

## THE TRANSFORMATION PROCESS FROM WRITTEN CURRICULA TO STUDENTS' LEARNING

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*In this report a theoretical framework that potentially facilitate to identify and to structure existing research results focusing on statistics teachers' will be discussed. This framework involving a curriculum model and a specific understanding of beliefs will be outlined. Afterwards, existing research focusing on statistics teachers' will be briefly discussed and possible shortcomings in this field of research will be identified.*

### INTRODUCTION

Over the past decades statistics educators consistently inquired into researching the statistics teachers' conceptions of probability and statistics teaching (e.g. Batanero, Garfield, Ottaviani & Truran, 2000). However, Shaughnessy (2007, p.1001), more recently, stated again that "there has been very little research into [...] teachers' beliefs and attitudes toward statistics". The main rationale to claim research that focus on teachers is that:

- the teachers decide how they interpret the *written curriculum*, i.e. the curriculum prescribed by national governments (Stein, Remillard & Smith, 2007),
- the teachers' thinking about statistics and the teaching and learning of statistics have a high impact on their instructional practice (Philipp, 2007), and
- the teachers' instructional practices have a high impact on students' learning, i.e., on students' knowledge and beliefs concerning statistics (e.g. Hiebert & Grouws, 2007).

Accepting the transformation process as mentioned above reaching from the written curriculum to the students' learning, the impact of statistics teachers on this transformation process is considerable. For this reason, in this paper, a unifying theoretical framework for research focusing on statistics teachers' conceptions or beliefs referring to the teaching and learning of statistics will be proposed. Using this framework, existing research in this field will be discussed concerning results and challenges.

### THEORETICAL FRAMEWORK

#### *Model of a curriculum*

Stein et al. (2007) proposed a theoretical framework that facilitates describing the transformation process mentioned above (see Figure 1). Although it is possible to mention a lot of issues that a curriculum itself involves, the core of the term curriculum will be understood as a combination of instructional content and the objectives linked to this content (König, 1975).

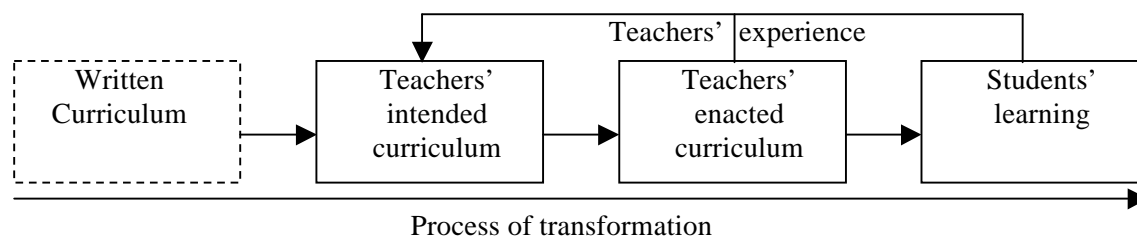


Figure 1. Four phases of a curriculum (cf. Stein et al., 2007)

Thus, regarding statistics, the *written curriculum* represents statistical content and goals linked to this content that are prescribed by governments and that represent an agreement in an educational and political community. The first stage of the transformation process involves the

statistics teachers' conscious selection of content and goals (*teachers' intended curriculum*), which may be impacted but not determined by the written curriculum. The statistics teachers may potentially try to enact their intended curriculum. However, how the students act in the classroom practice could transform the teachers' intentions. Thus, the teachers' enacted curriculum represents another stage of the transformation process. Finally, the individual *student's learning*, impacted but not determined by the classroom practice, is the ending of the transformation process that represents the main focus of any effort of educational research (Stein et al. 2007).

#### *Content and goals*

Concerning a curriculum, a specific content represents a basic goal. For instance, a possible content of a statistics curriculum is the median. To learn something about the median (the meaning, the formula, the connections to other statistical methods etc.) might be a basic goal of teaching statistics. A basic goal (learning something about the median) might be connected in an argumentative manner with another goal of a higher order. For instance, if someone learns something about the median, he will potentially be able to reason about distribution (e.g. Bakker & Gravemeijer, 2004). Thus, to reason about distribution is a goal that includes a rationale for the basic goal. Again, the goal to reason about distribution might be connected with a further goal of a next higher order (for example, to achieve statistical reasoning) and so on. In brief, a curriculum can be understood as hierarchically arranged system of goals that are connected in an argumentative manner (Eichler, 2006).

#### *Goals as part of human action*

From a psychological perspective, the teaching and learning of statistics can be described as specific form of human action (Hofer, 1986). *Action* itself is understood as "the physical behavior plus the meaning interpretations held by the actor" (Erickson, 1986, p. 126). Goals represent a central construct within the psychological construct of human action (Erickson, 1986, Hacker, 1994). Thus, goals are understood as impetus, and as monitoring aspect of human action (Hacker, 1994), which tends to eliminate the gap between a current state and a target state (Miller, Galanter & Pribram, 1960). Finally, the target state is connected with an individual's preference or rather an individual's conviction that the target state is important (Hacker, 1994). Hence, teaching goals within a curriculum describe target states that are understood as important for those who learn.

#### *Attitudes, beliefs, knowledge referring to statistics*

Attitudes, beliefs, and knowledge are common theoretical constructs to describe the teaching and learning of statistics (e.g. Shaughnessy, 2007). From the curriculum perspective that is discussed above, these three constructs are parts of a curriculum.

Firstly, Phillip (2007) defined *attitudes* as an individual's disposition or opinion towards a topic. Referring to the discussion above, teachers' attitudes represent their disposition towards a statistics curriculum (that describes specific target states) in general. These general dispositions might include a positive connotation ("to be an intelligent consumer, it is necessary to know something about statistics" - a pre-service teacher from Chick & Pierce, 2008), or they might include a negative connotation towards statistics ("it is easy to lie with statistics, I don't trust them at all" - another pre-service teacher from Chick & Pierce, 2008). Further, these attitudes represent general goals of a statistics curriculum: a central goal of the statistics curriculum is to produce intelligent consumers.

Secondly, *beliefs* can be understood as an individual's conviction concerning a specific subject, which shapes an individual's ways of both receiving information about a subject and acting in a specific situation (Pajares, 1992; Thompson, 1992). In addition, *belief systems*, following Thompson (1992), can be understood as an individual's internal organisation of beliefs. Belief systems might include contradictory clusters of beliefs, and might include beliefs that have different grades of importance (centrality) for an individual (Thompson, 1992). Referring to the discussion above, goals of a curriculum can be understood as specific form of beliefs. For instance, a German teacher (secondary high school) mentioned (c.f. Eichler, 2008a):

*Personally, concerning statistics, I emphasise the mathematical background involving, for instance, set theory. Other teachers think, the students do not need a broad background, but must understand how to apply statistical methods in real situations. This is for me a step away from mathematics, only pure application. [Translation from German]*

The conviction (belief), that an application-oriented way of teaching statistics is not appropriate, lead to the teacher's goal to teach the "mathematical background" of statistics involving set theory. As well as goals of a curriculum can be understood as beliefs the hierarchical system of goals that represents a curriculum can be understood as belief system.

Regarding students, the analogy between beliefs and goals has to be reconsidered. Students have not necessarily goals that are linked with the content they learn. However, the students might understand the aim or the sense, which is linked with the content they learn, in a way the teacher intended. For example, in an ideal way, a teacher might have the goal that his students understand the benefit of statistics for the modern society and impact his students' beliefs, who understand statistics as powerful tool for the modern society. Hence, the teachers' goals potentially correspond with the students' beliefs about the benefit of the content they learn.

Finally, *knowledge* shapes the statistics curriculum. Referring to the statistics curriculum, knowledge can be understood in a content oriented way (content knowledge, c.f. Shulman, 1986) divided, for instance, in a declarative, procedural and conceptual part (Hiebert & Carpenter, 1992). Even, knowledge can be understood in a teaching oriented way (pedagogical content knowledge, c.f. Shulman, 1986). Independent of these two different connotations of the term knowledge, from an individual's perspective, beliefs and knowledge are "inextricably intertwined" (Pajares, 1992, p. 324). Regarding the statistical "knowledge" of students (c.f. Eichler, 2008), the latter thesis seems to be obvious:

*As far as the Bernoulli experiments are concerned, they can be calculated by using binomial distribution. And we can do this for certain values of  $X$ , which is the random variable. [a student of a German secondary high school; translation from German]*

In the same way, a teacher's subject knowledge about statistical content or methods to teach statistics represent his individual conviction, i.e. his beliefs about statistics and teaching statistics. However, it is obvious that knowledge is an individual's precondition to form a teaching goal. For example, if a teacher does not know what the median means, he is not able to form the goal that his students have to examine the median.

Summarising this paragraph, from the curriculum perspective:

- attitudes that are close to general beliefs represent an individuals disposition referring to the statistics curriculum,
- the system of goals that represent the statistics curriculum are systems of specific beliefs, and
- knowledge (content knowledge and pedagogical content knowledge) is the precondition to form teaching goals.

This conceptual understanding will be used in the following section to identify and to arrange results and future challenges of research focusing on the teaching practice of statistics teachers.

## RESULTS AND FUTURE CHALLENGES OF RESEARCH FOCUSING ON TEACHERS

### *Research focusing statistics teachers*

Research focusing on statistics teachers is scarce. To identify existing research the proceedings of ICOTS (<http://www.stat.auckland.ac.nz/~iase/publications.php>), PME (<http://www.igpme.org/>), CERME (<http://ermeweb.free.fr/>), and the papers of the ICM/IASE study conference ([http://www.ugr.es/~icmi/iase\\_study/](http://www.ugr.es/~icmi/iase_study/)) were analysed as well as international journals, for instance the *Statistics Education Research Journal* or the *Educational Studies in Mathematics*. One striking pattern in the existing research results is that these results stem from

very few countries. For this reason, the following discussion is necessarily exemplary. For instance, it is an open question whether it is possible to generalise the discussed results for other countries. However, in the following the discussed research approaches should highlight main research results and challenges for future research.

#### *Transformation of the written curriculum to teachers' intended curricula*

Referring to teachers' attitudes, most of the existing research yielded that most of the teachers (in different countries) valued statistics in general in a positive way (e.g. Gattuso & Pannone, 2002). Further, research showed that the teachers intend to match the written curricula in respect to content, i.e. basic teaching goals (Begg & Edwards, 1999, Eichler, 2008b). The research of Eichler (2008a), however, yielded that, although the teachers' intended curricula did not differ concerning the content, the teachers' intended curricula differ considerably concerning the goals. The main reason for these differences seemed to be the teachers' different opinions about the *role of the context* (Shaughnessy, 2007) concerning the teaching of statistics. In contrast to the aspects mentioned above, there exists a greater amount of research focusing on teachers' knowledge about different statistical topics (cf. the reviews of Stohl, 2005 or Shaughnessy, 2007). Although a teacher's knowledge is a precondition to forming an intended curriculum, the knowledge seems not to determine the intended curriculum. For instance, a teacher investigated in the research of Eichler (2006) showed a deep knowledge concerning the probability axioms or set theory. However, he stated that as his students will not understand these topics, he did not teach these topics. Finally, there exist some results concerning the connection between teachers' knowledge and teachers' attitudes towards statistics. For instance, Estrada and Batanero (2008) reported that, surprisingly, the more experienced the teachers were in their teaching of statistics the less they valued the teaching of statistics.

In respect to this first stage of the transformation process of a curriculum, there might be two main challenges for future research:

- to investigate the teachers' attitudes towards statistics in more countries involving more representative samples of ordinary teachers, and
- to investigate the relationship between the teachers' knowledge and the teachers' teaching goals.

#### *Transformation of a teacher's intended curriculum to a teacher's enacted curriculum*

Referring to teachers' attitudes, it is yet not reported, whether positive or negative loaded attitudes have an impact on the teachers' enacted curricula or not. Further, the research of Eichler (2008a) yielded strong evidence that, in particular, the teachers' pursue their main goals (central beliefs), while they did not necessarily pursue peripheral goals. A crucial research result is that teachers plan or do their statistics teaching even in a different way when teaching is based on the same task or the same lesson plan (Burgess, 2008; Chick & Pierce, 2008; Pfannkuch, 2006). These results may be based on one of or both the statistics teachers' content knowledge and the teachers' pedagogical content knowledge. Eichler (2008a) explained these differences with the teachers' different goals, which impact the teachers' teaching style examining tasks or statistical content.

In respect to this second stage of the transformation process of a curriculum, there might be one main challenge for future research, i.e.,

- to investigate in more cases the impact of the statistics teachers' knowledge on the teachers' enacted curricula.

#### *Transformation of a teacher's enacted curriculum on his or her students' learning*

Again, it is not yet reported, whether positive or negative loaded attitudes have an impact on the students' learning or not. As well, there exists very few and vague research results that imply relationship between the teachers' enacted curricula and their students' learning. For example, Castro (1998) reported as result of a teaching experiment that a constructivist teaching style yielded a higher students' performance than an expository teaching style. However, this teaching experiment is restricted to teachers who have not had the possibility to teach in their own style or

rather follow their own goals. Referring to ordinary teachers', the research of Eichler (2008a) yielded some possible relations between the teachers' intended curricula, their enacted curricula, and the students' learning. For instance, there seems to exist a relationship between how the teachers emphasise real data sets or real examples, and the students' beliefs about the benefit of statistics for the society. However this research yielded only vague results concerning the relationship between the teachers' enacted curricula and the students' performance (concerning their declarative, procedural, and conceptual knowledge). Finally, the research of Pfannkuch (2006) yielded a direct connection between the students' inability to reason and the missed opportunities of the teacher to communicate a way of reasoning in an appropriate way.

In respect to this third stage of the transformation process of a curriculum, there might be one main challenge for future research, i.e.,

- to investigate possible impacts, i.e., the (statistics) teachers' attitudes, the teachers beliefs or goals and the teachers' knowledge, on the students' learning of statistics.

## CONCLUSION

In the discussion above, a proposal was given that should provide a unifying theoretical framework to identify and to arrange both existing results and future challenges of research focusing on statistics teachers. While it seems to be possible to structure existing research using this framework, the discussion above yielded that there are, in particular, two main gaps. Firstly, it seems to exist at most very little knowledge about the question of the relationships among the statistics teachers' statistical knowledge and the three aspects of the statistics curriculum, i.e. the teachers' goals, the teachers classroom practice and, finally the students' learning. The second gap concerns the at most few and vague research results that explain the relationship between the statistics teachers' intended, the teachers' enacted curricula and the students learning. Referring to both shortcomings of research focusing on statistics teachers, the statistics teachers' goals were proposed as main aspect of the statistics curriculum, which strongly impact on the reality of statistics classrooms.

Although the investigations concerning systematic impacts on the students' learning seem to be the most challenging question, it is probably the most crucial question. Thus, if we want to change the teaching of statistics it would be important to know how a changed teaching approach will change (or rather improve) the students' learning.

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