. The findings show the reciprocal relationship between topic-related emotions and domain-related attitudes.

In 1997, Gal, Ginsburg, and Schau were among the first to argue that attitudes are relevant for statistics education. They outlined the importance of attitudes for learning in a statistics course, the influence on an individual's willingness to choose more in-depth courses or programs and the effect on a person's propensity to make practical use of statistics outside of education in everyday life or at work.

Since that time, there has been much development. A milestone was certainly the development of the Survey of Attitudes Toward Statistics (SATS) (Schau, 2003; Schau et al., 1995), which measures six dimensions. *Affect* captures (positive) feelings toward statistics; *difficulty* asks about the perceived general/abstract difficulty of statistics; and *cognitive competence* captures perceptions of one's own ability with regard to statistics. The *value* of statistics is the perceived relevance and usefulness of statistics. In addition, the *interest* in the subject of statistics is surveyed as well as the amount of *effort* planned or already invested in the statistics course.

Using this instrument, researchers have argued that students' attitudes towards statistics do have an effect on their success in statistics courses (e.g., Abbiati et al., 2021; Chiesi & Primi, 2010; Nasser, 2004). Research also suggests that changes in attitudes predict success even better than attitudes themselves (Abbiati et al., 2021; Whitaker et al., 2022). In addition to the instrument, SATS dimensions of attitudes became a fixed canon for further, also qualitative, research (e.g., Songsore & White, 2018).

Despite these findings, little attention has been paid to changes in attitudes during a statistics course. Although some studies have attempted to elicit attitudes through changes in course design (e.g., Bateiha et al., 2020; Herman & Kerby-Helm, 2022), (qualitative) studies on the reasons for changes in attitudes are lacking. This research aims to fill this gap by conducting a qualitative panel study following six students through an introductory statistics course.

BACKGROUND

The Development of Attitudes in a Statistics Course

Even in the development of the SATS instruments, it was clear that attitudes are not very time-stable facets of the learning process but rather changeable personality traits (Schau, 2003). Both the original grounding of the SATS in Eccles' Expectancy Value Theory (1983) and later refinements of the theoretical grounding (especially Ramirez et al., 2012) not only suggest the possibility of change over time but even call for it as an educational goal.

Consequently, many studies have looked at changes in attitudes toward statistics. Their results, however, show a mixed picture: Although, for example, Abbiati and colleagues (2021) and Herman and Kerby-Helm (2022) see positive trends in introductory statistics students' attitudes over time, Schau and Emmioglu (2012), for example, find a negative trend. Meanwhile, Bateiha and colleagues (2020) and Cladera and colleagues (2021) find no significant change at all.

What several of these studies have in common is the finding of high rates of attitude change among students. However, these changes (partially) cancel each other out in the averaging across students because improvements and deteriorations occur in similar amounts (Abbiati et al., 2021;

Whitaker et al., 2022). From this, it can be concluded that not only do course-related factors have an influence on the development of attitudes, but also that there exist individual differences between students. This hypothesis is also supported by Xu and colleagues (2020). They found that the instructor has a high impact on the development of students' attitudes, and yet they find very heterogeneous development of attitudes within courses. Thus, the explanation for attitude changes must be at least partly at the individual level.

The Role of Attitudes and Their Development for Learning Statistics

Although research on individual reasons for changing attitudes is still largely open, the importance of these changes has been documented. It has been known for some time that attitudes toward statistics at the beginning of a course have predictive value for course success (Chiesi & Primi, 2010; Nasser, 2004). However, more recent studies show that changes during the course are even more predictive of exam success (Abbiati et al., 2021; Whitaker et al., 2022).

This finding further emphasizes the importance of changes in attitudes toward statistics. Yet, only Kerby and Wroughton (2017) take a closer look at the development of students' attitudes toward statistics. In a panel study that adds a midterm survey between the pre and post measures of attitudes, they find different results for the different dimensions assessed by SATS. Although affect improves slightly in the first half of the course and then remains roughly constant, value and interest describe a v-shaped progression. No significant changes can be found in the other dimensions. For the v-shaped progression in particular, Kerby and Wroughton (2017) assume a reality shock at the beginning of the semester that causes students' value and interest to drop, but students then recover later in the course. However, the researchers cannot provide evidence or deeper insights into the reasoning behind these changes.

METHODOLOGY

Because previous research demonstrates a high importance of changes in attitudes towards statistics, this study aims to uncover individual patterns of reasons for individual changes. In order to comprehensively represent and analyze individual reasons and their contexts, a qualitative study design is used. Because the changes are to be traced in the process and not only retrospectively, the study is conducted as a qualitative panel.

To implement the qualitative panel, 70 students from an introductory course in statistics for social scientists at a large German university were invited for interviews. The course is obligatory in the programs of these students. In the first interviews directly before the course began, 14 students participated. Subsequent interviews took place after weeks five and nine of the course as well as after completion of the 14-week course. During the first five weeks, students were introduced to descriptive statistics (e.g., central tendencies, dispersion, graphical representations of distributions). In the following four weeks, the theoretical introduction to inferential statistics including confidence intervals and hypothesis testing followed. In the last course section, bivariate statistics was introduced (Pearson's correlation, bivariate linear regression, relationships of two binary variables).

All interviews were held as guided, semi-structured interviews. The interviews always began with the question "What do you think about statistics in general?" and continued with several consistent questions about the six dimensions of attitudes outlined in the SATS. This was followed by questions about the students' learning behavior and satisfaction with the statistics course. Finally, interviewers were free to ask any open follow-up questions on topics that arose.

Six students participated in all four interviews. However, analyses of all 14 first interviews failed to establish that the attitudes of the six remaining students differed substantially from those of the eight students who dropped out of the study. The six students with the full four measurement points are therefore considered the six cases of this study.

The analysis of the 24 interviews follows Saldana's (2003) manual for the analysis of longitudinal qualitative data. Saldana therein proposes a three-step procedure: First, the interviews are to be coded per case as closely to the material as possible using in vivo coding and paraphrasing and then summarized into case reports. In the second step, the material is coded across individuals and time points for themes and patterns. In this step, it is also possible to use quantifying codes to make comparisons between persons and time points more tractable. In a third step, the case reports and the themes and patterns are synoptically combined to form an overall picture.

In the present work, *in vivo* coding and paraphrasing according to Miles and colleagues (2020) was used for the first step. This resulted in case reports, which are briefly summarized in the first part of the results.

The themes and patterns were examined using a qualitative content analysis creating categories, definitions, anchor examples, and coding rules for attitudes and reasons for attitudes following Mayring (2015). First, deductively obtained categories were used. For this purpose, the six dimensions of the SATS became first categories. Based on Songsore and White (2018), subcategories of value were assumed to be *value for future schooling*, *value for a future career*, and *value for everyday life*. Inductively from the material, the subcategories of *value for society* and *value for science* were added. In addition, the category of effort was split into two subcategories, *general effort* and *effort relative to other courses*. A category on *prior experience with mathematics* was added.

In order to identify patterns in addition to themes, two additional dimensions of categories were developed inductively from the material. First, it is easily seen that all statements can be positive or negative to varying degrees. Therefore, the *sentiment* of a statement was coded as *very positive*, *rather positive*, *neutral*, *rather negative*, or *very negative* following the example of a Likert scale. Secondly, the follow-up interviews show that students repeatedly evaluated specific content topics instead of statistics in general. This was therefore coded as the *frame of reference*, which can be either *topic-focused* or *statistics in general*.

Overall, each quote in the material was coded in all three dimensions, namely theme, sentiment, and frame of reference.

RESULTS

Case Reports of the Six Interviewed Students

Sophie, pseudonym for the first interviewee, starts her statistics course with positive attitudes towards statistics. She attributes a high value to statistics both for her future schooling and for everyday life. She sees mathematics as a central element of statistics, but this does not bother Sophie because she has “always liked math ... and never had big problems with it.” Therefore, she does not consider statistics to be difficult, but expects to put a lot of effort into the course. After five weeks in the course, it is confirmed for Sophie that she is doing well with the math in the course. She has also become even more aware of the social importance of statistics, evaluating it as “very useful, as you can also see now in election times.” Her attitude therefore improves to the highest sentiment. After nine weeks of the course, Sophie describes her attitude as unchanged overall and “still finds it very useful to learn statistics.” However, she compares topics with each other and reports that she found the most recently taught introduction to “inferential statistics more interesting than the topic before,” although she considers descriptive statistics to be more valuable. Even after the end of the course, her attitude remains very positive, and the value of statistics in particular continues to dominate this view because she finds it “very useful to learn statistics ... and a helpful different way of thinking about social questions.”

Chen starts the course with an overall neutral attitude toward statistics. He considers statistics to be important “to understand social contexts” and for science, but not so much for himself personally. Chen also considers statistics to be mathematical. Because he “never was good at calculations,” he considers statistics to be rather difficult. This fear was then confirmed for Chen after the first five weeks of the course. Because his problems with mathematics are even greater than expected, his attitude slightly tips toward the negative. However, Chen continues to see the general value as a good reason for statistics, because he sees “a legitimacy in statistics, but it is not necessarily fun.” After nine weeks, Chen primarily discusses inferential statistics, which he finds “not very interesting, but sometimes useful ... and really used in science ... and in papers I read.” His overall attitude therefore returns to a medium level and even becomes slightly positive at the end of the course because “statistics is an area you can make clear using examples ... from scientific papers.” The difficulty was also no longer considered to be as high because Chen saw that he “was able to pass the exam.”

Daniel enters the course with negative attitudes. He equates statistics with mathematics and “never liked nor was good at math.” He also states that he does “not need statistics so much because I rather want to take the qualitative research path.” After five weeks of the course, Daniel’s view has not really changed. He explains that statistics “is necessary in general and to understand sociology ..., but not really necessary for me.” After nine weeks, Daniel’s attitudes towards statistics are at an all-time low. He “doesn’t like it ... often left early ... hardly understood half of it ... and didn’t listen.” As a

result, Daniel drops out of the course after eleven weeks. In the interview after the course, Daniel reports that he still doesn't like statistics but now realizes that statistics has value. He understands “why you have to learn it. Simply so that you understand how to deal with quantitative data.” Daniel therefore wants to start the course next year with more commitment.

Emma starts with rather negative attitudes. The main reason is mathematics, which leads Emma to consider statistics as “very difficult.” At the same time, however, Emma “find(s) it interesting.” After five weeks, this view has been reaffirmed for Emma. She perceives statistics as “still rather difficult” but finds it “not so uninteresting” because “maybe you need it later in your job, when you have to analyze something or so.” After nine weeks, Emma's attitude has changed more. Overall, it falls slightly into the negative again. On the level of individual dimensions, her interest has increased further because she now also sees a high value in statistics, which is justified by the topic of inference. At the same time, however, she finds this topic more difficult—perhaps too difficult. She feels overwhelmed, “it's over my head ... it's just all a bit much for me.” She retains this feeling until she drops out of the course a few days before the exam. However, in the last interview, she still expresses a high value of statistics, calls it “relevant and interesting,” and discusses how bivariate statistics was even more interesting and valuable than the content before.

Selma starts with rather positive attitudes. She finds statistics “valuable and actually interesting. It can be complicated ..., but it is useful and interesting to somehow give information about a population.” After five weeks, there is some slightly positive attitude development, because she now perceives the value of statistics (as well as its difficulty) higher than before. After nine weeks, because of inferential statistics, Selma is “definitely less motivated. Before, the topics were probably a bit less complicated and easier to comprehend.” Nevertheless, she describes statistics as very valuable. The last part of the course, however, Selma likes more because she finds bivariate statistics less difficult than previous topics. Selma likes statistics now and finds it very useful: “In general ... statistics is actually a great thing, you can definitely use it, especially in the field of politics, when it comes to elections ... It's definitely helpful ... but there are certain difficulties.”

Alex starts with positive attitudes. Statistics is described as interesting and “quite relevant for me ... because I need it to do research and to be able to evaluate it.” Alex does not consider statistics to be difficult. After five weeks of the course, positive attitudes even increase. “By now, I think it's great. I am completely thrilled!” Especially because of the topic of the first weeks and because of experiences in another course, statistics is now described as outstandingly important. Alex still does not consider statistics to be difficult. After nine weeks, Alex has experienced a slight drop in positive attitudes. He still finds statistics important because “it is necessary for what I want to do later on,” but the topic of inference is very difficult for him. His motivation suffers, and he “didn't do as much as before.” By the end of the course, however, this development recovers because the rest of the course was no longer as difficult for him. He continued to find the course “interesting ... and definitely needed for scientific work.”

Themes and Patterns Across the Interviews

Looking at the categories assigned during the qualitative content analysis, the first thing to note is that the category value for future schooling is by far the most frequent. For Emma, this category only appears in her last interview, in which she sums up the course after dropping out. In the total of 20 interviews of the other five students, the category occurs at least once in every interview and is almost always positively evaluated. Only Daniel initially makes negative statements and revises his opinion in the last interview. It is also evident that about half of the statements in the follow-up interviews attribute the value for future schooling to specific content. Especially in the third interviews this can be observed for the introduction to inferential statistics. The value of statistics for future schooling thus appears overall as an important component of attitudes, which, apart from the very negative Daniel, also keeps the more reserved students on track.

Other categories of value are also coded frequently. The value for everyday life occurs more frequently for Sophie and Selma and only once for Chen and Daniel. However, these categories do not represent only positive attitudes but are a reason for the overall negative attitudes in Chen and Daniel. The same applies to the value for a future career. For Selma this is a noticeably frequent theme that changes in parallel with her overall attitude. Also important to her is the value for society, which she evaluates more consistently positively and which keeps her on track. Sophie and Chen also argue

positively for the value of statistics for society to some extent. The value for science drives Alex's positive attitudes, in particular, but also can be seen in Selma's and Chen's attitudes.

The second most frequently coded category after value was difficulty. Often the categories are related to prior experience with mathematics. Whereas each person's coded statements for mathematics are sentimentally similar, each person's sentiment towards difficulty is subject to slightly greater fluctuations. This can be explained, among other things, by the fact that difficulty is often attributed to specific topics. Half of the interviewees (Emma, Selma, and Alex) emphasize the particular difficulty of inferential statistics. Previous experience with mathematics, on the other hand, played no role in these third interviews. Personal cognitive competence is also often associated with difficulty. However, the interviewees do not distinguish between the general difficulty of statistics content and personal difficulty with learning the content but use the expressions practically synonymously.

Codes for the category of interest can also be found in all six students. Although Emma and Alex talk about interest in all interviews, Selma only talks about it in the first interview. Sophie, Chen, and Daniel each talk about their interest in the second and third interviews. It is noticeable that in these interviews in particular, interest is discussed in relation to the specific topic, although with very mixed evaluations of both topics.

Affect is coded least often overall. Sophie and Emma express nothing in terms of affect; Selma and Alex do so once each and Chen twice. Only in Daniel's case are there several codes for this category. No codes were evident in his first interview, but thereafter, affect is very pronounced and in direct context to the overall assessment of his attitudes.

Effort in some ways represents a special dimension because it relates more to the course than to statistics itself. Nevertheless, it does seem to affect students' attitudes as a whole, which can be seen from the many codes in this category. It is striking that the comments on effort in the first interviews refer exclusively to the general effort, whereas in the later interviews, comparisons to other courses are drawn more and more frequently.

CONCLUSION

This study of six students in an introductory statistics course complements existing findings on attitude development. Although simple pre and post comparisons may not show significant changes, there are more dramatic attitude changes throughout the course progression related to specific topics. Although Daniel, Emma, and Alex ended the course with the overall attitude they had at the beginning of the course and Sophie, Chen, and Selma experience only slight improvements; stability with the first interview can only be found in a total of four out of 18 follow-up interviews. In the course of the interviews, it becomes apparent that the second interviews are coded more positively than the first, the third often more negatively, and the fourth again somewhat more positively.

With regard to the reasons for these attitudes and their changes, it should first be noted that the value of statistics for the students' future schooling is a frequent and stable cornerstone. In the context of a compulsory course, a baseline level of attitudes only builds up from this. The heterogeneity of attitudes among the six interviewees is mainly related to the perceived value for everyday life and to the difficulty of statistics, the latter mostly in connection with previous experience with mathematics.

It is also evident that statistics is not perceived as a uniform block, but that students relate their evaluations to specific topics. It is noticeable that the introduction to inferential statistics is perceived to be both more valuable and more difficult. Depending on the previous perceived difficulty, a tipping point towards dropping out is often reached then, or attitudes rise again as value and interest increase.

For instructors, this can mean that they can act proactively to positively affect their students' attitudes, particularly in the area of the value of statistics. The value for the students' future schooling is generally shared but should be kept present in order to have a motivational impact. The value for everyday life and society seems less clear but is closely related to the overall evaluation in the explanations. Here, instructors can adjust instruction by providing convincing examples. Researchers should be concerned that inferential statistics continues to be perceived as very difficult, despite the fact that mathematics is not seen as a problem here. New approaches to good subject matter didactics would be helpful here.

At the same time, however, it must be noted that the six students interviewed have unique individual backgrounds and developments. Their opinions and explanations are therefore not necessarily

representative, and certainly not for other, differently organized courses. Nevertheless, they can point out sites of fracture that are worth reflecting on both for teachers and researchers.

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