The influence of the internship semester on the beliefs of pre-service mathematics teachers: An interview study

Simon Scherer; Benjamin Rott

University of Cologne, Germany

Abstract: Teachers' beliefs have a profound impact on the design and conceptualisation of their lessons. Those beliefs (e.g. regarding teaching methods) can go back to their times as school and university students. It has also been shown that beliefs are generally stable, and that a change is possible but requires intensive practical experience. The internship semester provides such stimulating experiences. An interview study was conducted to investigate whether and to what extent pre-service teachers' beliefs change during the internship semester. Ten university students from all types of teaching degree Master's programmes were interviewed individually before and after their internship semester. We analysed the interviews regarding how the students' beliefs about the nature of mathematics as well as teaching and learning of mathematics are reflected and justified in their statements. Two contrasting developments can be identified, particularly regarding the perspective on open, problem-oriented teaching formats. Before the practical experience, some students argue in favour of understanding-oriented and problem-oriented mathematics lessons designed as a cooperative and student-centred learning process based on the learning prerequisites. Afterwards, there is a shift towards more guided, solution-oriented teaching. For other students, there is a development in which they initially rely on their experiences in tutoring situations or their educational biography. This experience is used to argue in favour of a calculus-oriented and receptive teaching in which content is presented and practice phases are supervised. The experience gained during the internship semester can lead to a shift to more open teaching formats and an argumentation from the learner's perspective.

Keywords: beliefs, internship semester, development of beliefs, teaching and learning

Contact: simon.scherer@uni-koeln.de

1 Introduction

It is not only the professional knowledge of teachers that plays a key role in the conception and design of their lessons; subjective and individual beliefs also influence their teaching practice (Baumert & Kunter, 2013; Ernest, 1989a/b; Philipp, 2007; Rott, 2020; Thompson 1992). As Pehkonen has previously outlined,

> Beliefs have a central role as a background factor for a teacher's thinking and acting. A teacher's mathematical beliefs act as a filter which deals with almost all his thoughts and actions concerning mathematics. A teacher's prior experiences in mathematics teaching and learning, which strongly guide his teaching behavior (e.g. through models), fully act on the level of beliefs—usually

> unconsciously. When he is using his mathematical and pedagogical knowledge, beliefs are strongly involved. (Pehkonen, 1994, p. 187)

Particularly regarding teaching and learning of mathematics, there are beliefs that can be seen as more favourable and those that can be seen as less favourable for teaching mathematics (Ernest, 1989b; Rott, 2020; Yang et al., 2020). As beliefs are generally considered to be stable constructs, processes of change are considered difficult and complex and, therefore, time-consuming (Philipp, 2007; Thompson, 1992). Further research is needed to understand better the processes involved in changing beliefs. However, it has already been shown that prolonged and intensive (practical) experiences can trigger such changes (Bernack-Schüler et al., 2015; Safrudiannur et al., 2022). It therefore seems essential to study teachers' beliefs, their development, and the possibility of change. Particularly regarding beliefs about the teaching and learning of mathematics, there is a lack of research that helps us to understand the conditions under which beliefs are formed and changed in detail; particularly, there is a research gap regarding longitudinal qualitative studies.

Not only beliefs of in-service teachers should be analysed, but also those of pre-service teachers. Beliefs can probably still be changed, especially in the case of pre-service teachers. It is, therefore, particularly important to investigate how teaching and learning experiences affect their beliefs (Vesga-Bravo et al., 2022). These should be of particular interest in this study, and the focus should be on how pre-service teachers' beliefs develop at particular points during their university education. This is specifically interesting because pre-service teachers already hold beliefs about mathematics itself and about the teaching and learning processes of mathematics at the interface between school and university when they begin their studies (Geisler, 2023; Richardson, 2003). Such beliefs are likely to have developed from various long-lasting experiences within their educational biographies and are dominant at the start of their education.

However, it can be expected that the pre-service teachers' beliefs will change and develop during their time at university as a result of their active engagement with university mathematics and their participation in didactic courses during teacher education. These new impressions must be related to the school context in practical phases, which are points of contact with later professional practice, involving many moments of consultation and discussion. In particular, the internship semester, as the longest practical experience with most counselling offers, enables an intensive confrontation with theory-practice networking and can therefore be expected to lead

to processes of change in the sense of Bernack-Schüler et al. (2015). Initial studies (Scherer & Rott, 2022; Safrudiannur et al., 2022) have already shown that the internship semester can generate impulses for the development of beliefs, but further research is needed as we lack detailed knowledge about the nature of such changes and their prerequisites. This leads to a variety of research questions. Two of these are addressed below:

1. What beliefs about mathematics as well as teaching and learning mathematics do pre-service mathematics teachers hold, and how do they justify their beliefs?
2. Are there any changes based on the practical experience gained during the internship semester?

2 Beliefs, background and theory

Back in the 1990s, Pajares (1992) spoke of beliefs as a messy construct, and this description is frequently referred to. Therefore, it is not surprising that there is no clear consensus on a definition of the concept of belief. In particular, the characterisation of beliefs as incontrovertible and the connection between beliefs and knowledge have been identified as points of disagreement (Furinghetti & Pehkonen, 2002). As a working definition that corresponds to our understanding of beliefs, in this study, we use the definition by Philipp (2007). He describes beliefs as "psychologically held understandings, premises, or propositions about the world that are thought to be true" (Philipp, 2007, p. 259).

Beliefs operate as a kind of lens through which we perceive environmental influences that have already been (unconsciously) filtered through an existing perspective. Regarding mathematics teaching, teachers' beliefs significantly influence how specific teaching situations are perceived, how they are dealt with, and how future professional actions are designed (Pehkonen, 1994; Philipp, 2007). In this context, beliefs are conceptualised as part of and distinguished from affective constructs such as emotions or attitudes. Compared to emotions, beliefs can be distinguished in terms of their stability, intensity, and level of cognition. In contrast to emotions, beliefs are more cognitive, generally considered more stable and difficult to change, and less intense; attitudes can be located between these two poles (Philipp, 2007). The concept of beliefs can also be specified in terms of cognition in comparison to knowledge. An individual may have knowledge about different ways of teaching a specific subject of learning, which can be verified or falsified. The belief that a selected

method is the most suitable then involves personal and subjective assessment. It is no longer true or false but varies in terms of the level of argumentation (Kunter et al., 2020).

Building on this general clarification of terms, in the following, we address specific beliefs since beliefs can in fact, refer to all possible "belief objects." In this case, we are concerned with different beliefs of pre-service teachers that may influence the design and conceptualisation of mathematics teaching. Specifically, we draw on literature on beliefs about teaching and learning mathematics and about the nature of mathematics.

There are two different approaches to *teaching and learning* (of maths), that are often contrasted: the transmissive and the constructivist approach (Kunter et al., 2020; Lipowsky, 2020; Xie et al., 2018). For this study, we follow this comparison. Both are based on psychological and didactic theories, and they are often strongly linked to beliefs. Between both approaches, the role of the teacher differs significantly, and there may be different beliefs about the teacher's professional role in preparing and performing mathematics lessons, according to these learning theories. The transmission view is about developing an understanding of mathematics for the confident use of routines and rules, which should be achieved by instructing learners in this way. Understanding the teacher's task then involves efficient preparation of the subject content so that it can be easily transmitted and received. Characteristics of the teacher's behaviour would be the implementation of long periods of practice and quick corrective action when mistakes occur. The constructivist view is based on the idea that mathematical understanding is formed through (self-)active processes of constructing and linking new and existing knowledge. From the teacher's perspective, there is a much stronger mutual exchange between teacher and learner, in which learners need to be individually supported in their construction processes. For the teacher, the focus is on planning a learning environment that motivates discovery processes, as well as dealing with errors in a supportive way by offering individualised feedback and assistance (Kunter et al., 2020; Staub & Stern, 2002). As conceptualised by Jerome Bruner and Heinrich Winter, discovery-based learning is based on the ideas of the constructivist perspective as a didactic (teaching-learning) principle for mathematics education. On the other hand, transmission-oriented beliefs can be associated with receptive learning, as described by David Paul Ausubel (Möller & Rott, 2018).

Concerning beliefs about the *nature of mathematics*, Paul Ernest (1989a/b) proposed a separation into three significantly different so-called world views.

1. the instrumentalist view: Mathematics as an interplay of facts, skills, (algorithmic) procedures and rules, which can be compared to a toolbox. This is a product-oriented view of mathematics.
2. the Platonist view: Mathematics as a static body of knowledge that is linked by formal structures and can be (re)discovered.
3. the problem-solving view: Mathematics as a specific way of thinking and a dynamic and creative science that is constantly evolving. This is a process-oriented view of mathematics.

In addition to beliefs about the nature of mathematics, Ernest (1989a/b) also points to beliefs about the teaching and learning of mathematics and links both concepts. Again, the understanding of the teacher's role differs. Teachers who would belong to the instrumentalist view would presumably have a lecturing, demonstrating understanding of their role and would claim correct mastery of skills as their focussed goal. On the other hand, if the Platonist view of maths predominates, the teacher is likely to act in an explaining role, aiming at a broad conceptual understanding. A teacher of the problem-solving view, instead, acts in a moderating and mediating role regarding individual problem-solving processes and aims for confident problem posing and problem solving (Ernest, 1989a/b). Ernest's theories are still used today and have been further developed, particularly regarding the role of the teacher (Beswick, 2005; Safrudiannur & Rott 2020). For example, in a qualitative study combining classroom observations and interviews, Rott (2020) shows a correlation of teachers' beliefs and their behavior in the classroom. On the one hand, teachers who were categorised to primarily hold the instrumentalist view tend to focus more on outcomes (through taught approaches) rather than flexible strategies and different approaches. On the other hand, teachers who were categorised as primarily holding the problem-solving view, focus more on procedures than on results in the classroom and tend to discuss flexible strategies and different approaches.

3 Research design

To address the research questions, we do not rely on often-used, quantitative self-report instruments, but instead aimed for a qualitative approach.

3.1 Participants

The study was conducted at a university in North Rhine-Westphalia, in central Germany. North Rhine-Westphalia is the federal state with the largest population in Germany. The university is one of the largest teacher educational universities in Europe, where all common teacher education programmes can be studied. Accordingly, students from all teacher education programmes were selected to participate. The student community is, therefore, well represented, and many different perspectives can be included. The research question already limits the selection of possible participants. Selecting students to start the longest possible period of reflected practical experience is necessary. In this particular region, this is the internship semester—a whole practical semester at the learning environment of the classroom—which is part of the Master's programme. The structure of the internship semester commits students to making teaching experiences based on their lesson planning, which are (partially) assessed and reflected upon. Before the internship semester begins, students attend (didactically oriented) preparatory seminars. These courses indicate which students will serve their internship semester in the following semester. As we want to deal with processes of change initiated by the internship semester, it is necessary to have a pre-post design so that the study participants were recruited within these preparatory courses at the Institute of Mathematics Education. Participating both interviews was voluntary. This resulted in a sample of ten participants from almost all school types (primary, lower secondary, upper secondary, special needs education) and included both males and females. Two cases are reported in more detail (see section 4). To pseudonymise the data, the participants were counted alphabetically in the order of their participation, combined with the gender of the participant (f or m for female or male, respectively).

3.2 Methodical approach

The research design is qualitative. From the perspective of measuring and reconstructing beliefs, qualitative designs are more appropriate than quantitative approaches (Philipp, 2007). This can be argued by the fact that the research interest focuses on the reconstruction of beliefs about teaching and learning mathematics at different stages of (teacher) education. Therefore, there is an interest in basic research. The aim is to sharpen a process-based understanding of development processes and identify possible change criteria. Personal interviews were chosen as the methodological approach. Semi-structured interviews are particularly well suited

for this research study because the participants are asked to share a lot about their experiences (from their school days and experiences during the practical phase). It also allows the researchers to respond to the interviewees' statements and ask further questions. Personal interviews are also our method of choice because beliefs are subjective in nature and (strongly) justified in different ways, and they have successfully been used in this line of research before (e.g., Eichler & Erens, 2014).

Overall, deductive categories of beliefs about the nature of mathematics and the teaching and learning of mathematics were developed based on the literature described in section 2. For the interviews, we used a catalogue of key themes (see Figure 1) twice: before the students completed the internship semester (pre-interview) and after this experience (post-interview). To reconstruct the previously deductively developed beliefs from the transcribed interviews and to extend the inductive categories, for example, regarding possible arguments, qualitative content analysis (Mayring, 2020) was used.

Figure 1. Catalogue of key themes for the (pre-)interview

T1: personal view of school mathematics
T2: choice of mathematics as a subject
T3: experiences with maths lessons during their personal learning biography
T4: personal experiences in teaching mathematics
T5: personal view of good mathematics teaching
T6: view of their own professional role
T7: describing learning processes in mathematics lessons
T8: personal view of and ability to describe lesson planning

4 Results

The reconstructed beliefs and potential trajectories of beliefs about teaching and learning are presented below for pre- and post-interviews. In the twenty interviews, both instrumentalist and problem-solving views (in the sense of Ernest) could be identified. Regarding teaching and learning, both transmission-orientated and constructivist positions were found. As the research questions are aimed at changes in beliefs, two cases are presented below in which changes were particularly noticeable. This selection of cases aims to show the different beliefs that can be reconstructed at the beginning and end of the internship semester, which offers them the opportunity to gain practical teaching experience, as well as the direction of changes that can be observed and how the interviewees justify their belief positions.

4.1 The case of J_m

Student J_m is a male pre-service teacher for secondary schools for mathematics and geography. He reports positively on his time at school and justifies his career choice based on his own school experiences (especially referring to his maths lessons). For him, maths is an interplay between an applied science, which can have a strong connection to daily life, and solving problems. In university contexts, however, a stronger formalistic character is highlighted, while in school contexts, from the perspective of the learners, it is about the skills required to master daily tasks, while from the teachers' perspective, other skills, such as mathematical reasoning, may be relevant as well. In relation to his own time at school, he reported that maths has always been very enjoyable through riddling and solving problems. Nevertheless, he described that he learnt best when he was given solution schemes that could then be transferred.

Taking the experiences from the university part of teacher education into perspective, in the pre-interview, he mentioned that maths lessons should particularly encourage process-related skills such as modelling and problem solving. These are described as fundamental cornerstones of teaching mathematics, and the encouragement should be oriented toward application and include references to the real world. Mathematics lessons should be differentiated to enable understanding-orientated and problem-orientated learning and should therefore be student-centred. Regarding the preparation for a (problem-based) lesson, he highlighted that "[finding the right problems] is, in quotation marks, the king's way in maths" (pre-interview of Student J_m at minute 38; translated by the authors). The tasks and the teacher's role are described as being about preparing a learning environment and possible ways of solving problems that learners may pursue in class and in which they are supported. Furthermore, maths lessons should often be taught in small groups in which there should be a lot of communication and argumentation and from which the results are also presented—the teacher should allow the learners to speak most of the time. As a result, learning is understood as a collaborative and communicative process.

In the post-interview, he perceived school mathematics as an application-oriented discipline with a strong emphasis on calculus. He characterised mathematics by a formal and deductive characteristic of proof, with a systematic structure and connection. Regarding the gained practical experience, he reported that he planned and performed a complete series of lessons (of up to five weeks) by himself. He described that during this period, routines in planning and performance were already

established. Regarding the view of problem-orientated teaching, it can be reconstructed that problem-orientated mathematics teaching—in the eyes of student J_m—is an ideal-typical image of theory but is not suitable for practice. Some (experienced) limitations justify this position. On the one hand, structural aspects of this teaching format are seen as a handicap; for example, he argued that learners have problems with the open structure and that approaches and strategies can rarely be developed, not least because the toolbox is not sufficiently developed. In addition, the subject-specific and linguistic diversity of the group of learners is also described as a handicap, as problems represent an excessive barrier, especially for weak learners, so that learning processes are inhibited. In addition to subject-related differences within the learning group, subject-related linguistic differences in communicative (supporting) situations in mathematics lessons between teachers and learners have also been reported.

Furthermore, affective aspects, such as students' beliefs, are identified as a complicating factor in problem-oriented lessons. This is because students may assume that their approach to solving a problem is incorrect if it requires long-term engagement with the task. To summarise, he said that his general impression is that pupils do not prefer this kind of learning, but instead want to be taught formulas and transferable solution schemes. As a result, mathematics lessons should be designed to be solution-oriented and teacher-centred rather than student-centred, as this is the only way to guarantee the accuracy of results and (partial) products. The teacher's role is to act as an expert in their own field and to provide explanations. Indeed, the teaching profession is said to require the ability to explain.

Regarding the second research question, it can not only be summarised that processes of change were observed for J during the internship semester, but also that a development took place that moved from a strong position on one side towards the other extreme. In particular, it can be noted that both positions (partly from personally experienced situations) are backed up by different arguments. Specifically, a constructivist understanding of learning predominated at the beginning of the internship semester, while transmission-oriented beliefs dominated afterwards. Regarding the beliefs about the nature of mathematics he shows indications for both instrumentalist and problem-solving views in the pre-interview. In the post-interview he mostly argues in favour of the instrumentalist view. In relation to this, the understanding of the teacher's role has also changed—in line with Ernest's understanding—from a supporting mediator to an explanatory function.

Correspondingly, the aims of learning processes are subsequently less about active knowledge construction processes and more about the confident use of rules (through passive knowledge reception) (Beswick, 2005; Ernest, 1989a/b; Kunter et al., 2020; Safrudiannur & Rott, 2020; Staub & Stern, 2002).

4.2 The case of I_f

Student I_f is a female pre-service secondary school teacher for mathematics and art. Regarding the understanding of (school) mathematics, school mathematics is described as the outcome of university mathematics since you learn and apply only schematically (and application-orientated) those algorithms which you are allowed to apply based on deductive proofs of university mathematics. She reported that she experienced a lot of frontal teaching in her school days, which was perceived as being good. In these lessons, the topic was first presented, and the algorithms were introduced and demonstrated before they were practised afterwards—in addition, the positive benefits of rule books for her learning were highlighted, as she could constantly refer back to them.

The beliefs about mathematics teaching are based on experiences gained at school and tutoring situations. In particular, she believes that maths lessons should be clear in structure, which refers to the transparency of the topic and its application, as well as the process of solving tasks and the required tools. Understanding the teacher's role involves presenting and explaining the mathematical learning objects to the learners. The comprehension process should then be supported in the practice phases by answering questions, searching for errors, and (directly) correcting them. A typically designed lesson would look like this: new concepts and rules are explicitly explained, and rules and procedures are then explained using examples of tasks. Afterwards, these are written down in the rule books before the procedures are practised on contextualised tasks.

Even in the post-interview, school mathematics is still seen as a broken-down, application-orientated version of university mathematics. Regarding gained experiences, it is not reported that a complete series, but several unrelated lessons, were planned and realised. From these experiences and the further observations of the mentor, it was concluded that the planning effort was underestimated before the internship semester commenced and that mathematical lessons can be structured and understood in a multitude of different ways. It was only through the experiences and observations that the understanding of problem-oriented teaching, including

planning, was developed, and the practical relevance of the university's educational content could be identified. Overall, a positive understanding of problem-orientated teaching has been established. In addition, the motivation to teach in open formats more frequently was increased. To achieve this, the aim is to abandon a strongly explanatory approach. However, restrictions are still outlined here due to the time efficiency of other formats and the pressure of the centralised final exams at the upper secondary level. Nevertheless, problem-based lessons are described as one of the most effective methods for designing mathematics lessons. The reflection of the first independently taught lessons and the feedback received from the mentor caused the understanding of the teacher's role to change. It is no longer the dominant view that teachers can be seen as explainers but that a supportive aspect is also fundamental. In addition, the understanding of teaching maths is focusing more on the central needs of the students. This can be achieved, for example, by addressing different representations or by taking the students' desire for their own active (discovering, researching) part into particular consideration.

Regarding Ernest's beliefs about the nature of mathematics, no specific change can be noticed—school mathematics is seen as a broken-down version of university mathematics that aims at schematic applications of algorithms and can, therefore, be assigned to Ernest's instrumentalist view. With regard to the perspective on teaching and learning processes, it could be recognised that there has been a change. From a position that favours a transmission-oriented presentation of content with an explaining and instructing role of the teacher to a constructivist, learner-oriented position in which knowledge is rather constructed (Beswick, 2005; Ernest, 1989a/b; Kunter et al., 2020; Safrudiannur & Rott, 2020; Staub & Stern, 2002).

5 Discussion

5.1 Discussion and outlook

Firstly, it can be stated that beliefs regarding both, the nature of mathematics itself and teaching and learning theories, can be reconstructed from the pre-service teachers' statements. Likewise, the beliefs of some of these pre-service teachers change. In contrast, the positions of other participants do not change; rather, they become even stronger, and it is argued in their favour in a more experience-oriented way. It can, therefore, be confirmed that the internship semester as an intensive and long-term practical experience can cause changes in beliefs (cf. Bernack-Schüler,

2015; Scherer & Rott, 2022).

In the context of this study, both directions of changes in beliefs about teaching and learning mathematics can be empirically documented. Regarding the second research question, it turns out that not only processes of change in the direction that university theories regard as ideal-typical can be observed but also trajectories in the opposite direction. Developments from constructivist understandings to transmission-oriented ones have been reported in previous studies (Safrudiannur, 2022; Scherer & Rott, 2022). However, to the best of our knowledge, a development towards a constructivist view has been observed here for the first time.

The two cases presented as examples illustrate changes in different directions so that we can conclude that such change processes are independent of the beliefs that predominated in the beginning and that the internship semester does not necessarily lead to the acceptance and adoption of specific beliefs. Initial possible explanations could refer to the fact that the reconstructed beliefs of the post-interviews are strongly orientated towards concise (previous) experiences—in the case of pre-service teacher J_m in relation to experiences of his educational biography and his type of learning and in the case of pre-service teacher I_f through a mentor who pointed out new perspectives and developed into a kind of role model.

More recent efforts for researching learning processes have criticised classical learning theories. This is particularly evident in the absence or inadequate inclusion of social processes and interactions (Grotlüschen & Pätzold, 2020). We also need to address this criticism, so that socio-cultural aspects can offer a broader perspective for the analysis of our research data, which can be added to the transmission and constructivist perspectives. On the one hand, this could relate specifically to the interviewees' beliefs about the role of social interaction in (cooperative) learning processes. Here, the choice of specific social forms, the promotion of argumentation and communication, and the role of the peer group could become important, as J_m, for example, emphasized in the pre-interview. On the other hand, the interviewees' own learning and professionalisation process could also be considered from this perspective. For example, it could be explored to what extent the teaching staff function as a kind of peer group and to what extent social interaction with colleagues – especially with supervising mentors – strengthens perspectives or initiates development processes. This also may raise questions about the training system, and whether teaching mentors should be actively selected, trained and supervised to ensure greater integration of teaching and research practice.

However, we can also find (structural) restrictions for problem-orientated or constructivist teaching structures in the presented statements of student I_f, which lead to the planning of receptive, transmission-orientated learning situations. Frequently, especially before forthcoming exams, the priority is attached to teaching and repeating transferable procedures that lead to (supposedly) dealing successfully with the exam. It can also be noted that the relationship between beliefs about mathematics and the influence on the individual's teaching can be found in the form of the understanding of the teacher's role, as already suggested by Ernest (Ernest, 1989a/b; Beswick, 2005; Safrudiannur & Rott, 2020).

Regarding the impact of practice phases in the context of the relationship between theory and practice in teacher education programmes, the question arises as to what didactic consequences might result from the reconstructed changes. Presumably, the internship semester would have to be (even) more didactically supervised and specific opportunities for (classroom) reflection would have to be created. A stronger connection between theory and practice also seems relevant because many in-service teachers report a lack of or not enough (96% in total) consideration of the teacher's occupational field during their studies (Bungartz & Wynands, 1999). This is why they often refer to their existing experiences—a phenomenon also reconstructed here. However, such monitoring and reflection processes would require a closer look at the arguments and an analysis and reconstruction of the causes of change.

5.2 Limitations

First of all, it should be noted that the qualitative study design and the associated sample size do not result in any intention of generalisation. A targeted sample is being used by focussing on students during their internship semester, which can also be described as selective due to the voluntary nature of participation. Furthermore, the beliefs are reconstructed entirely using the statements made during the interviews and without additional classroom observations or similar data. Therefore, this is a purely subjective report of experience. Many students, especially in the pre-interview, argue in a way that leads to difficulties in identifying their beliefs: Some of their statements appear to be unreflected, which indicates a lack of conscious reflections on their beliefs regarding the nature of as well as teaching and learning mathematics. As a result, only tendencies rather than clear positions were identifiable in some cases.

Restrictions could also arise due to the acquisition of participants in the preparatory seminars, as socially desirable response behaviour related to the seminar

content could occur. However, such a distortion of results must be considered critically, as beliefs from both perspectives could be reconstructed for the first and second interview dates. A further limitation might be that the results only refer to a sample of a specific region in Germany—other regions of Germany do not have internship semesters. This would lead to the follow-up question of whether comparable contexts might also trigger such changes or whether purely didactic courses, without concrete, practical experience, can be planned and performed in a way that leads to belief changes.

Research ethics

Author contributions

S.S.: conceptualization, investigation, methodology, data curation, writing—original draft preparation, writing—review and editing
B.R.: conceptualization, supervision, writing—review and editing

All authors have read and agreed to the published version of the manuscript.

Artificial intelligence

DeepL was used to help with translation from German to English language.

Institutional review board statement

All participants were of legal age and informed consent was obtained.

Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

Due to data privacy reasons video and audio data of the interviews cannot be distributed. Transcript data will be released upon request.

Conflicts of interest

The authors declare no conflicts of interest.

References

Baumert, J., & Kunter, M. (2013). The COACTIV model of teachers' professional competence. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers. Results from the COACTIV project* (pp. 25–48). Springer. https://doi.org/10.1007/978-1-4614-5149-5_2

Bernack-Schüler, C., Leuders, T., & Holzäpfel, L. (2015). Understanding pre-service teachers' belief change during a problem solving course. In C. Bernack-Schüler, R. Erens, A. Eichler, & T. Leuders (Eds.), *Views and beliefs in mathematics education: Proceedings of the MAVI 2013 conference* (pp. 81–94). Springer. https://doi.org/10.1007/978-3-658-09614-4_7

Beswick, K. (2005). The beliefs/practice connection in broadly defined contexts. *Mathematics Education Research Journal, 17*(2), 39-68. https://doi.org/10.1007/BF03217415

Bungartz, P. & Wynands, A. (1999). Wie beurteilen Referendare ihr Mathematikstudium für das Lehramt Sek II? Retrieved November 21, 2024, from http://www.math.uni-bonn.de/people/wynands/Referendarbefragung.html

Ernest, P. (1989a). The impact of beliefs on the teaching of mathematics. In P. Ernest (Ed.), *Mathematics teaching: The state of the art* (pp. 249–254). Falmer Press.

Ernest, P. (1989b). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of Education for Teaching: International research and pedagogy, 15*(1), 13–33.

Eichler, A., & Erens, R. Teachers' beliefs towards teaching calculus. *ZDM Mathematics Education, 46,* 647–659. https://doi.org/10.1007/s11858-014-0606-y

Furinghetti, F., & Pehkonen, E. (2002). Rethinking characterisations of beliefs. In: G. C. Leder, E. Pehkonen & G. Törner (Eds.), *Beliefs. A hidden variable in mathematics education?* (pp. 39–57). Kluwer Academic. https://doi.org/10.1007/0-306-47958-3_3

Geisler, S. (2023). What role do students' beliefs play for a successful transition from school to university mathematics? *International Journal of Mathematical Education in Science and Technology, 54*(8), 1458–1473. https://doi.org/10.1080/0020739X.2023.2170291

Grotlüschen, A., & Pätzold, H. (2020). Lerntheorien. In der Erwachsenen- und Weiterbildung. Bielefeld, wbv Publikation. https://doi.org/10.36198/9783838556222

Kunter, M., Pohlmann, B., Decker, AT. (2020). Lehrkräfte. In E. Wild & J. Möller (Eds.), *Pädagogische Psychologie* (pp. 269–288). Springer. https://doi.org/10.1007/978-3-662-61403-7_11

Lipowsky, F. (2020). Unterricht. In E. Wild & J. Möller (Eds.), *Pädagogische Psychologie* (pp. 69–118). Springer. https://doi.org/10.1007/978-3-662-61403-7_4

Mayring, P. (2020). Qualitative Inhaltsanalyse. In G. Mey & K. Mruck (Eds.), *Handbuch Qualitative Forschung in der Psychologie*. Springer. https://doi.org/10.1007/978-3-658-26887-9_52

Möller, A., & Rott, B. (2018). Teaching via problem solving or teacher-centric access – Teachers' views and beliefs. In B. Rott, G. Törner, J. Peters-Dasdemir, A. Möller, & Safrudiannur (Eds.), *Views and Beliefs in Mathematics Education. Proceedings of the 23rd MAVI Conference* (pp. 215–226). Springer. https://doi.org/10.1007/978-3-030-01273-1_18

Pajares, M. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research 62* (3), 307–332. https://doi.org/10.3102/00346543062003307

Pehkonen, E. (1994). On teachers' beliefs and changing mathematics teaching. *Journal für Mathematik-Didaktik 15*(3/4), 177–209.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning: A project of the national council of teachers of mathematics* (pp. 257–315). Information Age Publishing.

Richardson, V. (2003). Preservice teachers' beliefs. In J. Raths & A. C. McAninch (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education* (pp. 1–22). Information Age Publishing.

Rott, B. (2020). Teachers' behaviors, epistemological beliefs, and their interplay in lessons on the topic of problem solving. *International Journal of Science and Mathematics Education, 18*(5), 903–924. https://doi.org/10.1007/s10763-019-09993-0.

Safrudiannur, Belke, L., & Rott, B. (2022). A pseudo-longitudinal approach for investigating pre-service teachers' beliefs during their university education. *International Journal of Science and Mathematics Education, 20,* 1099–1122. https://doi.org/10.1007/s10763-021-10194-x

Safrudiannur, & Rott, B. (2020). Measuring teachers' beliefs: A comparison of three different approaches. *Eurasia Journal of Mathematics, Science and Technology Education, 16*(1), 1–16. https://doi.org/10.29333/ejmste/110058

Scherer, S., & Rott, B. (2022). Eine Interviewstudie zum Einfluss des Praxissemesters auf die Überzeugungen von Mathematiklehramtsstudierenden. In IDMI-Primar Goethe-Universität Frankfurt (Ed.), *Beiträge zum Mathematikunterricht 2022*. Münster, Germany: WTM. http://dx.doi.org/10.17877/DE290R-23812

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology 94*(2), 344–355. https://doi.org/10.1037/0022-0663.94.2.344

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: A project of NCTM* (pp. 127–146). Macmillan Publishing Co, Inc.

Vesga-Bravo, G. J., Angel-Cuervo, Z. M., & Chacón-Guerrero, G. A. (2022). Beliefs about mathematics, its teaching, and learning: Contrast between pre-service and in-service teachers. *International Journal of Science and Mathematics Education, 20*, 769–791. https://doi.org/10.1007/s10763-021-10164-3

Yang, X., Kaiser, G., König, J., & Blömeke, S (2020). Relationship between pre-service mathematics teachers' knowledge, beliefs and instructional practices in China. *ZDM Mathematics Education, 52*, 281–294. https://doi.org/10.1007/s11858-020-01145-x