

# Factors Influencing Domain-Specific Beliefs of Secondary Biology Teachers

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## *Abstract*

Research on teachers' professionalism is mainly conducted in the area of teachers' professional knowledge. Only few studies are about teachers' attitudes and beliefs and how they influence teachers' instructional behaviour as well as their students' outcome, whereas nearly no studies are on biology education. In a previous study, we identified three prototype teachers with characteristic biology-specific beliefs (Neuhaus & Vogt, 2005). In the present study, we acquired socio-demographic data of 614 biology teachers from all over Germany to investigate factors influencing their biology-specific beliefs. In particular, the different types of teachers in terms of their beliefs were analysed with regard to socio-demographic factors: age, teaching experience, second teaching subject and school location (federal state, urban or rural). Data analysis revealed that teaching experience correlated with teachers' biology-specific beliefs only in the first five years of teaching. The federal state in which a school is located was found to have a significant influence on teachers' beliefs. Furthermore, a strong relationship was found between other subjects these biology teachers taught and their biology-specific beliefs. Because teachers' beliefs strongly affect their teaching, factors influencing these beliefs should be considered when implementing educational innovations.

**Key words:** domain-specific beliefs, biology, classification, science education, in-service teachers

## Introduction

What makes a good biology teacher? Today's studies in the area of teacher professionalism mainly focus on four different aspects: the teachers' professional knowledge, their motivation, their abilities in self-regulation, and their attitudes/beliefs (Baumert & Kunter, 2006). Whereas many studies are conducted in the area of teachers' professional knowledge (e.g., LMT-Study: Hill et al., 2005; MT21-Study: Blömeke et al., 2008; Blömeke et al., 2010; or the COACTIV-Study: Baumert et al., 2010) – that comprise at least teachers' content knowledge (CK), pedagogical content knowledge (PCK), and pedagogical knowledge (PK) – only few studies are on teachers' attitudes and beliefs. And even fewer studies are on the question of how these attitudes and beliefs influence teachers' instructional behaviour as well as students' outcome. One of the most important German studies in this area is the COACTIV-Study (Baumert et al., 2010) that analysed the influence of all four dimensions (knowledge, motivation, self-regulation, attitudes/beliefs) on teachers' instructional behaviour and students' outcome in mathematics education. The COACTIV-study showed that the attitudes and beliefs of teachers with less constructive orientations influence their instructional behaviour as well as their students' outcome negatively (Dubberke et al., 2008).

In our study reported here, we focus on the beliefs that are specific for biology teachers. Analysing the biology teachers' beliefs, we were able to classify teachers into three distinctive groups: the Scientific-Innovative Type, the Pedagogical-Innovative Type, and the Scientific-Conventional Type (Neuhaus & Vogt, 2005). This classification will be used in a future video-study to analyse the influence of biology teachers' beliefs on their instructional behaviour as well as their students' outcome. Here we present data on factors influencing these domain-specific beliefs.

### *Literature Review*

Teachers' beliefs and their content knowledge are assumed to be good indicators of teachers' decisions, and therefore these may influence instructional behaviour (see Clark & Peterson, 1986; Fang, 1996; Thompson, 1992). Kagan (1992, p. 85) summarized that “the more one reads studies of teacher belief, the more strongly one suspects that this piebald form of personal knowledge lies at the very heart of teaching.” A widely discussed problem is that the concept of ‘belief’ is often not precisely defined (e.g., Leder & Forgasz, 2002; Furinghetti & Pehkonen, 2002). Pajares (1992) therefore summarizes that the distinction between beliefs and attitudes, values, judgments, axioms, opinions, ideologies, perceptions, conceptions, or explicit theories is not clear. Research on teachers' educational beliefs mostly focuses on their beliefs about learners, learning, teaching, the subject, the self, and the teaching role, as well as on learning how to teach (Calderhead, 1996).

Because beliefs are related to a vast area of different subjects (Törner, 2002), it is important to be able to structure beliefs into superordinate concepts. In a previous study, we developed a questionnaire that could be used to classify biology teachers into three groups based upon their biology-specific educational beliefs: the Pedagogical-Innovative Type, the Scientific-Innovative Type, and the Scientific-Conventional Type (Neuhaus & Vogt, 2005).

Teachers belonging to the category of the Pedagogical-Innovative Type emphasize social aspects of learning biology. They also believe that connections to everyday life are important in biology classes, whereas teaching factual knowledge is less important for them. Furthermore, they enjoy trying out new things in class. Teachers of the Scientific-Innovative Type believe that teaching factual knowledge as well as laboratory activities, is most important, whereas social aspects of learning are an issue of secondary importance. Teachers of this type also stress the importance of biology lessons for everyday life. For this type of teachers neither experiments, nor cross-linking to everyday life, are of high importance for teaching biology. In addition, teachers belonging to this type are less open to new methods and topics. Instead, they mainly focus on teaching factual knowledge.

In this article, we explore how the differences between the three types of teachers' beliefs develop, and by which factors the distinct types of teachers are affected. The analyses are based on the same data set that was used for the classification of the three types of teachers.

#### *The origin of educational beliefs*

Pajares (1992) attributed the origin of educational beliefs to a process of enculturation and social construction. Therefore, educational beliefs are developed incidentally or explicitly throughout life, beginning with teachers' first experiences as learners, going on with their experiences within the educational graduate programs, and their daily experiences as a teacher. In summary, teachers' beliefs grow as a consequence of their experiences (Bullough, Knowles, & Crow, 1992). Richardson (1996) identified three categories of experiences that influence the development of educational beliefs: personal experience, experience with schooling and instruction, and experience with the school.

Beliefs affect perception and the processing of new information (Nespor, 1987). The earlier a belief is developed by a person, the more difficult it is to modify, whereas newly developed beliefs are highly vulnerable (Pajares, 1992). An important period, during which a new set of beliefs develops in teachers, is the transition from pre-service to in-service teaching (Richardson, 1996). Especially the teachers' first contact with students is assumed to change teachers' beliefs. Cochran-Smith (1991) describes that pre-service teachers become more authoritative and conservative after their first contact with students at school. Black and Ammon (1992) reported that experiences make teachers move from a more behaviourist view of teaching and learning to a more constructivist one. Brousseau and co-workers (1988) found that more experienced teachers believe more often that their students are trustworthy.

#### *Teacher characteristics influencing their educational beliefs*

Teachers' educational beliefs influence their instructional behaviour and therefore also students' achievement. Educational beliefs are developed throughout the teachers' own entire education from early encounters with learning until their first years of teaching. However, once established, beliefs are hard to change (e.g., Lortie, 1975; Hollingsworth, 1989; Wilson, 1990). If it were possible to identify socio-demographic factors interacting with those beliefs, this knowledge could help to indirectly influence beliefs through educational reforms.

Furthermore, the knowledge of those factors could help in understanding differences in the teaching behaviours of different teacher types.

There are only few studies on the correlation between teachers' educational beliefs and socio-demographic characteristics (for a review, see Richardson, 1994). Concerning gender effects, Khan and Weiss (1973) described that female teachers have more positive views of their students than do their male counterparts. Regarding different kinds of schooling, large differences can be found between beliefs of elementary and secondary school teachers. Whereas elementary pre-service teachers are more child-oriented and more tolerant toward behavioural problems, secondary school pre-service teachers are more interested in their subject matter and have a higher self-concept (Richardson, 1994). The largest differences in educational beliefs are reported between traditional and non-traditional pre-service teachers, with non-traditional teachers defined as those having a gap in their educational vita (Richardson, 1994). Non-traditional pre-service teachers develop their beliefs more often from their experience with their own children or their previous work. Furthermore, they often have a better understanding of the complexity of teaching. Regarding the influence of the subject matter, John (1991) found large differences between how mathematics and geography teachers view their planning of a school lesson.

### *Objectives*

The present study aims to explore which teacher characteristics have an influence on biology-specific educational beliefs. Therefore, the socio-demographic distribution of different types of biology teachers was analysed. More precisely, the following research questions were investigated:

1. Is there any gender effect influencing teachers' educational beliefs?
2. Do age and years of practice influence teachers' educational beliefs?
3. Is there any impact of the teachers' second subject on their educational beliefs?
4. Are teachers' beliefs influenced by the federal state where their school is located?
5. Are there any differences between teachers' beliefs as a function of school type with regard to the school settings of urban, town or rural?

## **Methods**

### *Participants*

A representative sample of 614 biology teachers from 154 German public secondary schools was asked to complete an anonymous questionnaire. The response rate ranged from 48% to 90% depending on the federal state with an average of 65%. Fifty-four percent of the respondents were female; 38% of the teachers reported teaching in a city with more than 100,000 inhabitants; 40% reported teaching in a town with less than 100,000 inhabitants; and 22% reported teaching in a rural area. Their average age was 44 years.

### *Instruments*

A closed, 5-level Likert-scale belief questionnaire was used to classify biology teachers into three groups regarding their biology-specific beliefs: A Pedagogical-Innovative Type which emphasizes social aspects of teaching biology, a Scientific-Innovative Type which stresses the importance of experiments, and a Scientific-Conventional Type which focuses on teaching factual knowledge. The questionnaire is reliable and objective, and the classification of the three types of teachers is stable. Furthermore, socio-demographic background characteristics of the biology teachers were surveyed: gender, age, teaching experience, second subject, favourite subject, federal state in which they taught, and school type (urban, town or rural).

### *Procedure*

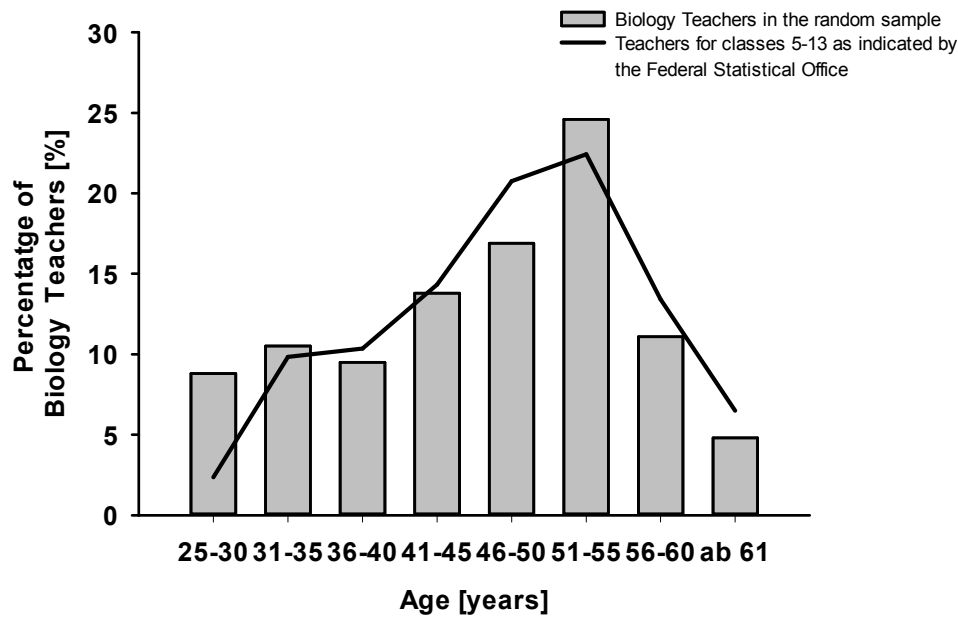
Utilizing the information from the German Census Bureau (Statistisches Bundesamt), a list of all registered non-private secondary schools (Gymnasium) was constructed (N = 2,493). Schools with special focuses, for example, girls' schools, boys' schools, or boarding schools, were not included in the list. From this pool of schools, 8 to 14 schools from each of the 16 federal states were randomly selected for the survey. If a school indicated willingness to participate in the project, all biology teachers of that school were asked to complete the questionnaire in the survey. The questionnaires were sent to the teachers via postal mail and collected within 5-14 days.

### *Analysis*

The SPSS 13.0 statistical package was used to analyse the relation between teacher characteristics and teacher type. The distribution of teacher types is presented here with reference to several socio-demographic variables. As frequencies were compared, statistical significance was computed using chi-square tests. The distribution of the three teacher types was tested against the distribution expected under the null-hypothesis of no statistical differences. Effect sizes could not be computed, because calculations were done on percentages, not on means. The relation between the teachers' age and the teachers' years of practice was analysed utilizing Pearson product moment correlation. For comparisons between the distribution of the teachers' age in the present sample with that in a national sample (as determined by a national census), a 95% confidence interval was computed.

## **Results**

A comparison between the teachers' age in the random sample in the present study and the age of German secondary teachers in a national sample suggested that the random sample is representative (see Figure 1). Even though the proportion of young teachers in the present study was slightly higher than what was observed nationally, the deviation within each age group lied within the 95 %-confidence interval.

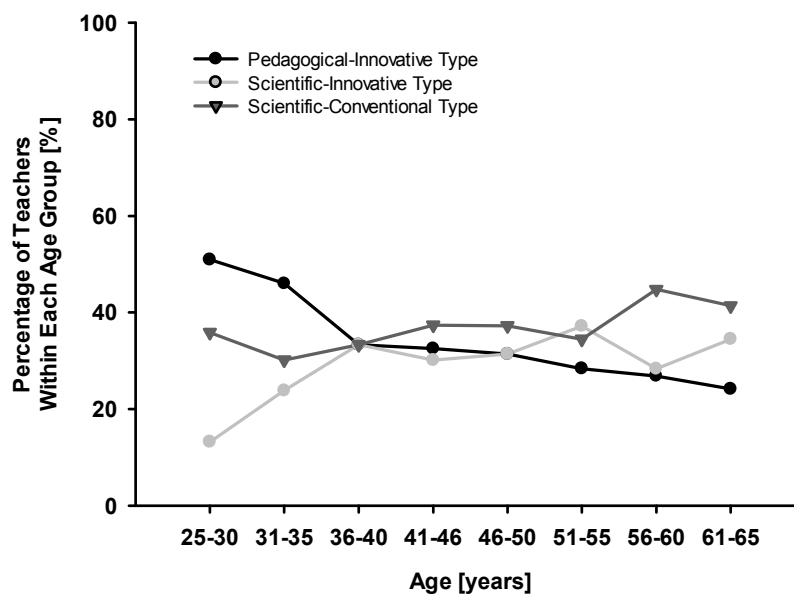


**Figure 1.** Distribution of the age of secondary biology teachers in the sample (bars) in comparison to German secondary teachers' age as published by the German Census Bureau (line).

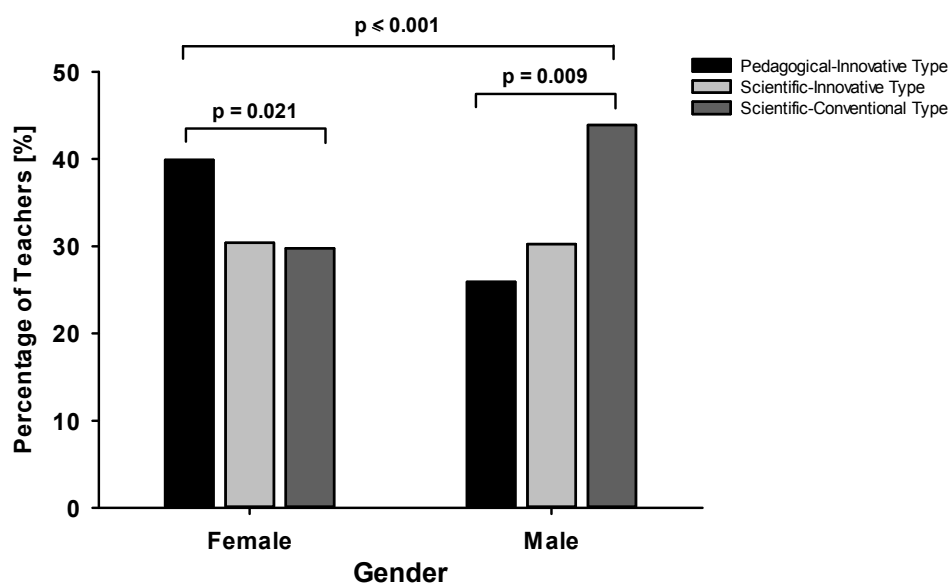
First, we compared the three different types of teachers – the Pedagogical-Innovative Type, the Scientific-Innovative Type, and the Scientific-Conventional Type – regarding their socio-demographic distribution. With respect to age (see Figure 2), significant differences in the proportions of different teacher types were found for the youngest teachers up to the age of thirty. Less of these teachers belonged to the Scientific-Innovative Type and relatively more belonged to the Pedagogical-Innovative Type. Within other age groups, the age of teachers did not significantly correlate with teachers' educational beliefs.

There are strong and significant correlations between teachers' age and teaching experience,  $r = .913$ ,  $p < .001$ ,  $N = 595$ , indicating that German university students who graduate as trained teachers pursue this profession immediately afterwards. Professionals who decide to become teachers later in life are rare in Germany. Recruiting programs familiar in the United States (Zumwalt & Craig, 2005) are relatively unknown in Germany.

Regarding gender differences, we compared the distribution of the different teacher types as a function of gender (see Figure 3). Female teachers predominantly belonged to the Pedagogical-Innovative Type,  $\chi^2(2, N = 326) = 7.68$ ,  $p = .021$ , whereas male teachers belonged predominantly to the Scientific-Conventional Type,  $\chi^2(2, N = 278) = 9.31$ ,  $p = .009$ . The Scientific-Innovative Type was distributed equally between both male and female teachers.



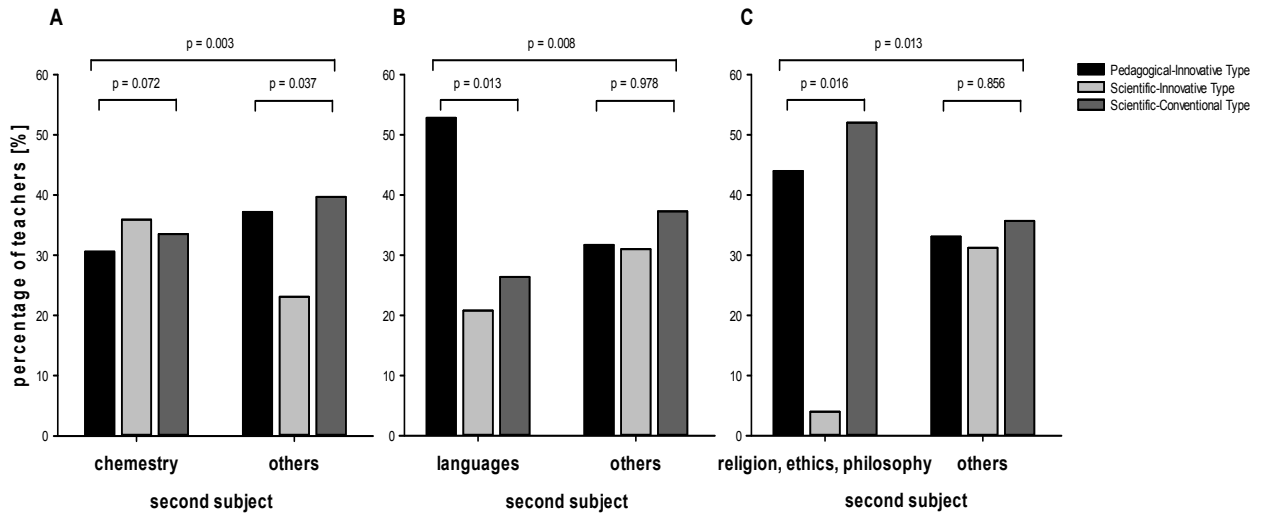
**Figure 2.** Distribution of the different types of teachers among different age groups.



**Figure 3.** Gender differences of biology teacher types concerning their educational beliefs.

In Germany, nearly all teachers study and teach at least two different subjects. Depending on how closely this second subject is related to biology, teachers can acquire very different approaches to the sciences. Our data analysis showed that the second subject a biology teacher taught had a strong influence on his/her educational beliefs. Biology teachers were more likely to be of the Scientific-Innovative Type when they taught chemistry as the second subject than when they taught any other subject (see Figure 4a),  $\chi^2 (2, N = 614) =$

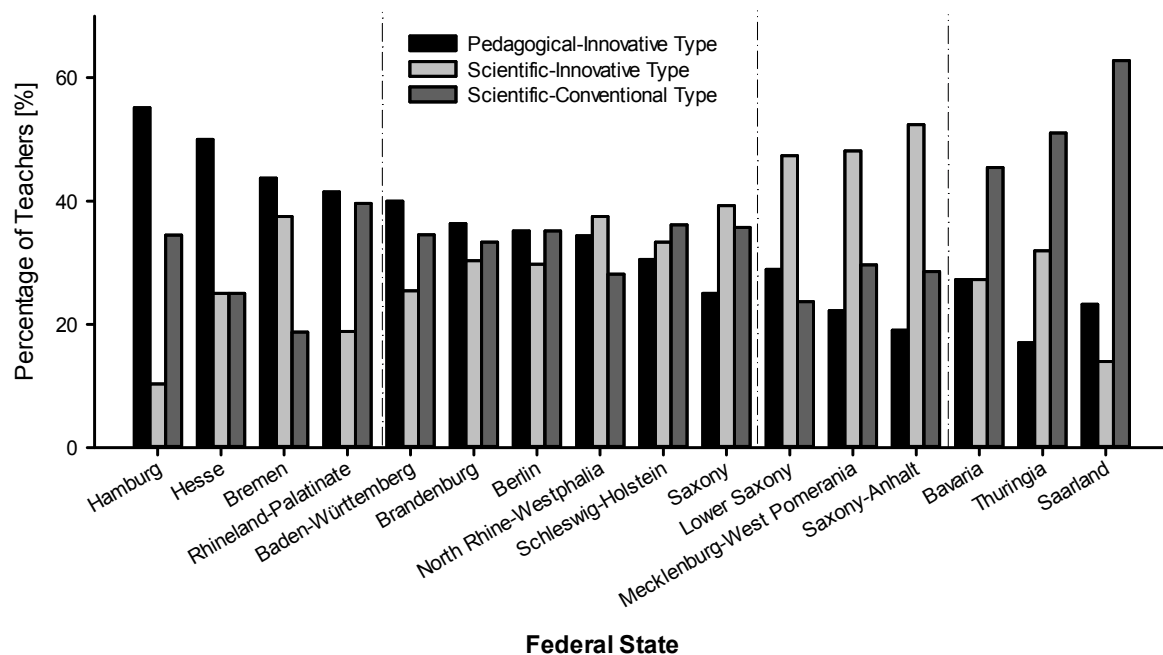
11.85,  $p = .003$ . Teachers who taught languages as their second subject belonged predominantly to the Pedagogical-Innovative Type (see Figure 4b),  $\chi^2(2, N = 614) = 9.7$ ,  $p = .008$ . And biology teachers teaching religion, ethics, or philosophy as a second subject, were nearly never classified as being the Scientific-Innovative Type (see Figure 4c),  $\chi^2(2, N = 614) = 8.5$ ,  $p = .013$ . Regarding these findings, it did not matter whether teachers preferred teaching biology or their other subject,  $\chi^2(4, N = 603) = 5.71$ ,  $p = .222$ .



**Figure 4.** *Distribution of the different teacher types as a function of the second teaching subject.*

In Germany, political decisions in educational matters are made by the federal states. As a consequence, school systems and teacher training programs differ largely between federal states. Because educational matters are decided by the federal states, the federal states in which teachers' training took place is another important factor which strongly influences their education. Our analysis suggested large differences in teacher type distribution as a function of German federal state (see Figure 4). For example, in Hamburg, a federal state in northern Germany, nearly 60% of biology teachers belonged to the Pedagogical-Innovative Type, whereas in the federal states of Saarland and Bavaria in the west and south of Germany, respectively, almost the same percentage of teachers belonged to the Scientific-Conventional Type. This difference was not related to socio-economic differences between regions, because the distribution of different types of teachers did not depend on whether the setting of the teachers' school was urban, a town, or rural,  $\chi^2(2, N = 613) = 8.07$ ;  $p = .09$ .





**Figure 5.** *Distribution of teacher types as a function of German states.*

## Discussion

In this study, factors influencing biology teachers' educational beliefs were explored by analysing the distribution of these beliefs among the biology teachers with regard to different socio-demographic variables: years of teaching experience, federal state in which they teach, their gender and second subject. Age and teaching experience influenced educational beliefs mainly during the first five years of practice. Furthermore, a strong correlation between the teachers' years of practice and their age was found, indicating that most university students pursue their first career as a teacher, whereas second career teachers are only rarely found in Germany. The largest differences in educational beliefs were found among teachers from different federal states, followed by differences between teachers with a science, and those with a language or philosophy, as a second subject, and then by the differences between male and female teachers.

### *Teaching experience*

The result that a correlation between teaching experience and teachers' beliefs can only be found within the first five years of practice is especially interesting. This result has particular implications for educational reforms. It has been reported in previous studies that the first contact between teachers and their students leads to changes in teachers' educational beliefs. Cochran-Smith (1991), for example, described that teachers become more conventional and more authoritative through their first experiences. This is confirmed in our findings. Our data analysis suggested that after those first five years of teaching, teachers' beliefs remained relatively stable. These findings suggested that continued teacher training might be more

effective during the first years of professional experience than at a later time when teachers' educational beliefs have become more stable. This result is not surprising as changes in teachers' beliefs mostly occur when their experiences come in conflict with their established beliefs and these changes occur predominantly during their first years of teaching (Philippou & Christou, 2002). Nevertheless, in our study, cohort effects might mask the results that would be more obvious in a longitudinal design. We suggest that studies with longitudinal designs be conducted in order to investigate the long-term stability of educational beliefs. Future studies should analyse the effectiveness of different kinds of training programs on teachers' educational beliefs against their years of teaching experience.

#### *Teachers teaching in different regions*

The largest differences in educational beliefs were found among teachers from different federal states. Two explanations for these differences are: (1) The federal states differ in their traditions and the sociocultural backgrounds of their inhabitants which, in turn, influence teachers' experiences and therefore their beliefs; and (2) the federal states differ in their educational systems.

PISA (2003) identified several economic, cultural, and social variables (e.g., number of single parents, socioeconomic status, parents' educational background, and parents' status of employment) that explained about 18% of the variance of German students' competences, but these variables differed greatly between different federal states (Prenzel et al., 2005). These factors could also influence the teachers' experiences and therefore their beliefs. On the other hand, in the present study, no differences between the beliefs of teachers of different school settings (urban, a town, or rural) were found, indicating that there must be additional factors other than the sociocultural background that include gender, age, teaching experience, second subject or favourite subject which impact upon the teacher types. Senkbeil (2005) compared schools' workload (e.g., equipment of the school, personal resources) and activities offered by schools (e.g., cooperation between teachers, evaluation, and cooperation with parents) within different federal states of Germany and found large differences between different federal states. In our study we could not find any connection between the averaged schools' workload or averaged schools' activities and teachers' beliefs.

If neither the sociocultural background, nor the workload and activities of the schools, could explain a considerable amount of the variance in the teachers' beliefs, the difference in the teachers' beliefs could also be a result of the differences in the federal states' educational systems. Teacher education in Germany is regulated by 16 individual federal states which have exclusive jurisdiction and authoritative control over educational matters such as the regulation of the curriculum, time schedules, professional requirements, teachers, school buildings, equipment, and recruitment of teachers (Riquarts & Wadewitz, 2003). Therefore, not only the syllabi differ between the federal states, but the programs for teacher education also differ. There are already some suggestions within the present study that provide a hint that the experiences during teacher education indeed influence the teachers' domain-specific beliefs. We found that federal states, in which teacher education is offered by only one single university, exhibit particularly large differences between the distribution of the three teacher

types (e.g., Saarland, Hamburg). In future studies, teachers' educational beliefs should be analysed by first grouping similar federal states.

If indeed the educational system causes differences in teachers' educational beliefs, it still remains unclear which factor – their own time as students at school, the experience during teacher education, or the initial teaching experiences – influences teachers' beliefs the most (cf. Richardson, 1996). As it is common for German pre-service teachers to study in that federal state in which they attended school and to become a teacher in the same federal state, one interesting future approach to differentiate between the three influencing factors (a teacher's own time at school as a student, experiences during teacher education, and initial teaching practice) would be to analyse in particular those teachers who moved into another federal state between their own time at school and their studies at university, or between their studies at university and their first teaching practice.

### *Teaching subject*

Large differences in educational beliefs were also found among teachers with a science, a language or philosophy as a second subject. Two explanations can be discussed. Either the teachers' experience with the second subject influences their beliefs, or students with different beliefs start to study different subjects at university. John (1991) found that the teachers' subject in general influences their educational beliefs. Therefore, it might be assumed that not only the teachers' first, but also their second, subject influences their beliefs and that teachers' educational beliefs are influenced by all subjects taught. For example, teachers choosing two natural sciences might have another view on students and education than teachers choosing, for example, biology and social science. As the second subject influences the teachers' beliefs, universities should consider which subjects can be combined. In some federal states of Germany only specific combinations of subjects are offered at university (such as biology and chemistry or biology and physics), and this condition might strongly influence the distribution of the teacher types.

### *Gender*

Regarding gender, we could observe that female teachers more often belonged to the Pedagogical-Innovative Type, whereas male teachers tended to be more often of the Scientific-Conventional Type. Khan and Weiss (1973) found that there is a higher percentage of females teaching at the elementary than at the secondary level, which is less pedagogical and more scientific. One possible conclusion is that this tendency does not change significantly over time. As both genders prioritize different aspects of schooling, it seems to be especially important that students mingle with teachers of both genders as early as possible.

## Conclusion

It is often argued that teacher changes do not happen or are only temporary and this is why intended reforms often fail. One reason why these reforms might fail is that they do not focus on changing teachers' beliefs. It seems unlikely that changes in teaching occur without fundamental changes in the teachers' beliefs (Wilson & Cooney, 2002). The question that is always posed is: How to provoke basic shifts in teachers' beliefs? One possible answer is, that basic shifts can only be provoked through reflection, as reflections "allow teacher to connect their thoughts and actions, to recognize and perhaps confront contradictory or otherwise problematic beliefs, and particularly, to change their behaviour" (Wilson et al., 2002, p. 142). Knowledge about domain-specific beliefs of teachers, as well as knowledge about the origin and development of those beliefs, will help teachers to reflect on their own beliefs and actions. If one knows in which ways one differs from others in thinking and acting, it is possible to reflect upon one's own beliefs and actions, and to experience alternative ways of teaching. Furthermore, existing core beliefs of teachers should be taken into account when planning educational reforms. As the success of educational reforms will always depend on teachers' identification with the goals of those reforms, changes can only be effected if prior knowledge and prior beliefs of teachers are accepted and then transformed, instead of neglected.

It is often stated, that changing teachers' practice will depend on changing their beliefs. Therefore, it is necessary to know teachers' existing beliefs as well as to know how they develop, if one attempts to improve teachers' practice (van Driel, Bulte & Verloop, 2007). Knowing the factors influencing teachers' beliefs will help science educators to change teachers' beliefs through in-service courses and educational reforms.

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