# GERMAN MATHEMATICS TEACHERS' VIEWS ON STATISTICS EDUCATION

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*Although knowledge about how to improve statistics teaching is steadily increasing, still very little is known about what statistics teachers actually know, think, and do in their classrooms. The present study is a first attempt to shed more light on the issue. Experienced mathematics teachers were asked about their views of statistics in general and of current curricula, as well as about their impressions of their students' views and abilities regarding statistics. In addition, they were asked to indicate what good statistics instruction should look like. We found that in general, teachers as well as students are quite interested in statistics but that students apparently experience greater difficulties in statistics classes than in classes on other mathematical topics. We identify several potential impediments to effective statistics instruction that might be good starting points for attempts to improve statistics education in German schools.*

## INTRODUCTION

There is an abundance of (often empirically based) suggestions about how statistics instruction in schools can be improved and what such courses should look like (e.g., Arbeitskreis Stochastik der GDM, 2003) but, at least as far as the German educational system is concerned, almost nothing is known about what statistics teachers really know, think, and do. In Germany, there are two special reasons for this state of affairs. First, there has never been a common curriculum concerning the content of statistics training for mathematics teachers at the universities. In extreme cases, mathematics teachers might even begin teaching without themselves having attended any course on statistics or probability. Therefore it is no wonder that teachers' conceptions about probability differ widely (Eichler, 2003, 2005). Second, the curricula for statistics education in the 16 German states still differ widely in respect to the content to be taught, at which grades, and at which type of school (Kaun, 2006). This state of affairs seems to be changing as expressed in an agreement among the German states to give higher priority to statistics education (KMK, 2003). So it is to be expected that statistics education will soon make up more of the mathematics curricula and will eventually become comparable for all German states (e.g., ISB, 2005). For many years to come, however, the current math teachers who may not be very well versed in statistics teaching will have to take on the burden of implementing the new curricula.

Many of these teachers might need help teaching successful statistics classes. However, without a clear picture of current practices and teachers' views on statistics education, the advice of researchers who, for instance, propose using specific formats to teach statistical concepts (e.g., Sedlmeier, 2007; Wassner, Martignon, & Sedlmeier, 2002) might not be followed because their suggestions might be too far removed from actual practice. Statistics education can only be improved if teachers are motivated to use new methods and tools that are suggested by researchers. And they will only be motivated if they find the suggestions useful and pertinent (Batanero, Godino, & Roa, 2004; Sedlmeier, Böhm, Lindner, & Schmidt, 2006; Thompson, 1992). Therefore, to have a firm basis for suggesting what measures should be taken to improve statistics education it seems absolutely necessary to determine the status quo of teachers' views of statistics and the possibilities they see for the improvement of statistics instruction. The study reported here is a first step in that direction. In particular, we wanted to find out about math teachers'

- views of statistics
- appraisal of current statistics curricula
- impressions about their students' views and abilities with respect to statistics
- views about what good statistics instruction should look like
- personal commitment to improving statistics education.

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We also wanted to look at possible connections between teachers' views and some demographical variables such as teachers' age and gender.

## METHOD

Because the study seems to have been the first of its kind, it was of an exploratory nature, and we did not attempt to recruit a representative sample of teachers from all over Germany. Instead we concentrated on mathematics teachers who also teach statistics in high schools (*Gymnasium*) in the states of Berlin and Bavaria. In Berlin, all high-school administrations were first contacted by telephone, and those schools that agreed to participate were sent questionnaires. The response rate, which could only be estimated because we did not have access to detailed information about how many math teachers actually teach statistics, was about 20%, which is not unusual in surveys at German schools (Sedlmeier et al., 2006). We obtained completed questionnaires from $n = 33$ (13 female, 20 male) Berlin teachers. The $n = 7$ teachers in Bavaria who also completed questionnaires (5 female, 2 male) had been contacted on a personal basis.

The questionnaire consisted of items that referred to the topics mentioned above: demographical variables such as gender and age, teachers' views of statistics, teachers' evaluation of the existing curricula, teachers' views about what their students think about statistics, teachers' views about how statistics should be taught, and some items on whether teachers were willing to invest any time and effort in continuing education in statistics issues. The relevant items will be introduced along with the results (the questionnaire also contained other items concerning the statistics textbook teachers used—we will not elaborate on those results here).

## RESULTS AND DISCUSSION

We will generally present the combined results for Berlin and Bavarian teachers, unless there are systematic differences, which we will point out. Overall, mean age (49 years) and gender distribution (43% females) in our sample are quite representative of German mathematics teachers in general.

### *Mathematics Teachers' Views of Statistics*

Teachers were first asked about the importance of statistics in daily life as compared to other areas of mathematics education. Participants had three choices: "higher importance," "no difference," and "lower importance." In addition, they were asked to indicate whether in their opinion, statistics should be given more hours per week even if it meant that other mathematical topics would get less. Possible answers were: "in any case" (more hours), "possibly," and "in no case." The results are shown in Figure 1.

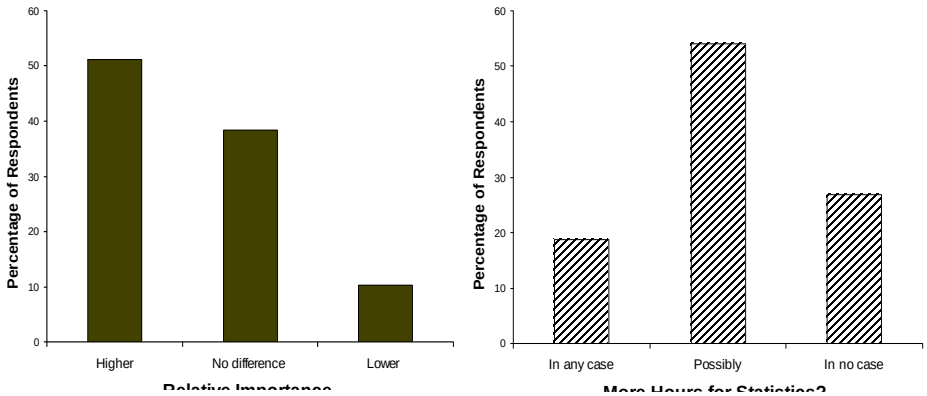


Figure 1. Mathematics teachers' views of statistics.

The results indicate that teachers generally acknowledge the practical importance of statistics (only about 10% think that statistics is less important than other mathematical topics) and are also willing to spend more time teaching statistics even if that means that other mathematical topics might receive less attention. These opinions seem not to be influenced by the age or gender

of teachers. However, as can be expected, there is a relatively strong positive relationship between judged relative importance and willingness to spend more hours on statistics teaching (Kendall's Tau = 0.40).

*Attitudes Toward Current Curricula Contents*

What do teachers think about their current curricula? To find out, we had them rate the following five items on a Likert-type scale ranging from 1 ("agree completely") to 5 ("disagree completely"):

- Amount to be covered is adequate for students ("Adequate")
- Topics covered are up-to-date ("Up-to-date")
- Content is application oriented and relevant to real life ("Reality")
- Interdisciplinary goals are transparent ("Interdisciplinarity")
- There are many possibilities for teachers to bring in their own ideas ("Possibilities").

The results are shown in Figure 2.

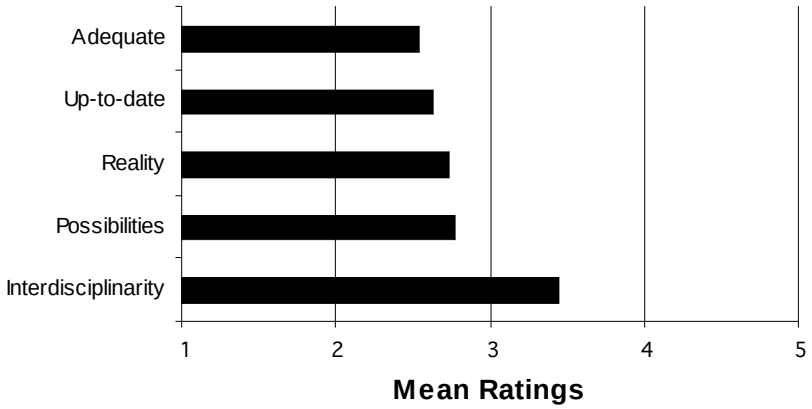


Figure 2. Teachers' opinions of curricula content.

The means of four of the five ratings were somewhat lower than the scale mean, and this might indicate that teachers are not too dissatisfied with their current curricula. Only the goal of interdisciplinarity has not been met by the curricula according to teachers' mean ratings. The results for the $n = 7$ Bavarian teachers were somewhat more pessimistic (0.38 scale points on average over the five items) than those for the Berlin teachers. But again, age and gender seemed to have no effect on teachers' ratings except that younger teachers tended to be less convinced that the content was application oriented and relevant to real life ($r = -0.28$).

*Impressions About Students' Views and Achievements*

Respondents were asked to characterize their students' views of and achievements in statistics. We were especially interested in how they judged students' interest, attention, understanding, and motivation as compared to other topics in mathematics education. Again, a five-point Likert-type scale was used, which ranged from 1 ("clearly higher" as compared to other mathematical topics) to 5 ("clearly lower" as compared to other mathematical topics). Figure 3 shows that students' interest, attention, and motivation for statistics courses were above average compared with other topics in mathematics education. However, teachers' responses also reveal that they might be in need of assistance in teaching statistics. In their view, statistics seemed to be harder to understand for students than other mathematical topics taught at school.

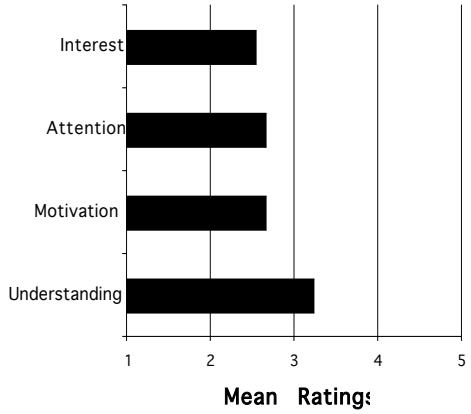


Figure 3. Teachers' opinions about students' views and achievements.

*Ingredients of Good Statistics Instruction*

To find out about teachers' conceptions of what good statistics instruction should look like, we had them judge the following statements, again using a five-point Likert-type scale with the values ranging from 1 ("very important") to 5 ("unimportant"). The items were preceded by the statement "Please judge the importance of the following issues for statistics instruction as compared to other areas of mathematics. In good statistics instruction…"

- connections with other subjects (non-mathematical) are made ("Other subjects")
- the relationship between content taught and daily-life issues is highlighted ("Daily life")
- statistical topics are taught using many relevant examples ("Relevant examples")
- several ways to solve a problem (including students' suggestions) are discussed ("Several ways")
- students' interests are addressed ("Students' interests")
- helpful visual formats/graphical models are used ("Graphical models")
- computers will be used (e.g., for data analysis, simulation, instruction) ("Computer use")
- work is done through student projects ("Student projects")
- students' intuitions are taken into account ("Students' intuitions")
- students collect their own data ("Own data")
- real experiments are conducted ("Real experiments")
- preparation for university plays a central role ("University preparation") .

Figure 4 shows that teachers rated all the suggestions more on the important side (means smaller than the neutral point of 3). Most important seems to have been the choice of good problems: they should be relevant to daily life. Teachers also found it very important that statistics instruction should be flexible, using different ways to understand a problem, and they appreciated the use of graphical models to foster understanding. The latter was confirmed by an additional question concerning the kinds of graphical representations teachers actually used. Every teacher indicated using at least one kind of graphical representation, and all teachers in our sample used some kind of tree diagram. Teachers were not as keen to base the instructional process to a larger extent on students' activities, such as having them conduct their own experiments or collect their own data; nor were they interested in putting more emphasis on students' interests. Especially remarkable is the teachers' relative reluctance to use computers, because their use is necessary for implementing many of the suggestions derived from research on how to improve the teaching of statistics. Teachers' views about good statistics instruction seem partly to depend on age and gender. Younger teachers tended to find it more important to make connections to daily life ($r$ = 0.42), to use different strategies to solve statistical problems ($r$ = 0.42), to conduct real experiments ($r$ = 0.30), and to use relevant examples ($r$= 0.30). However, contrary to what one might expect,

the judged importance of using computers was *not* related to age ($r$ = 0.05). In addition, more male than female teachers thought it important to use relevant examples ($r$ = 0.40), whereas the reverse was true for the judged importance of statistics instruction to prepare for university ($r$ = -0.39).

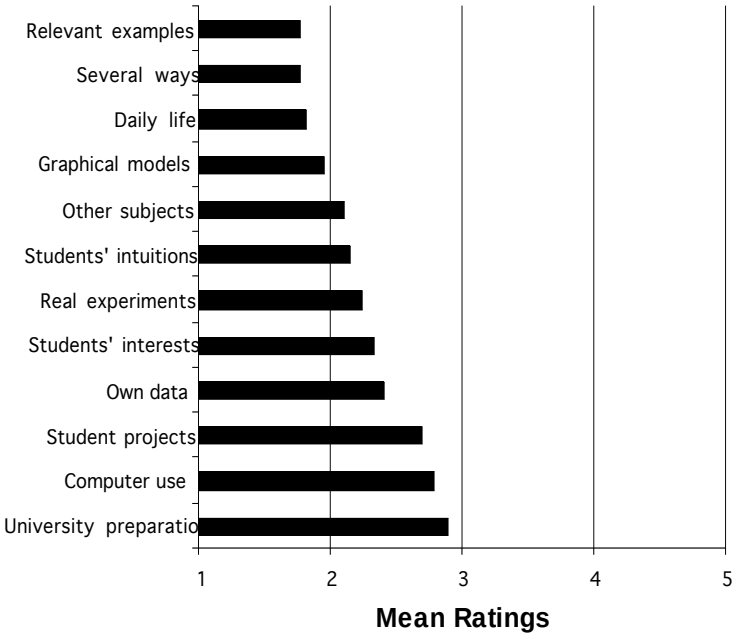


Figure 4. Teachers' views about what is important for good statistics instruction.

*Personal Commitment to Improving Statistics Instruction*

A good indicator of mathematics instructors' interest in statistics education seems to be whether they have spent any time undergoing additional training on statistical issues. We asked teachers whether they had ever attended such courses. (For German teachers it is mandatory to attend continuing education courses; they are, however, allowed to choose the topics themselves.) Overall, 45% of the teachers stated that they had already taken at least one continuing education course in statistics, and 80.6% indicated they would be interested in such a course. The remarkable difference between indicated interest and status quo might hint at an insufficient supply of relevant courses.

## CONCLUSIONS

Although our sample is quite representative of German mathematics teachers as far as age and gender are concerned, the low response rate (quite common in surveys of this sort) limits the strength of possible conclusions. First, the positive news: Both teachers' and students' views of statistics are positive, and the relevance of statistics in everyday life is acknowledged. Moreover, teachers indicated being quite willing to learn more about statistics in extra courses. Overall, teachers were only moderately content with the current curricula. This might have recently changed or may change in the near future because of the ongoing attempts in Germany to improve and standardize statistics curricula—a follow-up study to examine this issue is underway.

Especially important for attempts to improve statistics instruction in schools are teachers' views about what good instruction should look like. Here we find a certain reluctance to include student activities or to address students' special interests. Doing this certainly means more preparatory work (at least in the beginning), but it might also mean more fun for both students and teachers and could mean higher learning rates. It might help to offer easy-to-do sample projects of this sort on a broad basis. However, collecting data only makes sense if one also can analyze them easily. To do that, computers (and appropriate software) are almost indispensable. Herein might lie a serious problem: Teachers do not seem to regard the use of computers for data analysis,

simulation, and instruction as a highly important ingredient of good statistics instruction. This might be due to the relatively advanced age of German teachers who did not have the chance to use computers in their own education. If this is the case, one would expect a strong correlation between teachers' age and judged importance of computer use, which we did not find. Here it seems necessary to think about ways to motivate teachers to explore the possibilities good computer programs can offer for students' understanding of statistics (Batanero, Biehler, Engel, Maxara, & Vogel, 2005; Biehler, 1991; Sedlmeier & Köhlers, 2001). In the follow-up study, we will also address this problem more thoroughly.

Teachers often have the sense that decisions about changes in curricula and teaching methods are made over their heads. As a consequence, such changes might not be very effective. Only if mathematics teachers can be convinced that new approaches are really useful will such changes be effectively applied in schools. Convincing teachers to adopt new procedures, however, depends on understanding where they stand on the status quo. This study was an attempt to find out where that might be.

REFERENCES


Arbeitskreis Stochastik der GDM. (2003). Empfehlungen zu Zielen und zur Gestaltung des Stochastikunterrichts [Recommendations about goals and content of statistics education]. *Stochastik in der Schule, 23*, 21-26.

Batanero, C., Biehler, R., Engel, J., Maxara, C., & Vogel, M. (2005). Using simulation to bridge teachers' content and pedagogical knowledge in probability. In: *ICMI-Study 15* Online: www.weizmann.ac.il/G-math/ICMI/log_in.html.

Batanero, C., Godino, J. D., & Roa, R. (2004). Training teachers to teach probability. *Journal of Statistics Education, 12*. Online: www.amstat.org/publications/jse/.

Biehler, R. (1991). Computers in probability education. In R. Kapadia & M. Borovcnik (Eds.), *Chance encounters: Probability in education* (pp. 169-212). Dordrecht: Kluwer.

Eichler, A. (2003). Was ist Wahrscheinlichkeit? Individuelle Unterrichtskonzepte von Lehrerinnen und Lehrern [What is probability? Teachers' individual teaching concepts]. *Der Mathematikunterricht, 3*, 69-82.

Eichler, A. (2005). Individual Curricula—Beliefs behind teachers' beliefs. In A. Rossman & B. Chance (Eds.), *Proceedings of the Seventh International Conference on Teaching of Statistics* (ICOTS 7), Salvador: IASE, ISI.

ISB (Staatsinstitut für Schulqualität und Bildungsforschung). (2005). *KMK-Bildungsstandards - Konsequenzen für die Arbeit an bayerischen Schulen*, 1. Februar 2005 [Standards of the KMK—Consequences for Bavarian schools].

Kaun, A. (2006). Stochastik in deutschen Lehrplänen allgemeinbildender Schulen [Probability theory in German school curricula]. *Stochastik in der Schule, 26*, 11-17.

KMK (Beschlüsse der Kultusministerkonferenz). (2003). *Bildungsstandards im Fach Mathematik für den Mittleren Schulabschluss* [Standards in mathematics for middle schools]. Munich: Wolters Kluwer.

Sedlmeier, P. (2007). Statistical reasoning: Valid intuitions put to use. In M. Lovett & P. Shah (Eds.), *Thinking with data* (pp. 389-419). Mahwah, NJ: Erlbaum.

Sedlmeier, P., Böhm, M., Lindner, S., & Schmidt, M. (2006). PISA aus Lehrersicht: Mögliche Ursachen und Verbesserungsvorschläge [PISA as seen from the teachers' side: Possible causes and suggestions for improvement]. *Unterrichtswissenschaft, 34*, 46-69.

Sedlmeier, P., & Köhlers, D. (2001). *Wahrscheinlichkeiten im Alltag: Statistik ohne Formeln* [Probabilities in everyday life: Statistics without formulas]. (Textbook with computer program on CD) Braunschweig: Westermann.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook on mathematics teaching and learning* (pp. 127-146). New York: Macmillan.

Wassner, C., Martignon, L., & Sedlmeier, P. (2002). Die Bedeutung der Darbietungsform für das alltagsorientierte Lehren von Stochastik [The role of representational formats for the teaching of statistics]. *Zeitschrift für Pädagogik, 45* (Beiheft), 35-50.