

## TEACHERS' VIEWS RELATED TO GOALS OF THE STATISTICS CLASSROOM – FROM GLOBAL TO CONTENT-SPECIFIC

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*When teachers design learning opportunities in the statistics classroom, they should be aware of specific goals related to statistical literacy – and they should be able to refer to these goals when evaluating the learning potential of tasks. Consequently, possessing corresponding professional knowledge can be seen as a key requirement for teachers. However, as empirical research into these professional knowledge components is still scarce, this study focuses on this area and aims at identifying needs for professional development. The results suggest that many teachers did not see fostering students' understanding of statistical variation as a prominent goal and that they hardly acknowledged the learning potential of corresponding tasks.*

### INTRODUCTION

Clarity and goal orientation are crucial for instructional quality – but which goals do in-service teachers connect to the statistics classroom and to specific tasks? As there is still little empirical evidence related to this question, the research presented here concentrates on teachers' views related to major goals of statistical literacy. As rather general orientations of teachers might be less relevant for classroom practice than specific content-related professional knowledge and views, the research design further includes teachers' task-specific evaluations. The results indicate that the teachers saw a relatively low importance of dealing with statistical variation, which is considered a key goal of statistics instruction by the scientific community. This result was observed consistently both on a relatively global level of professional knowledge and on the very content-specific level of particular tasks, and hence highlighted a need of professional development. Further, as global goal orientations did not show high interdependencies with e.g. content-specific views, the findings reflect a spectrum of different relevant variables for teachers' perceptions of instructional goals of the statistics classroom, which should also be covered in follow-up research.

The paper starts with an overview of the (1) theoretical background, which leads to the (2) research questions. Information about the (3) design of the study will explain how these research questions were approached. Key (4) results of the study will be presented and interpreted in a concluding (5) discussion.

### THEORETICAL BACKGROUND

Teachers do not only need content knowledge in order to be able to design cognitively activating learning opportunities in the statistics classroom – also the extent to which they are aware of key goals related to statistical literacy may have a significant impact on what emphasis they put on different aspects of subject matter and students' understanding (Schoenfeld, 2011).

A focus on abilities of dealing with statistical variation, for instance, is considered as crucial for building up competencies in the area of statistical literacy (e.g. Watson & Callingham, 2003; Kuntze, Lindmeier & Reiss, 2008; Kuntze, Engel, Martignon & Gundlach, 2010). Teachers should hence be aware of this goal, as statistics instruction is not only an area of applying concepts or algorithms from the probability teaching unit to authentic everyday contexts: Dealing with variation is a key component of statistical thinking, as learners should – in the terms of Konold & Pollatsek (2002) – be enabled to distinguish “signal” from “noise” in statistical data.

Being aware of this goal requires specific professional knowledge. As different components of professional knowledge might be relevant for teachers' views of goals for the statistics classroom, a corresponding model (Figure 1; Kuntze, 2012) was used which affords an overview of components of professional knowledge: This model integrates the spectrum between declarative and procedural professional knowledge on the one hand and convictions/beliefs on the other hand (cf. Pajares, 1992), considering both as being contained in the notion of professional knowledge. The vertical columns in Figure 1 reflect Shulman's (1986) professional knowledge domains. As we have to take into account that individual professional knowledge is often organised

in an episodic structure (Leinhardt & Greeno, 1986), the model further distinguishes different levels of globality (Törner, 2002; Kuntze, 2012). Besides global components of professional teacher knowledge such as epistemological beliefs about mathematics as a whole (e.g. Törner & Pehkonen, 1996), content domain-related components are considered relevant, e.g., views connected with the content domain of data and chance (e.g. Chick & Pierce, 2008). Further, studies e.g. by Biza, Nardi and Zachariades (2007) as well as by Kuntze (2011) focused on views of teachers related to tasks, hence components of professional knowledge specific to a particular content. Finally, on an even more situated and less global level, views of teachers concerning (videotaped) instructional situations have been considered in empirical research (e.g. Kuntze, 2012).

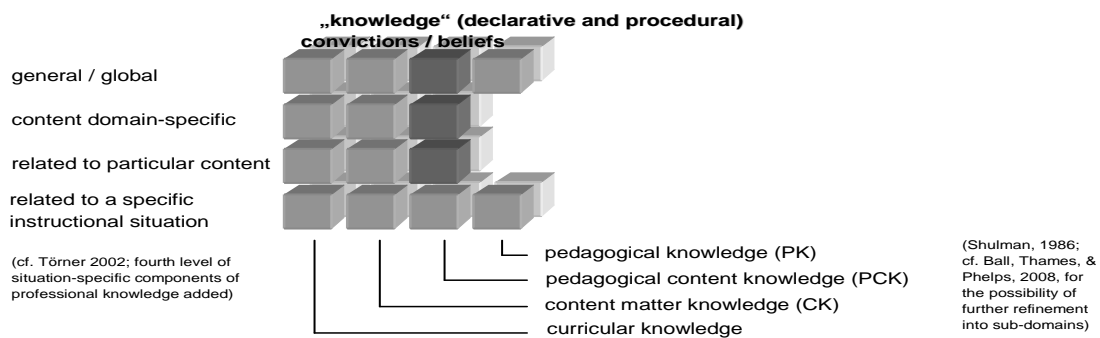


Figure 1: Model for components of professional knowledge (Kuntze, 2012)

Together these components of professional knowledge are likely to influence mathematics instruction and hence the learning opportunities for students in the statistics classroom in particular. Against the background of this model, teachers' knowledge and views about instructional goals (cf. Schoenfeld, 2011) can be described on different levels – for instance, on a general, on a content domain-related and on a content-specific level (see highlighted cells in Fig. 1). Moreover, the model in Figure 1 suggests devoting attention to questions related to goal consistency across different professional knowledge components. For example, it is interesting whether and how the perceived goals of statistics instruction are in line with more general goals of the mathematics classroom. Probably even more relevant for instructional practice is the question whether teachers have the necessary professional knowledge to acknowledge the learning potential of tasks which provide learning opportunities for the students' understanding of statistical variation. Such task-specific views held by teachers (cf. Biza et al., 2007) might be more strongly linked to instruction-related decisions than global or even content domain-specific views. In empirical studies, the perceived learning potential of tasks can be used as a cumulative indicator (e.g. Kuntze, 2011), providing insight into content-related PCK. Such PCK can be particularly meaningful for ways in which teachers see and implement goals, e.g. when choosing tasks for their classrooms.

## RESEARCH INTEREST

The theoretical background sketched in the previous section highlights the need of research into teachers' views and PCK related to goals of the statistics classroom. It is interesting in particular whether teachers acknowledge the students' understanding of variation as key goal both on the content domain-related and content-specific levels and how these views are connected with other professional knowledge. The study hence focuses on the following research questions:

- (1) What views related to key goals of the statistics classroom do in-service mathematics teachers hold?
- (2) How do the in-service mathematics teachers see the learning potential of tasks which make use of data and diagrams with or without focus on statistical variation? Which goals do they associate with these tasks?
- (3) Are there interdependencies of the teachers' perceptions of goals of the statistics classroom with other – more general or more situated – components of professional knowledge, such as task-specific views or global epistemological beliefs?

SAMPLE AND METHODS

The sample of this study consisted of 70 in-service mathematics teachers who were teaching at German academic-track secondary schools. The teachers had been teaching mathematics on average for 12.5 years (SD=10.7; 37 female, 32 male, 1 without data). These teachers (24 up to 35 years, 17 aged 36-45, 21 aged 46-55, 7 aged 56 years or more, 1 without data) had been recruited in the framework of an intervention study related to a learning environment for their students. The classes of the teachers had been recruited via the school administration. However, as the participation was voluntary, a selection effect cannot be excluded.

The teachers were asked to complete a multiple-choice questionnaire section with three short scales related to relatively general goals of the statistics classroom (see Table 2).

A second questionnaire section focused on the teachers' views related to four tasks. These tasks contained data and referred to incomplete diagram-like representations. The tasks were connected to relatively similar contexts (numbers of contraventions or crimes). However, their structure differed systematically with respect to the requirement of producing vs. completing a diagram on the one hand and with respect to the requirement of dealing with statistical variation in the data on the other. Table 1 shows the design characteristics of the tasks, Figure 2 displays two of the tasks the teachers had to evaluate. The teachers were asked about their views of the learning potential of the tasks in a multiple-choice format (sample item "Working on this task, students can learn a lot") and to note down goals they would think of when they were using the corresponding task in the classroom. Moreover, three indicator items per task were designed to tap how difficult the teachers expected the tasks to be for the students, whether the task impedes the learning goal of exactness and whether they considered it suitable for the classroom at all.

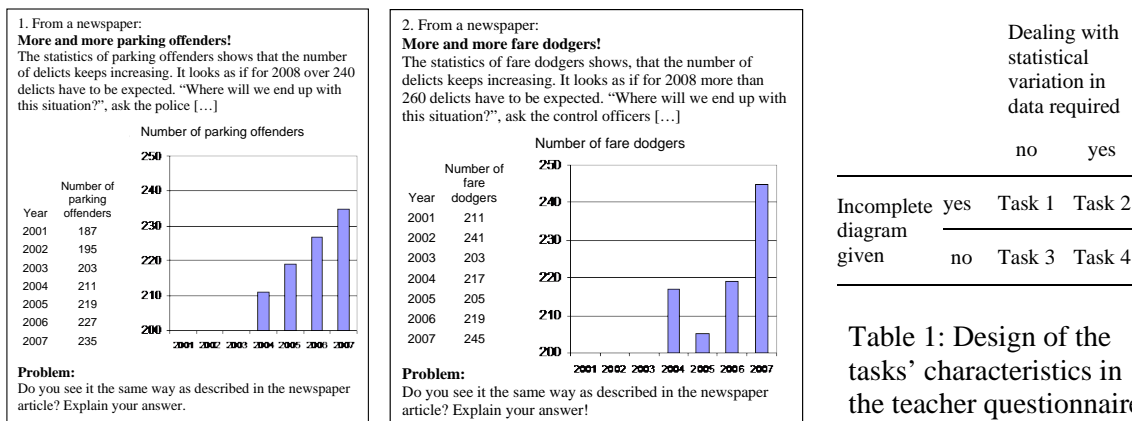


Table 1: Design of the tasks' characteristics in the teacher questionnaire

Figure 2: Two of the tasks the teachers were asked to comment on (task 1 and 2)

In an additional questionnaire section, which aimed at making an empirical link to more global views of the teachers (cf. Fig. 1) and thus was relevant for the third research question, the teachers were asked about global, i.e. non-content domain-specific epistemological beliefs towards mathematics, using an instrument by Törner & Grigutsch (1994). This questionnaire instrument focused on belief constructs, such as seeing mathematics as a toolbox of pre-defined algorithms, considering mathematics predominantly as a formal system, or seeing mathematics as a set of contents which can be applied in many everyday contexts (cf. Törner & Pehkonen, 1996).

RESULTS

The views related to goals of the statistics classroom focused in particular on the importance teacher attributed to the understanding of statistical variation in comparison to other goals such as forearming students against adulterant representations or aspects of application of algorithms and concepts related to probability. The reliability values of the three corresponding short scales are shown in Table 2 together with sample items. Given the low number of items, the reliability values ranged from good to still acceptable.

The results in Figure 3 show that the goals of deepening and applying probability knowledge in every-day contexts as well as the goal of forearming the students against adulterant

representations of statistical data were on average seen as important goals of the statistics classroom. In contrast, the teachers did on average rather not agree with items such as “in statistics instruction the main issue is the students’ ability to deal with different aspects of variation in data”.

Table 2: Short scales related to goals of statistics education: Sample items and reliability

Scale	Sample item	Number of items	$\alpha$ (Cronbach)
Understanding of statistical variation	In statistics instruction the main issue is the students' ability to deal with different aspects of variation in data.	2	0,30
Forearming against adulterant representations	In statistics instruction the main issue is that my students are forearmed to face adulterant representations of data.	2	0,82
Deepening /applying probability knowledge in every-day context	In statistics it is above all important to me that the students learn to know statistics as an area of application of probability contents relevant for every-day life and that they can like this deepen their knowledge in probability.	2	0,61

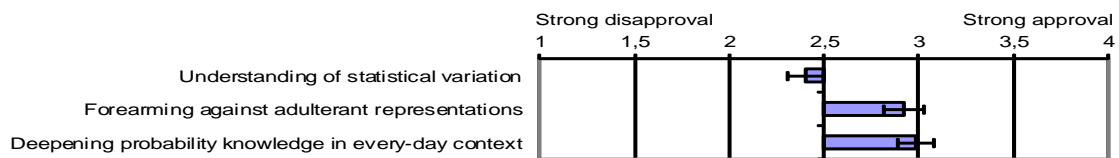


Figure 3: Teachers' views of the perceived importance of goals of the statistics classroom (means and their standard errors)

The second research question concentrated on content-specific views as reflected in the teachers’ evaluations of tasks. For each of the four tasks, three-item scales tapped the teachers’ views about the learning potential they associated with the corresponding task. The reliability values of these four scales were good, ranging from 0.82 to 0.84.

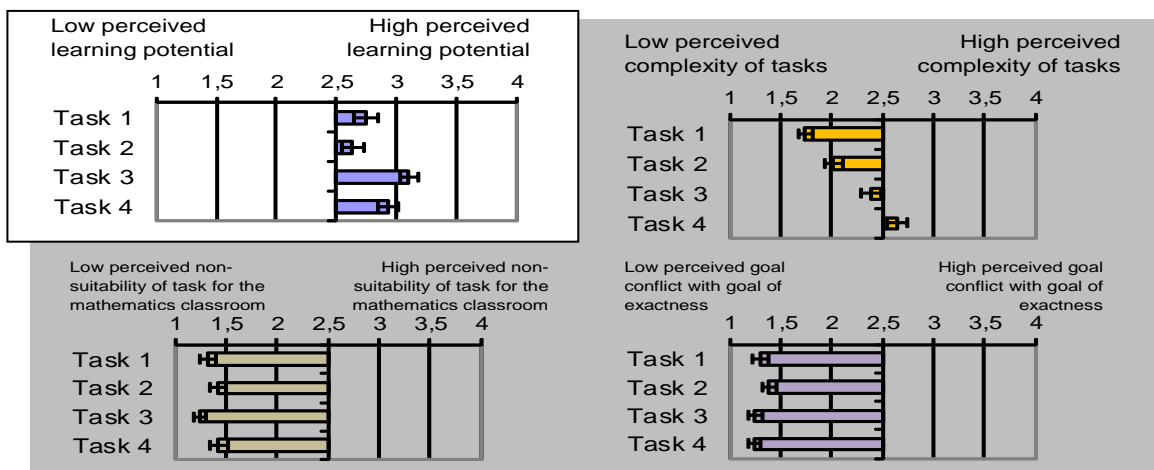


Figure 4: Task-specific views of the in-service teachers (means and their standard errors)

The results concerning the task-specific views are presented in Figure 4. Firstly, the teachers perceived on average a rather high learning potential of all the tasks. Secondly, the rather low or moderate perceived level of complexity – as well as the evaluations collected by the other two indicator items – suggest that the perceptions of the learning potential have not been influenced negatively by these perceived characteristics of the tasks on an over-all level. The two different task types with respect of the criterion “incomplete diagram given” (in task 1 and 2) vs. “diagram to be produced” (in task 3 and 4) were seen differently. At the same time, for both of these task types, there is a tendency that the tasks without real-world statistical variation in the data (task 1

and 3) were rated on average to have a higher learning potential. Exact and determinist linear modelling is possible in these tasks 1 and 3, so that the exact linear functional dependence in the data almost contradicts the experience of authentic contexts of statistical evidence.

Moreover, the teachers had been asked in an open format about the goals they would associate with the corresponding task. There were 139 comments (all four tasks taken together) specifying goals associated with the tasks by the in-service teachers. Among these were also comments expressing dissatisfaction with tasks, which could be interpreted as indirect evidence of goals the teachers had in mind in the context of the corresponding task. An overview coding distinguished different semantic domains the comments could be assigned to. Among the 139 comments related to goals, there were 9 comments with possible semantic relevance for statistical variation and 7 comments with possible semantic relevance for modeling or discussing models with realistic data. In comparison, goals related to technical skills and algorithms were more frequent: for instance, there were 46 comments related to technical skills in the area of functions and 47 comments related to technical skills of dealing with diagrams.

These comments to the open questions about what goals teachers would associate with the tasks can be illustrated by the following examples of teachers' answers (number of task added in brackets, respectively):

- Comments coded to have semantic relevance for statistical variation:
  - [A2:] “[...] additionally: recognising statistical up- and downturns as unforeseeable incidents”
  - [A4:] “finding an adequate model, reality requires adjusting and tolerating inexactness”
- Comments with semantic relevance for modeling or discussing models with realistic data:
  - [A1:] “boring ‘statistics’ – unrealistic”
  - [A4:] “I would say it is senseless and unrealistic to adapt a linear equation here. I would also say that to my students.”
- Comments coded to be related to technical skills in the area of functions:
  - [A3:] “crosslinking in the area of linear functions”
  - [A4:] “non-linear dependency cannot be described adequately by linear equations”
  - [A1:] “drawing a line and extrapolation, linear equation”
- Comments coded to be related to technical skills in the area of diagrams:
  - [A1:] “correct interpretation of diagrams, meaning of the scales of the axes, argumentation”
  - [A2:] “manipulation/spoofing by diagrams”
  - [A3:] “drawing of diagrams, transfer of previously learned [knowledge]”

The third research question focused on interdependencies of perceived goals with other components of professional knowledge. In a first approach, correlations were calculated. The findings suggest that the views related to key goals of the statistics classroom were not connected with general epistemological beliefs – with the exception of the application orientation of mathematics, which was positively correlated with the importance teachers gave to the goal of “deepening and applying probability knowledge in every-day contexts” in the statistics classroom ( $r=0.33$ ;  $p<0.05$ ).

Considering connections between the views related to the goal of fostering understanding related to statistical variation and content-specific professional knowledge, there were only correlations with the perceived learning potential of the tasks 3 and 4 ( $r=0.30$  and  $r=0.32$ ;  $p<0.05$ ).

## DISCUSSION AND CONCLUSIONS

Fostering students' competencies and understanding related to statistical variation was not perceived as a central goal of the statistics classroom by the German academic-track secondary teachers who took part in this study. The lack of awareness of this overarching goal could point to a need of developing corresponding PCK – and possibly also CK – as the emphasis put on this goal in statistics education research is hardly reflected in the teachers' views. The other two goals might appear as more obvious to the teachers, and they may be more dominant in the current textbooks as well. Considering the goals the teachers associated with the tasks and their evaluations of the learning potential, this interpretation is complemented by evidence on the content-specific level. In contrast to the design of the tasks, the teachers only rarely associated the tasks with goals related to dealing with variation or modeling, and they rather emphasised algorithmic procedures and technical skills in the areas of functions and diagrams. Consistently, they tended to evaluate the

learning potential of tasks containing data without real-world statistical variation as higher. Moreover they preferred tasks in which the students have to produce a diagram, which again represents a surface characteristic of tasks and relates to a rather technical activity. The preference for almost unrealistic, “determinist” data without real-world statistical variation supports the hypothesis that learning opportunities in statistics might be reduced to algorithmic aspects.

The correlations and non-correlations across levels of globality indicate that the constructs on the different levels do not coincide and hence are a set of variables of their own right. These findings in particular encourage follow-up deepening research about the interrelatedness of professional knowledge components in this domain. In such studies, more characteristics of tasks and even more detailed evidence about goals teachers associate with the statistics classroom should be included in the analysis.

Additionally, inter-cultural comparisons, research into the interrelatedness with instructional practice and competency development of students and into effects of focused professional development programs have high relevance for instructional practice.

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