INDIVIDUAL CURRICULA – BELIEFS BEHIND TEACHERS' BELIEFS

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This report focuses on a research project concerning individual curricula regarding the instruction of statistics and of probability theory. Individual curricula will be described as belief systems which contain teachers' subjective knowledge and conceptions about mathematics, about learning and teaching mathematics, and particularly about statistics and probability. This report stresses two aspects: the theoretical settings, and the methodological settings of the research. The theoretical settings concern central assumptions and theoretical constructs. The discussion of the methodological settings which will be illustrated by research results, includes the description of a five-step-methodology used for investigating individual curricula.

INTRODUCTION

> "How teachers make sense of their professional world, the knowledge and beliefs they bring with them to the task, and how teachers' understanding of teaching, learning, children, and the subject matter informs their everyday practice are important questions that necessitate an investigation of the cognitive and affective aspects of teachers' professional lives." (Calderhead, 1996, p. 709)

One important aspect of the research on teachers' beliefs is the conviction that they have a high impact on students' beliefs (Chapman, 2001). A further tenet in the research on teachers' beliefs is that one must accept the central role of teachers in changing or reforming mathematics education (Wilson and Cooney, 2002). Research shows that for Germany in particular, the implementation of reform ideas and of attempts at changing instructional practice in an administrative way will not work. This is especially the case in statistics and probability education (for the two, the term *stochastics* will be used in future). Therefore it is a major hypothesis to state that to grasp everything teachers contemplate for their teaching of mathematics is indispensable for any attempt at changing their instructional practice. Thus, the starting point for understanding teachers' reflections and decisions is to reconstruct how they plan their stochastics instruction, their individual stochastics curricula.

While individual curricula can be understood as teachers' belief systems according to the international didactical discussion, the results of research into teachers' beliefs are often globally categorised the latter into instrumentalist, formalist or a process-oriented type (Thompson, 1992). Hence, individual curricula are supposed to describe the beliefs behind these global types. This report focuses on the theoretical framework and methodology of the research on individually developed curricula (Eichler, 2005). The description of a five-step-methodology investigation will be illustrated by research results.

THEORETICAL FRAMEWORK

- *Fundamental terms and assumptions*: The investigation's approach is shaped by the central terms curriculum and individual curriculum. *Curriculum* means teachers' conscious choices of mathematical contents and their reasons for these choices. Other reflections are of importance only if they have directly influenced the choices lined out above.

The term teachers' *individual curriculum* is oriented to a model developed by Vollstädt *et al*. (1999). This report focuses on the third level of this larger model, the teachers' planning of mathematics instruction, i.e., the various individual curricula. It must be underlined here that the focus of research is on teachers' instructional planning and thus, in a psychological sense, on intentions of action which escape observation. Action itself is understood as "the physical behavior plus the meaning interpretations held by the actor" (Erickson, 1986, p. 126).

Both intention and action in their entirety are not observable and dependent on situations as well as on individuals' interpretation of a situation. Based on this central assumption, the approach of research is qualitative and interpretative. This approach implicates that the research focus is on *understanding* action as a non-observable internal process, as opposed to *explaining*

an observable behaviour in a mechanistic way (see for the duality of *Verstehen und Erklären* – understanding and explaining – Schwandt, 2000 and Gadamer, 1986).

Two more general assumptions shape the research into individual curricula. The first of these, which Groeben *et al*. (1988) named "epistemologisches Menschenbild" (epistemological human idea) involves understanding teachers as reflexive subjects who act autonomously and rationally, and end up by constructing their individual theories of mathematics, and of teaching and learning mathematics in much the same way researchers construct theirs. The second assumption is that teachers can provide insights into their own intentions of action (Pajares, 1992) while researchers are only able to approximatively grasp these intentions.

- *Theoretical constructs*: In the planning of their classroom practice, individual curricula are understood as teachers' belief systems, within which "knowledge and beliefs are inextricably intertwined" (Pajares, 1992, p. 325). Furthermore, individual curricula are understood to have been the outcome of a teacher's process of socialisation, including the teacher's schooling and professional experience. These belief systems were developed in the past, stand for the current state of lesson planning, and will be implemented in future instructional practice. As the construct of individual curricula is linked to the term of belief systems, it is anchored in two scientific approaches, i.e. the approaches of subjective theories and of goal-method-argumentation.

Firstly, the construct *subjective theories* is derived from a psychological research approach (Groeben *et al*., 1988). Subjective theories are defined as a complex system of cognitions (a complex belief system), which contains an at least implicit rationale. Hence, single cognitions are connected in an argumentative manner. Finally, this definition is based on the epistemological human idea (see above). Subjective theories contain

- subjective concepts and here subjective goals of instruction,
- the subjective definitions of these concepts or goals and, finally,
- the relations between the subjective concepts or goals that constitute the argumentative character of the cognitions system.

Secondly, the construct of *goal-method-argumentations*, which Groeben *et al*. (1988) have adapted as a technique to describe subjective theories, derives from a pedagogical research approach (König, 1975), which makes explicit the relationship of individual curricula and subjective theories. König argues that 'objective curricula' are constituted in a system of *normative* and *descriptive* sentences, where goals are connected by if-then-sentences. Just as the normative sentences represent curricular goals, the descriptive sentences represent methods for attaining a higher goal, or the motivations for setting a lower goal (see Figure 1).

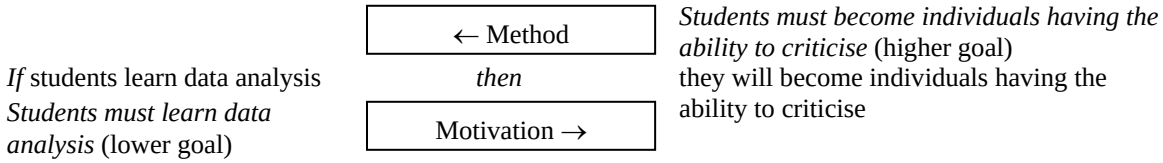

Figure 1: Goal-method-argumentation (example of the NCTM-standards)

With regard to the definition of the epistemological human idea (see above), the assumption is that individual curricula are constructed in much the same way as 'objective' curricula are, and for this reason include a system of normative and descriptive sentences.

METHODOLOGY

To illustrate the five-step-methodology investigation (see Figure 2), the discussions which follow will link theoretical reflections to brief examples of empirical results.

- *Data collection*: The basic methodological choice is to use the approach of case studies (Stake, 2000). A single case is defined as one teacher's individual curriculum. Case selection is aligned to *theoretical sampling* (Charmaz, 2000). The research's focus restricts possible cases to those teachers of secondary schools (grades 7 to 13) who have experience in stochastics education. For

our purpose, we have the cases of eight teachers. Data are collected by half-structured interviews that include several clusters of questions. These clusters involve subjective theories of

- the content of stochastics instruction,
- the goals linked with these contents,
- the goals of mathematics instruction,
- reflections on the nature of mathematics and of school mathematics,
- the students views on stochastics,
- institutional boundaries, and,
- textbook(s) used by the teachers.

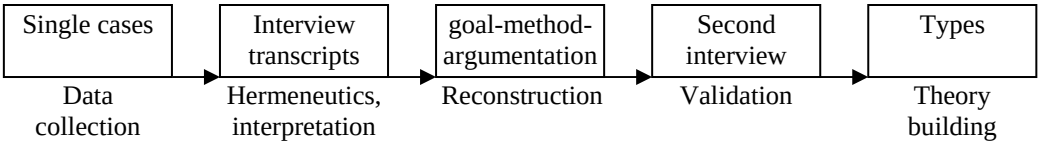

Figure 2: The five-step-methodology

The interviews are determined by the teachers within these obligatory clusters.

These clusters are the result of theoretical reflections pertaining to possible impacts on individual curricula, i.e., the analysis of the didactical issues of stochastics education. These impacts are structured according to three factors of influence on teachers individual curricula. Firstly, there is the teachers' examination of didactical approaches, or rather contents and goals of stochastics instruction. Secondly, there are teachers' experiences of the results of their stochastics instruction upon their students. Finally, there are institutional boundaries for teachers such as administrative curricula, or guidelines for stochastic curricula established by particular schools which include these schools' choices of textbooks to some degree. The intention of these theoretical considerations is twofold: to establish a basis for interview question clusters, and to expose the *prejudice* ('Vorurteil,' Gadamer, 1986) or the *theoretical sensibility* (Charmaz, 2000), which are prerequisites for analysing the impact of these three factors of influence on teachers individual curricula.

- *Interpretation*: The interviews are taped and transcribed verbatim. The transcripts have a length of 30 to 40 pages. The first step of analysis is to split the transcripts into episodes and label them in terms of the question clusters outlined above. A crucial step of case analysis is the sequential interpretation of the episodes. While Gadamer (1986; Schwandt, 2000), in his philosophical hermeneutics, discusses understanding as a human condition, he does not propose techniques for approximating understanding.

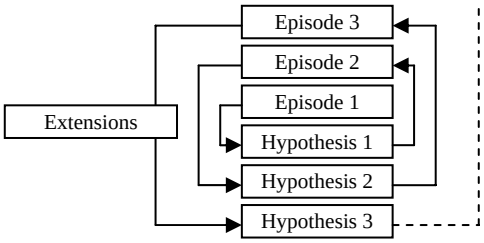

Figure 3: The hermeneutic spiral

Here, the classical hermeneutics in Schleiermacher's tradition (Gadamer, 1986) proposes an approach in the form of the hermeneutic spiral (see Figure 3), whose principles (Danner, 1998) are adapted for transcripts' interpretation. These principles and the hermeneutic spiral will be described and illustrated by a brief example of a transcript.

The following episodes involve Alan, a 55 years old teacher at a secondary school. Alan tells us about introducing the term of probability in grade 13, at a time when students mostly explore stochastics for the first time:

Episode 1: "In advanced courses of mathematics, it is unavoidable to examine frequencies. You try to make clear to students that probability is not defined. This is not

> yet existing, but it is derived from frequencies. It is in my opinion a difficult point to attain this turn, because upon using the Laplacean experiment, it is explicit, this is where you get the rectangular distribution. However, in grade 11 to 13 I will do this the other way around. Students will have to hit on what probability is. Soon afterwards, you start with frequencies, and next it is necessary to try a lot of random experiments."

A brief interpretation of this episode is as follows: Alan describes two approaches to the term probability, the statistical probability that results as an estimate from a long series of experiments, and the classical probability (Laplacean probability) that follows from reflections on the symmetry of random events. Alan seems to prefer the statistical approach in terms of a demand in grade 13. This condensed interpretation yields a first hypothesis:

> *Hypothesis 1*: The statistical approach to probability is central in Alan's individual curriculum.

The interpretation of episode 1 is a prerequisite for the interpretation of further episodes. In one further episode, Alan reveals something more about the introduction of the term probability:

> *Episode 2*: "Large numbers of random experiments will for example, serve simulation. However we had to restrict ourselves to, well, 100 attempts here. Someone drew a diagram, where stabilisation did not become visible yet, and when I asked for what happens later, the students showed me that they understood. "

The interpretation yields: Alan's central approach to the term of probability is the classical one (he uses the dice-tossing experiment). He interrupts the evaluation of this experiment before the students are able to recognise the phenomenon of the stabilisation of frequencies. The statistical approach seems to be an empirical rationale for the central approach, the Laplacean probability. Hence, the second hypothesis below results from interpreting episode 2:

> *Hypothesis 2*: The classical approach to probability is central in Alan's individual curriculum. The statistical approach has the function of empirically motivating the classical approach.

The interpretation of further episodes may lead to a deepening, to an extension, or to a modification of the interpretation of episode 1, or more generally, of the interpretations attained so far. In this example, the interpretation of episode 2 leads to a modification of episode 1. In general, the single interpretations are part of a global interpretation, the global interpretation affecting the parts, i.e. the single interpretations. In this way, a hermeneutic spiral evolves. Certainly, two episodes, and their interpretation will not be sufficient for an end hypothesis. More evidence must be gathered from other episodes, which may include concrete classroom tasks. Other crucial evidence can be gleaned, for example, from *extending* the interview transcript to including analysis of the teachers' textbooks. As well as 'normal' episodes, textbooks' analysis may lead to deepening, extending, or modifying the interpretation attained thus far.

All interpretations yield five aspects of an individual curriculum: the content, or rather basic content-oriented goals (aspect 1), the goals of stochastics instruction (aspect 2), the goals of mathematics instruction (aspect 3), the goals concerning teachers' beliefs about how students understand the usefullness of mathematics (aspect 4) and, finally, the goals concerning teachers' beliefs about the efficiency of their own classroom practice (aspect 5).

- *Reconstruction of goal-method-argumentations*: The next step of the case study is to generate the structure of the reconstructed goals, the goal-method-argumentations (see for example the excerpt from Alan's goal-method-argumentation concerning the goals of stochastics instruction in Figure 4). In this structure, the goals are arranged according to their grade of generality. Goals directly linked to specialised instructional contents stand among goals linked to clusters of instructional goals, to stochastics, or to mathematics in general.

The goal-method-argumentation includes the three aspects of a subjective theory: the subjective goals (italics), their subjective definitions (smaller font description in brackets) and the if-then-sentences, to which the goals are linked. The '!' in every goal is an abbreviation for 'will be attained,' the '+' means an addition of two goals.

- *Validation*: These formal goal-method-argumentations were developed for the five aspects of an individual curriculum outlined above. In general, teachers are not completely and precisely

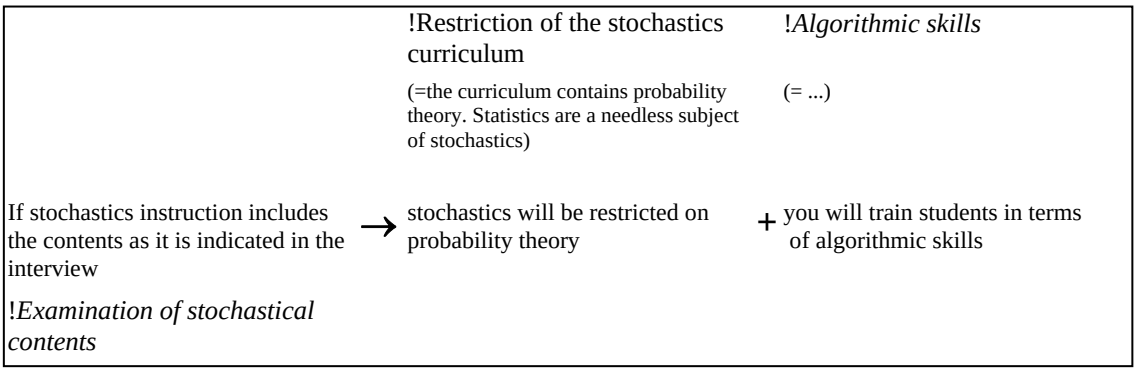

Figure 4: The goals of stochastics instruction, an excerpt of Alan's goal-method-argumentation

aware of these formal structures of goals and relations between them. For this fact, in particular, the fourth methodological step, communicative validation, is mandatory. The goal-method-argumentations were sent to the eight teachers along with the constructions rules. After one week, these goal-method-argumentations were made the basis of a second interview. This interview's objective was to reach consensus on the adequacy of the reconstructed and formalised individual curricula.

- *Theory building in terms of types*: The final methodological step provides a continuous process of abstraction and aim to identify patterns of structures or goals (Kelle and Kluge, 1999). This process yields four types of individual curricula that will be sketched as follows.
- *Traditionalists* (e.g., Alan) restrict their instructional content to probability theory. Statistics are understood as a needless subject of stochastics. The central goal of the stochastics curriculum and mathematics curriculum is to establish a theoretical basis of stochastics (or rather probability theory). This involves algorithmic skills and insights into the abstract structure of stochastics, but it does not involve stochastic applications.
- *Application-preparers* include the probability theory as well, but they also incorporate statistics. The central goal of both stochastics and mathematics curriculum is to have students grasp the interplay between theory and application. With regard to this interplay, application-preparers argue that mathematical theory is a prerequisite for coping with mathematical applications. For the application-preparers the concept of interplay is central for the beliefs concerning the nature of mathematics as an abstract system on the one hand, and the technical language on the other.
- *Every-day-life-preparers* develop stochastic methods while examining applications. The central goal of the every-day-life-preparers is to develop these methods in a process, the result of which will be the possibility to cope with both real stochastical problems and the ability to criticise. The every-day-life-preparers argue that this goal is particularly attainable for stochastics, since for many mathematical subjects it is more difficult to provide the process outlined above. The every-day-life-preparers distinguish between mathematics and school mathematics. Since the aspect of an abstract structure dominates mathematics, the aspect of application dominates school mathematics, which ultimate goal is to make students able to criticise.

Finally, the *structuralists* examine applications. However, they neither want to promote an interplay between theory and application (as the application-preparers do), nor do they wish to prepare students for dealing with real mathematical problems (as the every-day-life-preparers do). The structuralists understand applications as a starting point for exemplifying mathematical concepts. The central goal of their stochastics and mathematics curriculum is to encourage understanding of the abstract system of mathematics in a process of abstraction which begins with mathematical applications.

CONCLUSION

The intention of this report was to describe the theoretical framework, and the methodology used in a research project concerning teachers' individual stochastics curricula. One view of the objective of this report was to provide both an approach to the research on teachers'

beliefs, which is based on a psychological framework, and a five-step-methodology which yields four types of individual stochastics curricula. One crucial use of the research into individual curricula is that it identifies beliefs behind global beliefs that have been studied by several researchers (e.g., Thompson, 1992). It seems impossible to enhance these global types without using a holistic approach. As Cooney *et al*. (1998) stated: superficial similarities of global beliefs do not automatically indicate really similar beliefs. With regard to the research results sketched here, contents, parts of goals and goal-method-argumentations may be similar, but there are crucial differences in detail between the types presented.

Of course, one crucial question remains: How relevant are individual curricula, or types of individual curricula, in school practice? The five-step-methodology is unable to provide an empirical answer. However, first results of the author's current research project show that teachers' individual stochastics curricula *explain* the observable classroom practice. A further desideratum concerns the second remaining question: Which parts of teachers' individual curricula are integrated by students into their own cognitive structures? The author's current research project focuses on these questions as well.

REFERENCES

Calderhead, J. (1996). Teachers: Beliefs and Knowledge. In D. C. Berliner (Ed.), *Handbook of Education*, Vol. 4, (pp. 709-725). New York: MacMillan.

Chapman, O. (2001). Understanding high school mathematics teacher growth. *Proceedings of the 25th Conference of the International Group for the Psychology of Mathematics Education*, Vol.2, 233-240.

Charmaz, K. (2000). Grounded theory. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of Qualitative Research*, (pp. 508-535). Thousand Oaks, London, New Delhi: Sage Publications.

Cooney, T. J., Shealy, B. E. and Arvold, B. (1998). Conceptualizing belief structures of preservice secondary mathematics teachers. *Journal for Research in Mathematics Education*, 29(3), 306-333.

Cooney, T. J. and Wilson, M. (2002). Mathematics teacher change and development. In G. C. Leder, E. Pehkonen, and G. Törner (Eds.), *Beliefs: a Hidden Variable in Mathematics Education?*, (pp. 127-147). Dordrecht: Kluwer.

Danner, H. (1998). *Methoden Geisteswissenschaftlicher Pädagogik* (Methods of a Pedagogy Oriented Towards Humanities). Tübingen: Mohr.

Eichler, A. (2005). *Individuelle Stochastikcurricula von Lehrerinnen und Lehrern* (Teachers' Individual Stochastics Curricula) . Hildesheim: Franzbecker.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of Research on Teaching*, (pp. 119-161). New York: Macmillan.

Gadamer, H.-G. (1986). *Hermeneutik I, Wahrheit und Methode* (Hermeneutics I. Truth and Method). Tübingen: Mohr.

Groeben, N., Wahl, D., Scheele, B., and Schlee, J. (1988). *Forschungsprogramm Subjektive Theorien* (Research Programme of Subjective Theories). Tübingen: Franke.

Kelle, U. and Kluge, S. (1999). *Vom Einzelfall zum Typus* (From Individual Cases to Types). Opladen: Leske + Buderich.

König, E. (1975). *Theorie der Erziehungswissenschaft*, Vol. 1-3 (Theory of Educational Science). München: Wilhelm Fink Verlag.

Schwandt, T.A. (2000). Three epistemological stances for qualitative inquiry: Interpretivism, hermeneutics, and social constructionism. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of Qualitative Research*, (pp. 189-214). Thousand Oaks, London, New Delhi: Sage Publications.

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

Vollstädt, W., Tillmann, K.-J., Rauin, U., Höhmann, K., and Terbrügge, A. (1999). *Lehrpläne im Schulalltag* (Administrative Curricula in the Classroom). Opladen: Leske + Budrich.