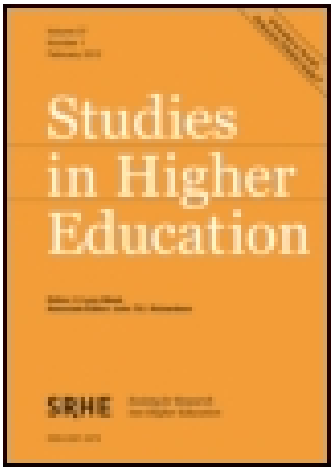

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Identifying and formulating teachers' beliefs and motivational orientations for computer science teacher education

Elena Bender[a], Niclas Schaper[a], Michael E. Caspersen[b], Melanie Margaritis[c] & Peter Hubwieser[d]

[a] Department of Social and Human Sciences, University of Paderborn, Paderborn, Germany

[b] Department of Computer Science, Aarhus University, Aarhus, Denmark

[c] Department of Computer Science, University of Paderborn, Paderborn, Germany

[d] TUM School of Education, Computer studies teaching, Technical University Munich, Munich, Germany

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Identifying and formulating teachers' beliefs and motivational orientations for computer science teacher education

Elena Bender[a]*, Niclas Schaper[a], Michael E. Caspersen[b], Melanie Margaritis[c] and Peter Hubwieser[d]

[a]*Department of Social and Human Sciences, University of Paderborn, Paderborn, Germany;* [b]*Department of Computer Science, Aarhus University, Aarhus, Denmark;* [c]*Department of Computer Science, University of Paderborn, Paderborn, Germany;* [d]*TUM School of Education, Computer studies teaching, Technical University Munich, Munich, Germany*

How teachers are able to adapt to a changing environment is essentially dependent on their beliefs and motivational orientations. The development of these aspects in the context of professional competence takes place during teachers' educational phase and professional practice. The overall understanding of professional competence for teaching computer science follows the notion of empirical educational research including beliefs and motivational aspects. This article aims to investigate relevant domain-specific beliefs and motivational orientations for teaching computer science and their consideration in curricula for computer science teacher education. Therefore, results of an expert interview study based on the critical incident technique lead to appropriate descriptions for domain-relevant beliefs and motivational orientations. Results of a broad curriculum analysis indicate how those aspects are normatively considered in computer science university and school education in Germany. The data were analyzed by qualitative content analysis.

Keywords: teachers' beliefs; motivational orientations; teacher education; computer science; competence modeling

Introduction

Recent research in teacher education is expanded by questioning which characteristics can be changed and thus can be acquired by learning. The teacher is in the center of a learning process and research seeks to explain how teachers themselves are learning and how they are able to adapt to their changing environment (Kunter and Pohlmann 2009). Most requirements necessary for the teachers' profession are factors that individuals develop during their educational phase or professional practice. Next to cognitive aspects, beliefs and motivational orientations belong to the core of professional competence which can be acquired in structured learning environments. In this context, the teachers' phase of education is assumed to be the most important opportunity for the development of these aspects (Kunter and Pohlmann 2009).

Regarding computer science teacher education, many challenges can be observed. First, implemented curricula contain a variety of didactical concepts, goals and learning contents creating an inconsistent situation. That leads to computer science teachers

*Corresponding author. Email: elena.bender@upb.de

believing that they are not properly prepared to fulfill their job tasks due to (missing) qualifications (Diethelm, Hildebrandt, and Krekeler 2009).

Second, computer science teachers practicing at schools seem to be in an unfavorable situation. Rapid changes in their subject due to fast changing technologies create high pressure to stay up to date. Furthermore, they are a minor group within the teaching community. With (often) only one computer science teacher at a school, collaboration, for example, to develop teaching material, is quite complicated (Diethelm, Hildebrandt, and Krekeler 2009). Computer science teachers are also not satisfied with their own planning and success in teaching (Hubwieser, Mühling, and Brinda 2010). The study conducted in the German State of Bavaria revealed that despite existing challenging teaching concepts, their implementation in the classroom seems to be difficult.

To address these challenges, the role of beliefs and motivational orientations is particularly important. They are supposed to influence how teachers behave in the classroom and how they cope with a changing environment. The beliefs have the effect of a lens through which teachers view their world and this influences how they interpret and evaluate the relevance of incoming information (Reusser, Pauli, and Elmer 2011). Thus, analyzing teachers' beliefs addresses challenges of how to implement didactical concepts or choose contents and learning goals out of various possibilities with few existing standards.

Furthermore, motivational orientations include the individual motives, goals and values attributed to their own teaching abilities and thus influence how teachers are able to cope with the daily job requirements (Kunter and Pohlmann 2009). For computer science teachers, the daily job requirements are mainly the described insecurities regarding cooperation and the pressure posed by rapid technological change.

Recent empirical approaches from related subject areas, like mathematics (Kunter, Baumert et al. 2013; Blömeke, Kaiser, and Lehmann 2008) and the natural sciences (Riese and Reinhold 2008), include beliefs and motivational factors as a part of professional teaching competence, showing the increasing importance of modeling beliefs and motivational orientations as relevant ability facets. Assuming that they are acquired and can be changed by learning, competences are understood as performance dispositions to solve complex situations (Weinert 2001). One further core assumption of recent approaches is 'domain specificity', which favors profession-specific factors over generic attributes. Empirical evidence supports the validity of these domain-specific approaches (Kunter, Klusmann et al. 2013).

Which domain-specific beliefs and motivational orientations are relevant for teaching computer science and which importance these aspects actually have for university and school education remain unclear. Thus, main goals of this article are to investigate and qualitatively model the relevant domain-specific beliefs and motivational orientations for teaching computer science at secondary school level and to analyze their implementation in current guidelines for computer science university and school education.

The research is embedded in the initiative 'Modeling and Measuring Competencies in Higher Education' (KoKoHs; Blömeke and Zlatkin-Troitschanskaia 2013) funded by the German Federal Ministry of Education and Research (BMBF).

Theoretical framework of teachers' beliefs

A central challenge in computer science education is that teachers have difficulties in implementing existing didactical concepts in class (Hubwieser, Mühling, and Brinda

2010). Teachers' beliefs are considered a responsible factor of influence in this context. Beliefs in general represent opinions, evaluations or subjective explanation systems of individuals (Pajares 1992) and they are responsible for the way individuals are dealing with information and taking their decisions (Bandura 1986). Literature lacks a consistent definition, but the main idea of the belief construct in the teaching context is that it structures the teachers' interactions with students and thus influences perception and behavior (Voss et al. 2011). Teachers' beliefs contain understandings and assumptions about phenomena and processes related to schools and lessons including an evaluating component (Kunter and Pohlmann 2009). They do not exist independently, but build a bundle of more or less complex thoughts (Reusser, Pauli, and Elmer 2011). The introductorily described lens or filter effect of beliefs for evaluating and interpreting incoming information (Reusser, Pauli, and Elmer 2011) makes them important for research in teacher education. Teachers' beliefs are highly responsible for behavior in class and for differences in instructional behavior (Fennema, Carpenter, and Loef 1990; Stipek et al. 2001). They are closely related to a subject area, as Koballa et al. (2000) could confirm in the natural sciences. Various interdependencies of teachers' beliefs and professional learning are reported in the subject mathematics (Goldsmith, Doerr, and Lewis 2014). For example, whether teachers reject or embrace elements of their professional development depends on their beliefs (Warfield, Wood, and Lehman 2005).

As the subject area of computer science is sparsely investigated, relevant domain-specific teachers' beliefs are derived from corresponding results of recent empirical studies, particularly in mathematics and the natural sciences. For further analysis, two domain-specific 'bundles' of teachers' beliefs are described. First, beliefs about the subject area of computer science and its teaching and learning are relevant, for example, for implementing didactical concepts in class. Second, beliefs affecting the use of information systems and the handling of data are relevant for teaching computer science. These beliefs already have high relevance in school education (CSTA 2011). Students should become sensitive to the use of media and computer systems in early educational stages. Consequently, their teachers play an important role as they are expected to develop this sensitivity and the appropriate underlying beliefs.

Beliefs about the subject computer science and its teaching and learning

One major type of belief investigated in mathematics teacher education focuses on the subject area and its teaching and learning (Goldsmith, Doerr, and Lewis 2014). These beliefs contain two different aspects. On the one hand, they contain epistemological beliefs about the subject area, in this case computer science. Epistemological beliefs are commonly referring to the nature of knowing and the process of knowing (Hofer 2001). On the other hand, they include beliefs about concepts of teaching and learning in computer science, based on learning theories, and mainly divided into transmissive and constructivist-orientated beliefs (Dubberke et al. 2008). From a constructivist viewpoint, learning is understood to be dependent on the individual's own constructive cognitive processes and on the role of the subject's prior knowledge concerning these constructive processes. This viewpoint is contrasted with the transmission approach which assumes that students pick up the content presented in the classroom so that knowledge is transferred directly from the teacher to the students (Dubberke et al. 2008). Positive effects of constructivist beliefs on student achievement are found in mathematics education (Kunter, Klusmann et al. 2013). Furthermore, in teaching mathematics, higher level subject-matter knowledge and pedagogical content knowledge is

connected to more dynamic beliefs about the subject. These beliefs influence the way teachers view their teaching and learning either in a constructivist or in a transmissive way (Blömeke 2012). Referring to results from mathematics, beliefs about the subject and its teaching and learning are considered highly relevant to computer science subject area with the underlying assumption that constructivist views enhance learning processes of computer science students.

Beliefs about data security and privacy

Beliefs affecting the use of information systems and the handling of data already have high relevance in standards for school education (for example, the K–12 Computer Science Standards; CSTA 2011) as a sensitive behavior in the context of data and legal aspects is particularly important for the use of media and computer systems. Regarding university education, the taskforce of ACM (Association for Computing Machinery) and IEEE (Institute of Electrical and Electronics Engineers 2012) in the USA includes these aspects in their standards for studies in the subject of computer science. They put a strong focus on aspects concerning intellectual property, privacy and civil liberties, security policies, laws and computer crimes. This has implications for related teachers' beliefs, especially the sensitivity for using and handling data, often with regard to the internet. These beliefs contain a sensitive understanding of community values and the laws by which we live, maintaining awareness of consequences, of ethical dissent and whistle blowing with regard to information systems. By being sensitive in this way, ethical issues that arise, for example, in software development, are adequately identified and candidates are able to determine how to address them technically and ethically (ACM/IEEE 2012). Moreover, these beliefs include a critical attitude towards reliability, authenticity and accuracy of information (CSTA 2011). For further analysis, the named aspects are summarized as beliefs about data security and privacy.

Theoretical framework of teachers' motivational orientations

The teaching profession requires high concentration, abilities to cope with failures, to get along with new situations and self-responsibly to take care of learning opportunities (Kunter and Pohlmann 2009). Whether a teacher is able to cope with the daily job requirements is dependent on the overall motives, goals or values attributed to his/her own teaching abilities, summarily referred to as motivational orientations. Motivational orientations describe the individually varying reasons for initiation, direction, intensity and maintenance of behavior (Kunter and Pohlmann 2009, 273). Referring to research in mathematics teacher education (Kunter, Baumert et al. 2013), motivational orientations that cover aspects of intrinsic motivational orientations and teaching efficacy can be described and specified for teaching computer science.

Intrinsic motivational orientations: aspects of enthusiasm and interest belonging to teaching computer science

Some motivational characteristics, such as interest and intrinsic motivation, can be observed as a group of socio-cognitive constructs forming a basis for functional behavior in the school context (Pintrich 2003). These constructs have an experiential

component of joy and excitement in common during the engagement with an object or activity. Several studies revealed two dimensions of intrinsic motivational orientations (a topic and an activity related dimension) being relevant for students' adaptive and persistent learning (Eccles and Wigfield 2002). Furthermore, intrinsic motivation is assumed to be context-specific as it arises from individuals' interactions with a certain context and thus can vary across different situations and contexts (Deci and Ryan 2000). Also, teacher enthusiasm is closely related to intrinsic motivational orientations; it can be defined as a degree of positive experience during teaching in the subject area (Kunter et al. 2011). Implicitly, it is considered to be demonstrated by certain behavior such as a motivating teaching style (Long and Hoy 2006). A central assumption concerning this construct is that teachers who are enthusiastic about their profession invest more effort in teaching, have higher endurance and receive better results (Eccles and Wigfield 2002). Teacher enthusiasm is assumed to be highly responsible for effective instruction and student motivation (Long and Hoy 2006). As context specificity is assumed for intrinsic motivational factors in general, this may also be true for teacher enthusiasm. In the context of computer science, this means interest regarding the rapidly occurring innovations in the subject area creates a willingness to stay up to date and enhances the motivation for learning. In congruence with the construct interest, the construct enthusiasm can be divided into one dimension belonging to the subject area and another dimension belonging to teaching in the subject area (Kunter et al. 2011).

Computer science teaching efficacy

Computer science teachers lack confidence to properly fulfill their job tasks (Diethelm, Hildebrandt, and Krekeler 2009). The subjective appraisal of the perceived competence (in contrast to the actual competence) has to do with teachers' sense of efficacy (Woolfolk Hoy and Spero 2005). Teachers' efficacy is a judgment of their capabilities to yield desired outcomes of student engagement and learning (Woolfolk Hoy and Spero 2005). It influences thoughts and emotions that are responsible for expending substantial effort in pursuing goals or in persisting in case of difficulties. Teachers' efficacy is strongly related to behavior in the classroom. In mathematics teaching, it influences especially the implementation of new content in class (Goldsmith, Doerr, and Lewis 2014). Furthermore, it has an effect on students' achievement (Ross 1992) and on students' motivational orientations (Midgley, Feldlaufer, and Eccles 1989). Teaching efficacy is defined as context- and subject matter-specific (Tschannen-Moran and Woolfolk Hoy 2001). Thus, this research seeks to specify relevant aspects of self-efficacy for teaching computer science. With regard to refinement of the category, research has mainly confirmed the existence of two factors (Hoy and Woolfolk 1993) distinguishing personal teaching efficacy reflecting self-efficacy beliefs about one's own abilities to teach, and (general) teaching efficacy, reflecting profession-related outcome expectancies based on Bandura's (1986) social cognitive theory. Although researchers agree on teachers' efficacy being situation-specific, defining the level of specificity is one of the most difficult issues to be resolved (Pintrich and Schunk 1996). Despite some attempts at measuring subject-specific efficacy (Riggs and Enochs 1990), existing research efforts do not seem to be applicable to refine the category of efficacy for teaching computer science. This approach assumes teachers' efficacy being specific for teaching computer science with regard to subject-specific challenges.

Research questions

The described theoretical analysis leads to assumptions that two main areas of beliefs (beliefs about the subject and its teaching and learning, and beliefs about data security and privacy) and two main areas of motivational orientations (intrinsic motivational orientations and teaching efficacy) are particularly important for teaching computer science. These assumptions are made by referring to results from related subject areas (like mathematics and the natural sciences) and overall standards for computer science school education and subject-matter education at universities, although without considering the specific form or requirements of these beliefs for computer science teachers. How the specific description of these types of beliefs and motivational orientations exactly looks and what importance these aspects actually have in the educational process for teaching computer science still remain unclear.

Thus, this research should clarify at first, how domain-specific beliefs and motivational orientations can be described adequately for teaching computer science in the overall context of modeling professional competence.

The second remaining question is how the defined aspects of beliefs and motivational orientations are currently taken into consideration in computer science teacher education and school education.

Methodology

Two empirical steps are conducted to clarify how computer science-specific beliefs and motivational orientations can be described and modeled adequately and which importance they have in the educational process for teaching computer science. An expert interview study should give answers to the first research question. A broad document analysis of curricula for teacher education at universities and for school education is used to answer the question of how these aspects are considered in the educational process.

Expert interview study

To address the first research question regarding the refinement and the adequate description of computer science-specific teachers' beliefs and motivational orientations, an expert interview study serves as an empirical approach and as the basis to accomplish this goal.

The interviews are conducted based on the critical incident technique. The method was modified slightly so that the experts were confronted with challenging situations (teaching scenarios developed by us) and had to answer the question how to cope best with the teaching demands in the situation. In the interview study, we used separate scenarios for the empirical elaboration of pedagogical content knowledge and teachers' beliefs and motivational orientations. Each scenario was embedded into a concrete computer science teaching context. To address each of the four described beliefs and motivational orientations, specific scenarios were developed. The experts were interviewed with open questions to describe all relevant requirements in the given situations. At the beginning of the interview, the experts received detailed information about the research background, the interview technique and the understanding of competences. Every interview lasted about one hour and included two or three scenarios.

The following scenario is an example of a teaching scenario we used to identify and refine beliefs about the subject computer science and its teaching and learning. Scenarios with similar challenging situations were used with regard to the other types of beliefs and motivational orientations.

> Imagine starting your career as a computer science teacher at a new school. The contextual conditions offer enough room for your own ideas regarding the subject computer science. You are now facing the challenge to prepare and structure your lessons to adequately activate all students.
>
> The main questions for the experts are:
>
> - Which beliefs about the subject computer science do you assume being useful and conducive in this situation?
> - Which beliefs about teaching and learning in computer science enhance students' active learning?

The interviews were conducted with a sample of 17 experts. Eight of them (three female and five male experts) are experienced computer science teachers practicing in secondary schools. They all passed a university degree in computer science (diploma or state examination) and are aged between 31 and 60 years, with a work experience between 3 and 30 years of teaching in the subject. Nine experts (two female and seven male experts) were selected from the domain of teacher education at university. This includes six professors and three assistant professors for computer science teacher education. They are aged between 36 and 60 years, and hold their current position at least for 1 year and at maximum for 14 years. Beyond experience from their current position, this group has a profound background of teaching practice and/or research in teacher education. When acquiring the sample, certain criteria are considered as described to represent different fields in the educational system and different federal states in Germany and to ensure an experienced and broad view on competent behavior, helpful beliefs and motivational orientations.

All interviews were recorded and systematically transcribed to ensure a reliable analysis. The data were analyzed (1) by a structuring qualitative content analysis technique and (2) a summarizing qualitative content analysis technique, according to Mayring (2010). Both types are analytical techniques for the coding of text material and follow certain strict rules. For the structuring analysis technique (see Mayring 2010, 93 ff.), the coders agreed on a coding manual in which the constructs of beliefs and motivational orientations are defined theoretically and the rules for extracting and coding the interviewees statements (called 'coding units') are determined. Essentially, one coding unit contains one sense-making unit. Working with the text material, the relevant statements of the interviewees were identified and in this step deductively allocated to the four categories of beliefs and motivational orientations described in the theoretical framework.

After structuring the text material, the summarizing analysis technique (see Mayring 2010, 68 ff.) was used to generate the refining descriptions of the beliefs and motivational orientations. Therefore, the structured statements of the experts within each category of beliefs and motivational orientations are paraphrased and generalized according to Mayring's (2010, 70) Z1- and Z2-rules. The raw statements of the experts are transformed into abstracted statements by reducing them to their core content. That includes withdrawing all text parts which are not directly content-relevant (e.g. explaining or repeating passages) and transforming the statements to a similar level of language regarding their level of abstraction. To interpret and generalize the statements, also theoretical assumptions relevant to the investigated constructs of

beliefs and motivational orientations are considered. In a further step, the generalized paraphrases within the categories of beliefs and motivational orientations are reduced according to Mayring's (2010, 70) Z3- and Z4-rules. Synonymous paraphrases are withdrawn. Paraphrases including similar contents are bundled and integrated into one and thus finally, the remaining central paraphrases serve in a rather inductive way for refining and specifying the four overall categories of beliefs and motivational orientations for teaching computer science and are described in the results section.

To take care of reliability issues concerning the use of the structuring technique, 20% of the expert interviews were analyzed by two raters using Cohen's (1960) Kappa as a measure for inter-rater agreement. For the interpretation of Kappa, Landis and Koch (1977) propose that values of more than .61 show substantial agreement and more than .81 confirm (almost) perfect agreement. The inter-rater agreement for the raters was found to be outstanding for the interview study with Kappa = .86 ($p < .001$) concerning the first-level categories of the beliefs and motivational orientations.

Curricular analysis

To address the second research question of how beliefs and motivational orientations are taken into consideration in computer science teacher education, a document analysis of curricula for secondary education in Germany is undertaken. As curricula represent the normative contents and objectives of computer science university and school education, the intended implementation of aspects in these guidelines indicates which relevance they *normatively* have for the education in computer science. Curricula for universities and schools were considered in parallel because they both contain learning goals about computer science education with regard to knowledge, abilities and attitudes that should be taught in computer science classes.

To conduct this research step, all available curricula (43) for computer science teacher education from German universities and school curricula of six federal states were collected. Three university curricula were being revised, and were thus not available at the point of our data collection. Selection criteria for school curricula are the three most recently developed ones and curricula of the three largest German federal states by population.

The data were also analyzed by a structuring qualitative content analysis technique according to Mayring (2010). All relevant text parts of the curricula are systematically allocated to the four theoretically described types of beliefs and motivational orientations. Additional aspects that may arise in the curricula would be analyzed to complement the aspects of beliefs and motivational orientations. The coders also agreed on a coding manual in which the categories are defined and the coding units are determined. For example, coding units to describe a category minimally consist of a word or a part of a sentence (like 'critical openness') and at maximum include complete sentences or even passages. The inter-rater agreement was found to be substantial with Kappa = .63 ($p < .001$) for the curricular analysis concerning the first-level categories of the beliefs and motivational orientations.

Results

The results from the interview study are considered to describe and define teachers' beliefs and motivational orientations in computer science referring to experts' knowledge. Experts' statements lead to a subject-specific refinement of these aspects in

terms of specific subject-related formulations of beliefs and motivational orientations. The results from the curricular analysis reveal how beliefs and motivational aspects are intended to be implemented in these documents and thus indicate the normative importance of these aspects for the educational process.

Formulations of teachers' beliefs with regard to computer science

The formulations of relevant beliefs for teaching computer science are refining the two areas of beliefs described in the theoretical framework: beliefs about the subject area computer science and its teaching and learning, and beliefs about data security and privacy.

Beliefs about the subject area computer science and its teaching and learning refer to concepts of epistemological beliefs and a constructivist view on teaching and learning which have proven to be empirically relevant. The interview partners paid a high attention to beliefs about computer science and its teaching and learning. The above-described integrative view on epistemological and learning-theoretical beliefs suggested for the subject area mathematics seems to be suitable, too, in the case of computer science. In line with those results, expert statements led to conclusions that the view on the subject area computer science and how knowledge is structured in this area is closely connected to the view on how students' subject-specific learning processes take place (Table 1). The subject computer science is often seen as a discipline where office applications or programming languages can be learned. But experts strongly underline that a complex view on the subject area is necessary for students' learning processes. This complex view on the subject is mainly expressed twofold. First, the subject should be conceived as a discipline which is guided by superordinate strategies and principles (Table 1, 1.1.1.). Second, a process view on the subject is strongly conducive (Table 1, 1.1.2.).

The strong connection between beliefs about the subject and beliefs about teaching and learning is also shown by the expert statements. Teachers should not only believe that the subject of computer science consists of superordinate strategies and principles, but they should also be convinced that the learning processes of students take place in the context of those strategies and principles (Table 1, 1.2.1). Experts also consider a constructivist view on learning and teaching in computer science as the most conducive (Table 1, 1.2.2).

Table 1. Formulation of competence-relevant beliefs about the subject computer science and its teaching and learning.

1. Competence-relevant beliefs about the subject computer science and its teaching and learning
1.1. *Beliefs about the subject computer science*
1.1.1. Teachers are convinced that superordinate strategies and principles make up the subject computer science and are relevant to all sections of subject
1.1.2. Teachers are convinced that the core of computer science consists of processes that can always be traced back to relationships between information and data
1.2. *Beliefs about teaching and learning in computer science*
1.2.1 Teachers believe that learning in all parts of computer science takes place in the context of the superordinate strategies and principles of the subject
1.2.2. Teachers are convinced that students are learning in an autonomous way and by critically approaching computer science contents

Table 2. Formulation of competence-relevant beliefs about data security and privacy.

2. Competence-relevant beliefs about data security and privacy
2.1. Teachers are convinced that sensitivity to the responsible use of their own and other persons' data is important content for computer science lessons
2.2 Teachers have a critical and evaluative attitude towards dealing with computer science systems and always check on their credibility and authenticity
2.3. Teachers are convinced that knowledge of the legal framework is essential for responsibly dealing with computer science systems

Beliefs about data security and privacy have an even higher degree of subject specificity. The described theoretical derivation of these beliefs is mainly based on subject-specific standard documents from university education in the subject matter and from school education, without considering the special requirements for teachers. The experts' statements led to formulations in this belief area considering specific requirements in teaching computer science. The formulations described in Table 2 focus on three main aspects: concerning sensitivity to the use of data (Table 2, 2.1.), a critical and evaluative attitude when dealing with information systems (Table 2, 2.2.) and the conviction that legal aspects are an essential part of computer science (Table 2, 2.3.).

Formulations of motivational orientations for teaching computer science

Expert statements were strongly supporting the domain-specific refinement of the two theoretically described aspects of motivational orientations for teaching computer science: intrinsic motivational orientations and computer science teaching efficacy.

Intrinsic motivational orientations contain context-specific aspects of joy and excitement with regard to a certain topic or action. The results from the expert interview study led to a domain-specific refinement of these aspects for teaching computer science that go in line with previous empirical findings from the subject area of mathematics (see Kunter et al. 2011). Statements of the experts mainly reinforce aspects of enthusiasm or interest, on the one hand, with regard to the subject area, and on the other, with regard to teaching in the subject area (shown in Table 3). The specific formulations belonging to enthusiasm and interest with regard to the subject area focus on enthusiasm with regard to content in the subject area in general (Table 3, 3.1.1.), on the one hand, and on interest for technical innovations, leading to a willingness to expand the own knowledge (Table 3, 3.1.2.), on the other hand. The descriptions

Table 3. Formulation of competence-relevant intrinsic motivational orientations.

3. Competence-relevant intrinsic motivational orientations
3.1. *Enthusiasm and interest with regard to the subject*
3.1.1. Teachers have a high level of enthusiasm for the subject content in computer science
3.1.2. Teachers have a high level of interest for technical innovations in computer science and are willing to expand their own skills and knowledge
3.2. *Enthusiasm and interest with regard to teaching in the subject*
3.2.1. Teachers positively experience their teaching in computer science and convey joy and enthusiasm to their students
3.2.2. Teachers have a strong interest in the learning development of their students in computer science

Table 4. Formulation of competence-relevant computer science teaching efficacy facets.

4. Competence-relevant computer science teaching efficacy facets
4.1. *Efficacy referring to the specific tasks in computer science*
4.1.1. Teachers trust in their abilities to deal with the contents of the subject, in particular with respect to innovations and aspects of the legal framework
4.1.2. Teachers trust in their abilities to develop subject-specific solutions in computer science lessons *ad hoc*
4.2. *Efficacy referring to the profession as computer science teacher*
4.2.1. Teachers trust in their abilities to perform competently in computer science lessons with regard to changes belonging to subject content and the handling of data
4.2.2. Teachers feel able to solve critical situations in computer science lessons (i.e. in dealing with students or technical equipment)

referring to teaching in the subject area mention a positive experience with the teaching process itself (Table 3, 3.2.1.) and also interest in the learning development of computer science students (Table 3, 3.2.2.).

The second area of the motivational orientations assumed in theory to be relevant for teaching computer science is the construct of teaching efficacy. It is described as a judgment of their own teaching capabilities in the context of subject-matter teaching competences with only a few existing attempts of subject-specific descriptions. Results from the interview study led to a domain-specific teaching efficacy referring to subject-specific tasks and to profession-specific tasks for teaching computer science (described in Table 4). These dimensions seem to be related to each other as (prospective) teachers should not only trust in their abilities to deal with new developments in the subject (Table 4, 4.1.1.), but should also trust in performing competently in front of students with regard to these new contents (Table 4, 4.2.1.). Further aspects of domain-specific teaching efficacy of computer science teachers refer to trust in their own abilities to develop subject-specific solutions *ad hoc* in class (Table 4, 4.1.2.) and the conviction of the ability to solve critical situations in lessons (Table 4, 4.2.2.).

In summary, the interview study supports the domain-specific refinement of the areas of beliefs and motivational orientations described in the theoretical framework. Results can be considered as the first attempt for concrete subject-specific formulations in the depicted fields of computer science teachers' beliefs and motivational orientations.

Consideration of beliefs and motivational orientations in curricula for university and school education

The described results show how the defined beliefs and motivational aspects are implemented in curricula for university and school education and indicate which importance these aspects normatively have for the educational process.

Referring to 49 analyzed documents (43 university curricula and 6 school curricula), 60% (29) of the curricula contain aspects regarding the described beliefs and 30% (15) of the curricula consider aspects of the depicted motivational orientations as described in Table 5.

According to the four investigated types of beliefs and motivational orientations, their consideration varies among the analyzed documents. The beliefs about data security and privacy have the highest relevance in the analyzed curricula; 40% of all documents include these beliefs. The 6 examined school curricula all focus on aspects concerning beliefs about data security and privacy and one-third of

Table 5. Number of curricula which consider the specific types of beliefs and motivational orientations.

	Categories			
	Beliefs		Motivational orientations	
Number of curricula	1. Beliefs about the subject computer science and its teaching and learning	2. Beliefs about data security and privacy	3. Self-efficacy facets	4. Intrinsic motivational orientations
University curricula (total: 43)	8	14	1	12
School curricula (total: 6)	1	6	2	0
Curricula (total: 49)	9	20	3	12

the 43 university curricula do, too. For example, a text passage of a school curriculum belonging to this type of beliefs is called 'respect of intellectual property' (translated from Ministry of Cultural affairs, Youth and Sports Baden Württemberg 2004, 441).

The beliefs about the subject area and its teaching and learning are considered by nearly one-fifth (9) of the 49 curricula. Eight universities reinforce those aspects and among the school curricula, one concentrates on this area of beliefs. For example, the beliefs about the subject area and its teaching and learning are described as 'methods to promote autonomous learning in the lessons' (translated from Georg-August-University of Göttingen 2011, 39).

With regard to the motivational orientations, aspects of intrinsic motivational orientations are mentioned in one-quarter of the examined curriculum documents. But these aspects are only spread among the university curricula: 12 documents (one-third) cover aspects of intrinsic motivational orientations, but no school curriculum does. Considered aspects mainly refer to the field of openness towards new IT developments (e.g. ' … represent a critical openness towards new IT developments' (University of Education Schwäbisch Gmünd 2012, 81).

Finally, aspects of self-efficacy are only included by three of the examined documents, two school curricula and one university curriculum. The efficacy facets considered in those curricula only refer to subject-specific tasks. For example, a relevant description is 'to be confident when dealing with a software, even if the whole range of functions cannot (yet) be mastered' (translated from Ministry of Education and Science of Land Schleswig-Holstein 2002, 28).

Discussion and conclusion

Results from this research reveal firstly which types of beliefs and motivational orientations are relevant in the sparsely investigated field of computer science teacher education and secondly how these aspects are currently implemented in curricula for university and school education.

Regarding the first point, the main results from the conducted expert interview study are the identification and formulation of concrete domain-specific beliefs and motivational orientations. Their identification and specific description are the first

attempt in the research field of computer science teacher education. Results are in the long run assumed to enhance the unfavorable situation for computer science teachers at schools. This includes, for example, uncertainties regarding the implementation of modern constructivist didactical concepts or the fulfillment of job tasks properly as described in the introduction. Future research should clarify which beliefs and motivational orientations teacher students in computer science actually have, how beliefs and motivational orientations during the educational phase are related to future teaching success in the subject, and which differences exist between beliefs and motivational orientations in the educational phase and professional practice. Future challenges are to develop valid measurement instruments to determine the occurrence of the described beliefs and motivational orientations among computer science student teachers and experienced teachers. The development of subject-specific measurement approaches is anything but trivial. With regard to the examined constructs of teachers' beliefs and motivational orientations, existing measurement approaches mostly refer to self-assessment and small convenience samples with open methodological questions (Tschannen-Moran and Woolfolk Hoy 2001; Schraw and Olafson 2008). Moreover, it is essential to investigate how motivational factors and beliefs should be operationalized and can be measured to implement them into the educational process. Such assessment approaches should focus on reflection processes and conscious rechecking of the underlying explanatory systems to enable teachers to adapt their beliefs according to more professional orientations (Kunter and Pohlmann 2009).

Regarding the second point, the main results of the curricular analysis show that the examined types of beliefs and motivational orientations are inconsistently implemented in curricula for computer science teacher education and school education. Beliefs are considered in nearly twice the number of analyzed documents compared with motivational orientations. The beliefs about data security and privacy seem to have the highest importance in the educational process, broadly implemented in curricula for school education and mentioned in one-third of the curricula in teacher education. With regard to the formulations describing the beliefs and motivational orientations in the examined curricula, a rather high degree of abstraction is used. Fragmented or abstract formulations (like 'respect of intellectual property') are used and complete sentences in terms of competence-relevant formulations describing an expected outcome often miss the curricula. This leads to conclusions that curricula development processes in some cases do not systematically refer to research concerned with professional teaching competence. Consequently, if categories of teachers' beliefs and motivational orientations prove to be theoretically and empirically relevant requirements, but curricula do not consider them, then conclusions can be drawn that the curricula have deficits with regard to these aspects. Thus, curricular gaps can be identified and curricula development processes can be enhanced. Reinforced consideration of subject-specific beliefs and motivational orientations in curricula can be seen as fostering these aspects *normatively* in the educational process. Further empirical evidence is needed to draw conclusions for classroom situations. Especially, research about how the determined domain-specific beliefs and motivational orientations affect future teaching success in computer science and how they are actually spread among students and teachers can help to resolve related questions.

To summarize, this research is intended as a first step on the way to more specific descriptions of beliefs and motivational orientations in the context of professional competence for teaching computer science with the overall goal to address the existing domain-specific challenges in teacher education.

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References

Bandura, A. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall.

Blömeke, S. 2012. "Does Greater Teacher Knowledge Lead to Student Orientation? The Relationship between Teacher Knowledge and Teacher Beliefs." In *Teachers' Pedagogical Beliefs*, edited by Johannes König, 15–35. Waxmann: Münster.

Blömeke, S., G. Kaiser, and R. Lehmann, eds. 2008. *Professionelle Kompetenz angehender Lehrerinnen und Lehrer: Wissen, Überzeugungen und Lerngelegenheiten deutscher Mathematik-Studierender und –referendare – Erste Ergebnisse zur Wirksamkeit der Lehrerausbildung*. [Professional Competence of Prospective Teachers: Knowledge, Beliefs and Learning Opportunities of German Mathematic Students and Trainees – First Results of the Effectiveness of Teacher Education]. Münster: Waxmann.

Blömeke, S., and O. Zlatkin-Troitschanskaia, eds. 2013. "The German Funding Initiative 'Modeling and Measuring Competencies in Higher Education: 23 Research Projects on Engineering, Economics and Social Sciences, Education and Generic Skills of Higher Education Students." KoKoHs Working Papers, 3. Berlin & Mainz. Accessed March 20, 2014. http://www.kompetenzen-im-hochschulsektor.de/Dateien/KoKoHs_WP3_Bloemeke_Zlatkin-Troitschanskaia_2013.pdf

Cohen, J. 1960. "A Coefficient of Agreement for Nominal Scales." *Educational and Psychological Measurement* 20 (1): 37–46. doi:10.1177/001316446002000104.

CSTA (The Computer Science Teachers Association) Standards Task Force. 2011. "K–12 Computer Science Standards. Revised 2011." New York. Accessed March 20, 2014. https://csta.acm.org/Curriculum/sub/CurrFiles/CSTA_K-12_CSS.pdf.

Deci, E. L., and R. M. Ryan. 2000. "The 'What' and 'Why' of Goal Pursuits: Human Needs and the Self-Determination of Behavior." *Psychological Inquiry* 11: 227–68. doi:10.1207/S15327965PLI1104_01.

Diethelm, I., C. Hildebrandt, and L. Krekeler. 2009. "Implementation of Computer Science in Context – A Research Perspective Regarding Teacher-Training." Koli Calling, 97–100. doi:10.1145/2078856.2078859.

Dubberke, T., M. Kunter, N. Mcelvany, M. Brunner, and J. Baumert. 2008. "Lerntheoretische Überzeugungen von Mathematiklehrkräften: Einflüsse auf die Unterrichtsgestaltung und den Lernerfolg von Schülerinnen und Schülern." [Learning Theoretical Beliefs of Mathematics Teachers: Factors Influencing the Instructional Design and the Learning Success of Students]. *Zeitschrift für Pädagogische Psychologie* 22 (3–4): 193–206. doi:10.1024/1010-0652.22.34.193.

Eccles, J. S., and A. Wigfield. 2002. "Motivational Beliefs, Values and Goals." *Annual Review of Psychology* 53: 109–32. doi:100901.135153.0084-6570/02/0201-0109.

Fennema, E., T. P. Carpenter, and M. Loef. 1990. *Teacher Belief Scale: Cognitively Guided Instruction Project.* Madison: University of Wisconsin.

Georg-August-Universität Göttingen. [Georg-August-University of Göttingen]. 2011. "Modulverzeichnis für den Bachelor-Teilstudiengang "Informatik"-zu Anlage II.20 der Prüfungs- und Studienordnung für den Zwei-Fächer-Bachelor-Studiengang." Accessed December 3, 2012. www.uni-goettingen.de/de/version-am-ii-2012122011/493074.html

Goldsmith, L. T., H. M. Doerr, and C. C. Lewis. 2014. "Mathematics Teacher's Learning: A Conceptual Framework and Synthesis of Research." *Journal of Mathematics Teacher Education* 17: 5–36. doi:10.1007/s10857-013-9245-4.

Hofer, B. K. 2001. "Personal Epistemology Research: Implications for Learning and Teaching." *Journal of Educational Psychology Review* 13 (4): 353–83. doi:10.1023_A_1011965830686.

Hoy, W. K., and A. Woolfolk. 1993. "Teachers' Sense of Efficacy and the Organizational Health of Schools." *The Elementary School Journal* 93: 356–72. doi:10.1086/461729.

Hubwieser, P., A. Mühling, and T. Brinda. 2010. "Erste Ergebnisse einer Lehrerbefragung zum bayerischen Schulfach Informatik." [First Results of a Teacher Survey on the Bavarian School Subject of Computer Science]. In *Didaktik der Informatik - Möglichkeiten empirischer Forschungsmethoden und Perspektiven der Fachdidaktik*, edited by I. Diethelm, C. Dörge, C. Hildebrandt and C. Schulte, 45–56. Bonn: Köllen.

Koballa, T., W. Gräber, D. C. Coleman, and A. C. Kemp. 2000. "Prospective Gymnasium Teachers' Conceptions of Chemistry Learning and Teaching." *International Journal of Science Education* 22: 209–24. doi:10.1080/095006900289967.

Kunter, M., J. Baumert, W. Blum, U. Klusmann, S. Krauss, and M. Neubrand. 2013. *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers: Results from the COACTIV Project*. New York: Springer.

Kunter, M., A. Frenzel, G. Nagy, J. Baumert, and R. Pekrun. 2011. "Teacher Enthusiasm: Dimensionality and Context Specificity." *Contemporary Educational Psychology* 36 (4): 289–301. doi:10.1016/j.cedpsych.2011.07.001.

Kunter, M., U. Klusmann, J. Baumert, D. Richter, T. Voss, and A. Hachfeld. 2013. "Professional Competence of Teachers: Effects on Instructural Quality and Student Development." *Journal of Educational Psychology* 105 (3): 805–20. doi:10.1037/a0032583.

Kunter, M., and B. Pohlmann. 2009. "Lehrer." [Teacher]. In *Einführung in die Pädagogische Psychologie*, edited by J. Möller, and E. Wild, 261–82. Berlin: Springer.

Landis, J. R., and G. G. Koch. 1977. "The Measurement of Observer Agreement for Categorical Data." *Biometrics* 33 (1): 159–74. doi:10.2307/2529310.

Long, J. F., and A. W. Hoy. 2006. "Interested Instructors: A Composite Portrait of Individual Differences and Effectiveness." *Teaching and Teacher Education* 22 (1): 303–14. doi:10.1016/j.tate.2005.11.001.

Mayring, P. 2010. *Qualitative Inhaltsanalyse*. [Qualitative Content Analysis]. Beltz: Weinheim.

Midgley, C., H. Feldlaufer, and J. Eccles. 1989. "Change in Teacher Efficacy and Student Self- and Task-Related Beliefs in Mathematics during the Transition to Junior High School." *Journal of Educational Psychology* 81: 247–58. doi:10.1037/0022-0663.81.2.247.

Ministerium für Kultus, Jugend und Sport Baden Württemberg. [Ministry of Cultural affairs, Youth and Sports Baden Württemberg]. 2004. "Bildungsplan. Bildungsstandards für Informatik. Gymnasium –Kursstufe." Accessed December 3, 2012. http://www.bildung-staerkt-menschen.de/service/downloads/Bildungsstandards/Gym/Gym_Inf_wb_bs.pdf

Ministerium für Wissenschaft, Bildung, Forschung und Kultur des Landes Schleswig-Holstein. [Ministry of Education and Science of Land Schleswig-Holstein]. 2002. "Lehrplan für die Sekundarstufe II des Fachbereichs Informatik. Gymnasium, Gesamtschule, Fachgymnasium." Accessed December 3, 2012. http://lehrplan.lernnetz.de/index.php?wahl=109

Pajares, M. F. 1992. "Teachers' Beliefs and Educational Research: Cleaning Up a Messy Construct." *Review of Educational Research* 62 (3): 307–32. doi:10.3102/00346543062003307.

PHS (Pädagogische Hochschule Schwäbisch Gmünd). [University of Education Schwäbisch Gmünd]. 2012. "Studienordnung für den Studiengang Lehramt an Werkreal-, Haupt-, und Realschulen." Accessed December 3, 2012. http://www.ph-gmuend.de/deutsch/downloads/studien_u_pruefungsordnungen_2011/3.3.1_StudO_LA_WHRS_20_07_12_2_.pdf

Pintrich, P. R. 2003. "A Motivational Science Perspective on the Role of Student Motivation in Learning and Teaching Contexts." *Journal of Educational Psychology* 95: 667–86. doi:10.1037/0022-0663.95.4.667.

Pintrich, P. R., and D. H. Schunk. 1996. *Motivation in Education: Theory, Research, and Applications*. Englewood Cliffs, NJ: Merrill/Prentice-Hall.

Reusser, K., Pauli, C., and A. Elmer. 2011. "Berufsbezogene Überzeugungen von Lehrerinnen und Lehrern." [Work-Related Beliefs of Teachers]. In *Handbuch der Forschung zum Lehrerberuf*, edited by E. Terhart, H. Bennewitz, and M. Rothland, 478–79. Münster: Waxmann.

Riese, J., and P. Reinhold. 2008. "Entwicklung und Validierung eines Instruments zur Messung professioneller Handlungskompetenz bei (angehenden) Physiklehrkräften." [Development and Validation of an Instrument to Measure Professional Competence for (Prospective) Physic Teachers]. *Lehrerbildung auf dem Prüfstand* 1 (2): 625–40.

Riggs, I., and L. Enochs. 1990. "Toward the Development of an Elementary Teacher's Science Teaching Efficacy Belief Instrument." *Science Education* 74: 625–37. doi:10.1002/sce.3730740605.

Ross, J. A. 1992. "Teacher Efficacy and the Effect of Coaching on Student Achievement." *Canadian Journal of Education* 17 (1): 51–65. doi:10.2307/1495395.

Schraw, G. J., and L. J. Olafson. 2008. "Assessing Teachers' Epistemological and Ontological Worldviews." In *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures*, edited by M. S. Khine, 25–44. New York: Springer.

Stipek, D. J., K. B. Givvin, J. M. Salmon, and V. L. MacGyvers. 2001. "Teachers' Beliefs and Practices Related to Mathematics Instruction." *Teaching and Teacher Education* 17 (2): 213–26. doi:10.1016/S0742-051X(00)00052-4.

The Joint Task Force on Computing Curricula, Association for Computing Machinery and Institute of Electrical and Electronics Engineers. 2012. "Computer Science Curricula 2013 – Strawman Draft." Stanford University.

Tschannen-Moran, M., and A. W. Hoy. 2001. "Teacher Efficacy: Capturing an Exclusive Construct." *Teaching and Teacher Education* 17 (7): 783–805. doi:10.1016/S0742-051X(01)00036-1.

Voss, T., T. Kleickmann, M. Kunter, and A. Hachfeld. 2011. "Mathematics Teachers Beliefs." In *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers*. *Results from the COACTIV Project*, edited by M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, and M. Neubrand, 235–57. New York: Springer.

Warfield, J., T. Wood, and J. D. Lehman. 2005. "Autonomy, Beliefs and the Learning of Elementary mathematics teachers." *Teaching and Teacher Education* 21 (4): 439–56. doi:10.1016/j.tate.2005.01.011.

Weinert, F. E. 2001. "Concept of Competence: A Conceptual Clarification." In *Defining and Selecting Key Competencies*, edited by D. S. Rychen and L. Salganik, 45–66. Seattle: Hogrefe and Huber.

Woolfolk Hoy, A., and R. B. Spero. 2005. "Changes in Teacher Efficacy during the Early Years of Teaching: A Comparison of Four Measures." *Teaching and Teacher Education* 21: 343–56. doi:10.1016/j.tate.2005.01.007.