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Pre-Service Teachers' Cognitive Learning Processes with regard to Specific Teaching and Learning Components in the Context of Professional Vision – A Mixed-Methods Exploration

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Abstract

The focus of this thesis is on pre-service teachers' cognitive learning activities to gain general pedagogical knowledge in university-based teacher education. Recently, it was shown that this kind of teacher knowledge is one of the most important influencing factors on instructional quality, and that pre-service teachers, however, often struggle in applying their knowledge learned in university to later classroom practice. In this context, however, less attention has been directed to understand the cognitive learning processes to be fostered for meaningful knowledge acquisition in initial teacher education. Reasons for that are often attributed to the available measurement approaches to elicit cognitive processing, while simultaneously taking the contextualized and situated nature of teacher knowledge into account, which is particularly challenging in ill-structured domains such as general pedagogical knowledge. Therefore, the aim of the thesis is to describe, how pre-service teachers are engaged in the deep level processes of elaboration and organization when selecting and processing information in this knowledge domain. In addition, it aimed at developing and exploring different methodology approaches to study pre-service teachers' cognitive learning processes in a contextualized way. In this line, two exploratory studies in the context of observing and analyzing classroom situations were conducted. In study 1, pre-service teachers' elaboration processes were investigated with a video-based qualitative approach, and validated with a second, quantitative measure. Study 2 focused on the assessment of pre-service teachers' organization processes and on their differential changes during a teaching and learning course through an approach that combined video with concept mapping. Overall, the findings reveal that pre-service teachers show capacities to engage in elaboration and organization activities, however, rather on a low level, as well as they differ in their capacities and changes over time depending on their prior knowledge level. Furthermore, the exploratory study findings provide first evidence that the implemented alternative and contextualized methodology approaches can be successfully used to study cognitive learning processes in teacher education. In sum, this thesis contributes to the advancement in research on pre-service teachers' cognitive processes in learning to teach, and provides suggestions and tools for activating elaboration and organization processes in university-based teacher education.

1 Introduction

> "In the same way that conducting looks like hand-waving to the uninitiated, teaching looks simple from the perspective of students who see a person talking and listening, handing out papers, and giving assignments. Invisible in both of these performances are the many kinds of knowledge, unseen plans, and backstage moves – the skunkworks, if you will – that allow a teacher to purposefully move a group of students from one set of understandings and skills to quite another over the space of many months" (Bransford, Darling-Hammond, & LePage, 2005, p. 1).

The question of how teachers learn and develop to become professionals has been given a lot of attention by teacher educators and researchers in the last years and decades (Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2005). This is not surprising in societies like ours, where education plays an essential role for the societal participation of individuals as well as for the success of whole nations (Darling-Hammond & Bransford, 2005). Since there is growing empirical evidence, that teachers' knowledge is an important determinant of instructional quality that affects student achievement, questions of how pre-service teachers' initial acquisition of knowledge takes place and how learning processes can be supported in teacher education – as the foundation of teachers' professional development, arises more and more (Bauer & Prenzel, 2012; Baumert et al., 2010; Cochran-Smith, 2003; Darling-Hammond, 2006; Darling-Hammond & Bransford, 2005).

Recently, concerns have been raised about the effects of theoretical university courses on fostering pre-service teachers' knowledge relevant to the teaching practice (Kennedy, Ahn, & Choi, 2008). A perceived gap between the content taught at university and the skills needed in the classroom is also part of critics (Feiman-Nemser, 1990; Fenstermacher, 1994; Wubbels, Brekelmans, & Hooymayers, 1992). Several studies have provided evidence that novice teachers often have difficulties in applying their knowledge learned in university settings to classroom practice, and often face a practice shock after finishing their university-based teacher education (Cochran-Smith, 2003; Gruber, Mandl, & Renkl, 2000).

Two factors, which might contribute to these difficulties, are related to how pre-service teachers' knowledge is organized and stored in memory and how and what kind of prior knowledge pre-service teachers activate in complex classroom situations (Mandl, Gruber, & Renkl, 1991). In this context, cognitive psychology research provides evidence that the deep level processes of elaboration and organization foster the integration of new information and the construction of knowledge representations (Steiner, 2001). This ensures a better comprehension and in turn, facilitates the later retrieval and effective application in authentic (problem) situations (Friedrich & Mandl, 2006; Rumelhart & Norman, 1978).

However, so far, a deeper understanding about the way in which pre-service teachers process new information, and detailed descriptions about the quality of pre-service teachers' cognitive

learning activities during knowledge acquisition processes in university-based teacher education courses are still rare (Desimone, 2009; Hammerness, Darling-Hammond, & Shulman, 2002; Putnam & Borko, 2000; Zeichner, 2005). However, it can be assumed that the question of how (well) pre-service teachers learn is necessary, because answers to this question may result in suggestions for the design and improvement of powerful teacher education programs and teachers' further professional development in order to overcome the perceived theory-practice-gap (Zeichner, 2005).

Alongside the importance of understanding how knowledge acquisition processes take place, the issue of suitable measures for assessing pre-service teachers' cognitive learning processes has to be addressed (Cochran-Smith, 2003; Darling-Hammond & Bransford, 2005; Koster, Brekelmans, Korthagen, & Wubbels, 2005). Although, progress has clearly been made in studying cognitive learning processes with "soft" measures (e.g. subjective judgments of their abilities), rather few advancements have been made so far in developing and testing new assessment approaches taking the contextualized and situated nature of teacher cognition into account (Artelt, 2000a; Kersting, Givvin, Sotelo, & Stigler, 2010; Oser, Curcio, & Düggeli, 2007). *Therefore, this dissertation thesis attempts to broaden the understanding of pre-service teachers' cognitive learning activities as crucial parts of their knowledge acquisition processes and to explore new contextualized methodology approaches.*

Open questions

When studying pre-service teachers' cognitive learning activities and knowledge acquisition processes with regard to elaboration and organization, empirical findings based on the situated cognition approach (Brown, Collins, & Duguid, 1989) and the expertise paradigm (Ericsson, Charness, Feltovich, & Hoffman, 2006) have shown that processes of knowledge acquisition are domain-specific and determined by the context and conditions under which they take place. Against this backdrop, cognitive processes in this thesis are studied in the domain of general pedagogical knowledge. Based on Shulman's conceptualization (1986; 1987) general pedagogical knowledge is, beside subject matter knowledge and pedagogical content knowledge, an integral part of university-based teacher education. This kind of teacher knowledge is necessary to create and optimize teaching-learning situations across subjects and teaching contexts, including knowledge of classroom management, teaching methods, classroom assessment, and student diversity (Hammerness et al., 2002; Voss & Kunter, 2011). Research provides evidence that teachers' general pedagogical knowledge is one of the most important influencing factors on instructional quality and students' learning

success (e.g. Cochran-Smith & Zeichner, 2005). *However, it has seen – differently to subject matter and pedagogical content knowledge – so far limited systematic empirical investigation within teacher education – mainly because only a few measures have been available.* For a long time, subjective judgments of pre-service teachers' abilities or rather distal indicators, such as degrees, courses taken or certificates achieved, were used (Voss, Kunter, & Baumert, 2011; Wayne & Youngs, 2003).

This causes, that pre-service teachers' cognitive learning activities allowing effective knowledge application (Artelt, 2000a) *in the field of general pedagogical knowledge are so far uninvestigated and in turn, relevant processes, which should be fostered in teacher education, are barely known* (Kunter, Baumert, Blum, Klusmann, Krauss, & Neubrand, 2011; Seidel & Shavelson, 2007). However, answers to these questions would be especially relevant for the field of general pedagogical knowledge, as in this area serious problems regarding the enabling of pre-service teachers to apply their knowledge exist (Bauer & Prenzel, 2012; Terhart, 2009).

Thus, to investigate pre-service teachers' cognitive learning activities in the field of general pedagogical knowledge, measurement approaches, considering the contextualized and situated nature of teacher knowledge by assessing these processes in a concrete situation, are necessary (Artelt, 2000a). This implies, however, that capturing all necessary parts of general pedagogical knowledge for implementing an effective instructional practice goes beyond what can be measured within a single contextualized instrument and puts beside, too much cognitive load on pre-service teachers (Seidel & Stürmer, 2014). Therefore, knowledge about teaching and learning components, considered as a relevant part of general pedagogical knowledge, is in the focus of this work; specifically the components of goal clarity and learning climate as they have been repeatedly shown as relevant for students' cognitive and motivational learning by teaching effectiveness research (Herweg, 2008; Meyer, Seidel, & Prenzel, 2006; Seidel et al., 2006).

For investigating elaboration and organization processes regarding these specific teaching and learning components in an authentic and situated way, the concept of professional vision (Goodwin, 1994; Van Es & Sherin, 2002) is used as an indicator. Professional vision is one learning outcome that is of particular interest, as it has been identified as an element of teacher expertise that can be developed in teacher education (Bromme, 1992; Stürmer, Könings, & Seidel, 2013). For teachers, professional vision is the ability to activate professional knowledge (in this case knowledge about effective teaching and learning components) in order to select (notice) and process (reason) relevant features of classroom

situations (Van Es & Sherin, 2002). Research within this field uses video for studying teacher knowledge (Brophy, 2004b; Goldman, Pea, Barron, & Derry, 2007; Kersting, 2008), and has its foundation in expertise research (Bromme, 1992). So far, diverse noticing and reasoning abilities have been ascertained, indicating that different cognitive information processes are involved during knowledge application (Carter, Cushing, Sabers, Stein, & Berliner, 1988; Schwindt, 2008; Seidel & Prenzel, 2007). Higher abilities refer to the use of meaningful cognitive strategies, which enable teachers to activate prior knowledge and reduce complexity. Low abilities, instead, indicate the lack of the meaningful cognitive strategies (Putnam & Borko, 2000). *Although, significant advancements have been made in studying in-service teachers' cognitive processes in the context of professional vision (Kersting et al., 2010; Van Es & Sherin, 2002), initial processes of knowledge acquisition and their development in university-based teacher education, especially in the domain of general pedagogical knowledge, have not been studied intensively (Brouwer, 2010; König & Seifert, 2012; Koster et al., 2005).* So far, it is known that pre-service teachers are often not able to direct their attention to relevant elements of classroom instruction in order to select events and situations, that have been shown to influence student learning, and also have deficits in reasoning about noticed events (Schwindt, 2008; Seidel & Prenzel, 2007; Star & Strickland, 2008). Furthermore, it could be shown that pre-service teachers acquire knowledge during teaching and learning courses relevant for professional vision and specifically, their reasoning ability improved (Stürmer, Könings, et al., 2013; Stürmer, Seidel, & Schäfer, 2013). In this context, some studies have analyzed pre-service teachers' noticing process (e.g. Star & Strickland, 2008), some studies focused on their reasoning (e.g. Schwindt, 2008), and still others did not separate between noticing and reasoning (e.g. Santagata & Angelici, 2010*). Thus, it remains, so far, an open question whether pre-service teachers show different elaboration capacities during noticing and reasoning or if they are interrelated. Furthermore, analysis approaches that investigate, if pre-service teachers activate knowledge in an adequate manner to interpret their observations, are also missing.* However, knowledge about these kinds of interrelations could advance the understanding about pre-service teachers' elaboration processes in the context of professional vision. Therefore, the assessment of pre-service teachers' elaboration processes, as indicated by their knowledge activation within the interrelation of their noticing and reasoning in the context of specific teaching and learning components, is one research aim of this thesis.

Furthermore, detailed insight into pre-service teachers' knowledge structure and organization processes is not provided so far. A reason for that can be seen in the fact, that

cognitive research tools needed to explore organization processes have not been applied to the context of professional vision yet. Teachers' professional vision has been studied, so far, by using video tools and qualitative analysis approaches. Advances also have been made in developing quantitative measures (Kersting, 2008; Seidel & Stürmer, 2014). Therefore, it seems promising to expand the available measurement tools for assessing cognitive processes from other research fields and apply, for example concept mapping, a cognitive research technique to explicit learners' knowledge structures and changes in knowledge organization, to research on organization processes in the context of professional vision.

Clearly, not all knowledge that is necessary to deal with the multiple challenges of classroom practice can be fully developed and learned in pre-service teacher education. Teaching will never be completely routinized, even not for experienced teachers (Feiman-Nemser, 2008; Hammerness et al., 2005). Thus, it is important, that teacher education provides opportunities which help pre-service teachers in becoming "adaptive experts" (Hammerness et al., 2005). This means, that they get enabled to do a variety of teaching activities at the same time without having to spend too many attentional resources. Furthermore, that they get prepared to move beyond existing routines and developing new practices. Preparing pre-service teachers to draw upon and use their professional knowledge in addressing these challenges of practice, various affords have been made in teacher education, so far. In order to foster cognitive learning processes to transfer theoretical knowledge to actual teaching situations, different approximations and representations forms have been implemented into theoretical courses of university-based teacher education programs (Grossman, Compton, Igra, Ronfeldt, Shahan & Williamson, 2009; Stürmer, Könings, et al., 2013). For example, video is a prominent tool (Blomberg, Sherin, Renkl, Glogger, & Seidel, 2013; Brophy, 2004b). Reflection tools and learning portfolios have also become quite popular in teacher education (Brouër, 2007a, 2007b; Dyment & O'Connell, 2011; Gläser-Zikuda, Voigt, & Rohde, 2010; Hascher, 2010). *However, empirical evidence if these elements contribute to pre-service teachers' initial cognitive learning processes, by linking theory to practice and through reflecting on what have been learned in detail, are still scarce.* Few studies indicate positive effects of video on pre-service teachers' knowledge application (Blomberg, Sherin, et al., 2013) and of structured learning portfolios on the use of elaboration strategies (Schäfer, Blomberg, Stürmer, & Seidel, 2012). *University-based teacher education courses using video as "representations of practice" in combination with learning portfolios to foster meaningful cognitive learning processes, especially with regard to organization processes, have not been*

under study in detail yet. Thus, this thesis aims to explore individual learning trajectories and changes of pre-service teachers' organization processes in such settings.

Synthesizing, in order to investigate pre-service teachers' initial knowledge acquisition phases in the field of teaching and learning at universities, pre-service teachers' elaboration and organization learning activities have to be studied as they are central to knowledge acquisition and application. Thereby, assessment approaches are necessary which are able to measure elaboration and organization processes, while simultaneously taking the quality of pre-service teachers' knowledge structure and the contextualized nature of teacher knowledge into account. In order to advance the understanding of changes towards integrated knowledge organization during courses on teaching and learning, individual differences between pre-service teachers and their learning trajectories have to be studied.

Main objectives and research context

The present work aims to contribute to the advancement in the research field of teacher learning, by investigating pre-service teachers' cognitive learning processes with regard to specific general teaching and learning components in the context of authentic and complex classroom situations. Thereby, it can be assumed that pre-service teachers who are engaged in meaningful cognitive learning processes, indicated by the use of elaboration and organization strategies, are more able to encode and process relevant information about teaching and learning in classrooms. This thesis also makes a first attempt in applying different combinations of contextualized and cognitive measures to the study context of professional vision.

The main research questions are:

a) To what extent do pre-service teachers report on elaboration and organization cognitive learning processes in the context of professional vision?
b) Is there indication that alternative measurement and analysis approaches yield valid and reliable information for assessing pre-service teachers' cognitive learning processes in the context of professional vision?

To investigate these objectives, two studies were designed in the context of the DFG project *Observe* (Seidel, Blomberg, & Stürmer, 2010a; Seidel & Prenzel, 2007; Seidel, Prenzel, Schwindt, Stürmer, Blomberg & Kobarg, 2009). Both studies go beyond the research agenda of the DFG project. Study 1 focuses on the investigation of pre-service teachers' elaboration

processes by combining video with an open answer format for which a coding scheme was developed. The aim of Study 2 is to examine pre-service teachers' organization processes and changes through the combination of video and concept mapping. Also therefore, coding frameworks based on assumptions from cognitive science and cognitive psychology research were developed.

The *Observe* project explores pre-service teachers' professional vision about specific teaching and learning components, as an indicator for integrated general pedagogical knowledge. Rationales of the project are current reforms and reorientations of teacher education in Germany against the background of discussions what skills pre-service teachers need to develop and how these skills need to be conveyed, in order to enable pre-service teachers to successfully apply what they have learned and face future job demands (Koster et al., 2005; Schwindt, Seidel, Blomberg, & Stürmer, 2009; Seidel et al., 2009). In the framework of the DFG priority program "Competence Models for Assessing Individual Learning Outcomes and Evaluating Educational Processes" (Leutner, Klieme, Fleischer, & Kuper, 2013), the project was scheduled for six years (2008-2014) and divided into three phases, dealing with different issues and certain characteristics of pre-service teachers' professional vision in the context of diagnosing general pedagogical competencies in university-based teacher education. In the first phase (2008-2010), descriptive knowledge gained from qualitative research was used to model the structure of the second sub-component of professional vision – teachers' reasoning about classroom events – and was tested empirically. Therefore, a video-based, standardized instrument called "*Observer Tool*" was developed (Seidel et al., 2010a; Seidel & Stürmer, 2014). The development of the instrument involved three steps: (1) the selection of video clips that represent situations relevant for specific teaching and learning components as prompts to elicit teacher knowledge, (2) the development of ratings tapping pre-service teachers' reasoning. Both parts were then (3) integrated into an online platform. Results from the first phase showed that the video clips used in the *Observer Tool* served the purpose to represent valid examples of relevant teaching and learning components and that the instrument provides a reliable standardized measure of pre-service teachers' reasoning.

In the second phase of the project (2010-2012), the instrument was used as a formative assessment tool and the focus was on deepening the scientific understanding of pre-service teachers' knowledge application and development of professional vision. Results showed positive changes in professional vision with regard to reasoning during a university-based theory practice term (Stürmer, Seidel, et al., 2013) and phases of knowledge acquisition in teacher education courses (Stürmer, Könings, et al., 2013). Differential changes are shown for

the content of the courses as well as for the instructional approaches used (Seidel, Blomberg, & Renkl, 2013; Stürmer, Könings, et al., 2013).

The third phase of the project (2012-2014) has a focus on the relationship between professional vision and pre-service teachers' first teaching experiences. As the research topic of this dissertation is part of the second phase of the *Observe* project, these research findings are not presented in this work.

Overall, this thesis contributes to and deepens the research activities of the *Observe* project by looking closer at cognitive learning processes of pre-service teachers as fundamental prerequisites for meaningful learning and knowledge acquisition.

Study 1 of this dissertation focuses on pre-service teachers' application of elaboration strategies within the interplay between information encoding (noticing) and processing (reasoning) by using a video-based qualitative approach. For this purpose the video-based *Observer Tool* was adapted, as the video clip selection of the *Observer Tool* is based on the identification of relevant teaching and learning components (Seidel & Stürmer, 2014). Furthermore, to test the validity of the qualitative approach the *Observer Tool* rating items were used as a second, quantitative measure of pre-service teachers' reasoning and we were compared to the qualitative achieved results.

Within Study 2, the dissertation explores different aspects of pre-service teachers' organization strategies during information encoding and processing from a videotaped classroom situation. The use of video in combination with a concept mapping task as a new assessment approach for organization processes in the context of professional vision was applied. Therefore, one more video clip from the *Observer Tool* was adapted.

Outline

In the following, I will present firstly the theoretical outline of the thesis, which is divided into three main paragraphs. The first part concerning "learning, knowledge and information processing" (chapter 2) discusses theoretical approaches and empirical findings from cognitive psychology research which defines learning as knowledge acquisition, and relates it to information processing, teacher learning and cognition. It will be shown, what characteristics complex teacher knowledge have and what are important cognitive learning strategies to acquire complex knowledge representations and are therefore, relevant in the analysis of pre-service teachers' cognitive learning processes. The second part, regarding the "knowledge about teaching and learning components as an integral part of university-based teacher education" (chapter 3), presents a current cognitive process-oriented teaching and

learning model, which build the theoretical basis for knowledge about teaching and learning components. Furthermore, the relevance for fostering knowledge about goal clarity and learning climate as specific teaching and learning components in teacher education is exposed. Empirical findings regarding the support and the assessment of learning processes and knowledge in teacher education build a further basis. Within the third part, an integration of the former outlined paragraphs are given, by displaying how cognitive learning processes necessary for acquiring knowledge about teaching and learning components can be assessed in a contextualized way. Therefore, approaches and empirical findings regarding the concept of "professional vision as a proximal indicator for investigating pre-service teachers' learning processes in the context of teaching and learning components" (chapter 4) are discussed.

Derived from the theoretical part, the aims of the present research will be summarized in chapter 5. Afterwards, Study 1 will be addressed in chapter 6. Thereby, the research aims and central research questions with hypotheses will be introduced as well as the methodology used. In the following, the results of Study 1, including a discussion will be presented. In chapter 7, the same procedure is applied to Study 2. Finally, in chapter 8, the results of both studies are discussed regarding their theoretical, methodological, and practical implications.

2 Learning, Knowledge and Information Processing

In debates and research on competency-based learning in teacher education, knowledge acquisition is considered as one of the most recurring topics (Kunter et al., 2011). The acquisition of elaborated and well-organized conceptual knowledge, which is applicable and transferable to diverse settings and classroom situations, has been recognized as a key element of teacher expertise. This fact requires university-based teacher education to create learning opportunities, fostering the development towards it (Berliner, 1986; Borko & Livingston, 1989; Sternberg & Horvath, 1995). To this purpose, questions concerning cognitive learning processes and conditions favorable to gain expert-like knowledge structures arise, however, which have not been studied intensively in initial teacher education yet. The current work wants to address this issue, by investigating the engagement of pre-service teachers in meaningful cognitive learning processes. Thus, it is necessary at the beginning, to present approaches and important results of research on learning that are relevant to the topic of pre-service teachers' cognitive learning processes. Hereby, I integrate research traditions coming from diverse domains of psychology, including educational, developmental, and cognitive psychology, and relate it to the context of teacher education. First, theoretical approaches referring to learning as knowledge acquisition in the context of information processing are addressed. Afterwards, theoretical models and empirical findings based on the expert paradigm about the acquisition of complex teacher knowledge are targeted. The role of elaboration and organization processes on knowledge acquisition and empirical findings on their assessment are presented in the last section of this first theoretical paragraph.

2.1 Pre-service teachers' learning as the acquisition of knowledge in the context of information processing

Without a notion on how people – and this not specific to the teacher profession – are supposed to learn and develop cognitive structures, it is not possible to answer questions concerning how to foster the engagement in meaningful learning processes. Following current definitions, learning in the context of knowledge acquisition under the restrictions of cognitive architecture (Atkinson & Shiffrin, 1968; Baddeley, 1998; Kintsch, 1974) is characterized as a domain-specific and context dependent information process, that include four main components or phases (Klauer & Leutner, 2007; Reusser, 1998; Steiner, 2001). First of all, relevant information has to be selected through focusing the attention on specific aspects of the presented material (*selection*). Afterwards, the selected information has to be

transferred to working memory, where relations between the single information pieces have to be built (*construction*); specifically as working memory is limited with regard to its capacity (Miller, 1956). Thereby, the amount of available information in working memory can be increased through the aggregation of single items to *chunks* (Sweller, Van Merrienboer, & Paas, 1998). After this construction-phase, information has to be processed to long-term memory to store it permanently (*acquisition*). During the last phase (*integration),* the new information is integrated into the existing knowledge base by actively transferring prior knowledge from long-term memory to working memory, and by building connections between new and old knowledge pieces (Sweller et al., 1998).

Overall, selection and acquisition processes decide the amount of what should be learned, and in contrast, the processes of knowledge construction and integration are responsible for the understanding of the acquired knowledge, as they determine knowledge organization and coherence. This emphasizes that knowledge is created and made meaningful by each learner individually through cognitive activities during information processing what in turn, facilitates problem-solving, considered as knowledge transfer and application (Prenzel & Schiefele, 1986; Reinmann & Mandl, 2006). Therefore, successful problem-solving can be interpreted as a consequence of domain-specific knowledge acquisition, as it is per definition the search for a solution in order to overcome a perceived barrier (Dörner, 1976). In the light of Dewey (1910), pre-service teachers' learning in the context of problem-solving situations is the most successful, when they are involved in elaborated reflective processes. These require novice teachers on the one hand to link the problem situation with prior knowledge in a critical way, and on the other hand to inquire the problem through processes of problem reformulation, trials on solution, and revisions (Dewey, 1910; cf. Schön, 2002 "professional inquiry").

Synthesizing and relating it to the context of the present work, pre-service teachers' learning defined as knowledge acquisition in the context of information processing can be understood as an active, reflective and reciprocal process of prior knowledge activation and integration of new information, which should help them to notice relevant information and to process and understand this information in order to transfer it successfully to problem situations in classroom practice (Klauer & Leutner, 2007; Prenzel & Schiefele, 1986; Reinman & Mandl, 2006; Steiner, 2001). This requires pre-service teachers, to be actively engaged by employing effective and flexible strategies to encode, understand, memorize and solve problems related to the classroom context (Mandl & Friedrich, 1992). Hereby, learning in university-based teacher education occurs under its best, when pre-service teachers participate in activities that

are perceived to be relevant for real classroom practice, and when pre-service teachers monitor their learning processes (Klauer & Leutner, 2007; Steiner, 2001). A graphical illustration about the complex process of learning is provided in figure 1, highlighting that this thesis focuses on the cognitive information processes of pre-service teachers (grey box).

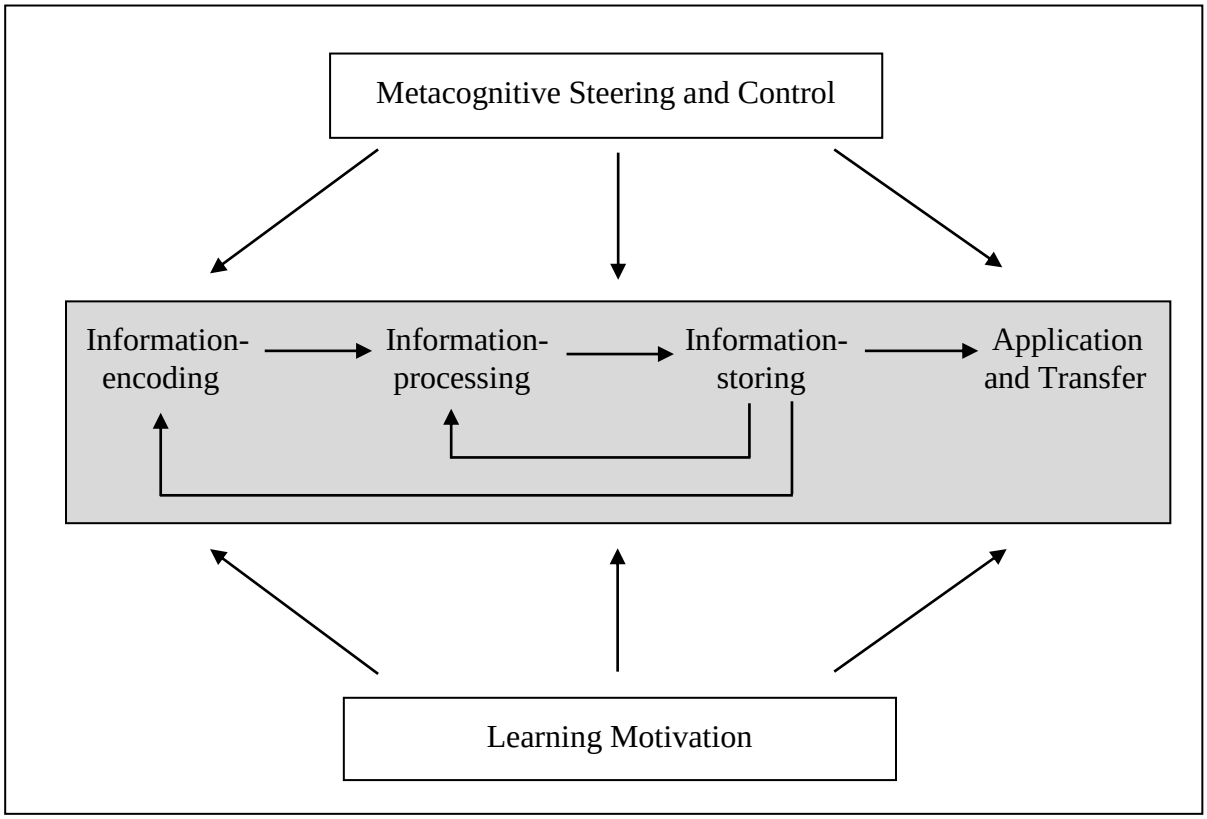


Figure 1. Learning as knowledge acquisition in the context of information-processing (adapted from Klauer and Leutner, 2007; translation by author)

2.2. Acquisition of complex teacher knowledge

When analyzing cognitive learning processes of pre-service teachers, it matters what assumptions are already made so far about complex knowledge structures, as it gives insight into what kind and type of knowledge pre-service teachers are supposed to develop and acquire in best case. Cognitive psychology distinguishes between different types of knowledge and their mental representation in the cognitive structure (Helmke, 2012). Both aspects are addressed in the following two sub-sections. In the third sub-section, the outlines on complex teacher knowledge are summarized and related to the study context of teacher education.

2.2.1 Characterization of teacher knowledge

Alongside the definition of learning as knowledge acquisition goes the question of what are types of knowledge, that are essential for pre-service teachers to acquire. In this line, dimensions like the consciousness, the scientific nature, and beliefs are affected in cognitive research, and which also play a crucial role for teacher knowledge (Calderhead, 1987; Dochy & Alexander, 1995; Krause & Stark, 2006). The domain-specific character of teacher knowledge and its impact on teaching performance is targeted as another component by expertise research (Berliner et al., 1988; Chi, 2006).

A common classification in cognitive research distinguishes between declarative and procedural knowledge (Anderson, 1983). Declarative knowledge can be defined as knowledge about facts, objects, ideas, principles and concepts within one domain, sometimes shortly called *knowing that*. Procedural knowledge is related to actions or cognitive mechanisms that enable a person to accomplish a task or a procedure, and can be defined also as *knowing how* or as *competent performance*. The border between both types of knowledge is not always clear, and knowledge often involves declarative and procedural elements simultaneously. Teacher knowledge, in particular, includes interconnected declarative and procedural parts (Hiebert, Gallimore, & Stigler, 2002). For example, the fact, that a teacher needs knowledge about the concept of a "meaningful learning environment" and "the implementation of such an environment through goal oriented teaching", shows such linkages. Anderson' ACT model about human cognition (1983) builds on that interwovenness of knowledge types. The model includes declarative knowledge in terms of chunks, and procedural knowledge represented through production rules. Both types are necessary elements of knowledge acquisition processes and are assumed as interacting elements during knowledge deployment.

A similar distinction for the domain of teaching is made by Fenstermacher (1994), who introduced the terms of *formal* and *practical* knowledge. Formal knowledge includes discipline-based theories and concepts derived from bodies of coherent and systematic knowledge. According to Shulman's conceptualization (1986; 1987), subject matter knowledge, pedagogical content knowledge and general pedagogical knowledge are part of teachers' formal knowledge, as far as they are based on scientific reasoning and evidence. Commonly, formal knowledge is represented through propositions and can be described through semantical networks, which will be described in the next paragraph in detail. However, much of teacher knowledge comes also from experience in the classroom (Fenstermacher, 1994; Hiebert et al., 2002). This is considered as practical knowledge and refers to particular problems, decisions and actions embedded in a specific domain. Practical

knowledge can also be interpreted as teachers' performance; and although, it might be most of the time difficult to explicit it during teaching, its application is based on justification and warranty (Hiebert et al., 2002).

The current work focuses on formal knowledge, as university-based initial teacher education has a main function to support pre-service teachers in acquiring theoretical and conceptual knowledge. However, as video examples of classroom situations are used, pre-service teachers' practical knowledge about specific situations and cases is represented in some way too (see chapter 5ff.).

Consequently, this introduces another important type of teacher knowledge, the aspect of episodic knowledge, which is assumed to be highly context-related and organized around personal experiences (Schank & Abelson, 1977). This type of knowledge is needed to act in everyday teaching situations, and is defined as knowledge about "events occupying the mental life of ordinary individuals, which could be understood and expressed in ordinary language" (Schank & Abelson, 1977, p. 4). *Routines* are defined as one form of episodic knowledge relevant for teaching, which are additionally a variant of highly automatized procedural knowledge (Leinhardt & Greeno, 1986). According to Leinhardt & Greeno (1986, p. 76), routines of teachers are "a large repertoire of activities that they perform fluently" and are considered as "small, socially scripted pieces of behavior that are known by both teachers and students". Another variant of episodic knowledge is discussed under the aspect of *case knowledge* (Schön, 2002). Case knowledge covers techniques, strategies, expectations related to personal experiences, and is considered as highly important in the context of ill-structured situations like classrooms, which Schön (2002) describes as "professional inquiry". For example, if teachers realize misunderstandings in students' responses, knowledge about a similar case in the past can help to find a way to carefully solve their misunderstandings. If no suitable case can be retrieved, new solutions have to be carried out. Ideally, learning takes place, when the new case is accumulated into the set of familiar cases and can be used in the future for new and similar problem situations (see section 2.1).

Another knowledge phenomenon, which plays an essential role during pre-service teachers' learning and information processing, is known as *inert knowledge*. Inert knowledge refers to knowledge, which has already been acquired under certain conditions but cannot be used and applied in other situations (Whitehead, 1929). This knowledge form should not be mixed up with tacit or implicit knowledge, what implies that teachers are able to apply knowledge but cannot make it explicit and communicate it to others (Anderson, 2007). According to Renkl, Mandl, and Gruber (1996), explanations for the phenomenon of inert knowledge are

connected to learning processes during knowledge acquisition and can be classified along three types: One can be found in deficits of meta-cognition skills, for instance a lack of management skills. But also structural deficits of the knowledge base can be the reason, why knowledge remains inert, for example knowledge is not automatized and relevant knowledge facets are not connected to each other. A third explanation is related to the context of the situations, what means, if the context of learning differs from the context of knowledge application, the phenomenon of inert knowledge might probably occur. This is based on the fact that the retrieval of knowledge is easier in situations, which are similar to the situation during learning. This phenomenon often happens to pre-service teachers, as research indicates that they have difficulties in applying their theoretical knowledge learned in university in real classroom situations (Cochran-Smith, 2003). Instead, they tend to revert to intuitive theories and beliefs that rarely correspond with scientific knowledge (Calderhead, 1991; Lampert & Ball, 1998). According to Nespor (1987), teacher beliefs have a number of properties: (1) they can contain of assumptions about the existence of entities beyond teacher's control or influence; (2) they can include conceptualizations of ideal situations that differ from the real situation; (3) they may rely heavily on affective feelings and evaluative components; (4) they have a strong semantic structure and are associated with well-remembered personal experiences; (5) they are not open to outside evaluation or critical examination, and finally (6) specific beliefs are not domain-specific. Based on these features, pre-service teachers' beliefs have to be considered when analyzing their knowledge acquisition processes (Nespor, 1987). Especially in situations, where knowledge remains inert, beliefs are often used to deal with complex, ill-defined classroom events (Calderhead, 1991). Furthermore, beliefs might be also part of teachers' episodic knowledge, integrated in plans or strategies to successfully carry out a certain goal or to solve a problem in the classroom (Schön, 2002).

In this line, it should be considered that every type of teacher knowledge is domain- and situation-specific, as teachers' cognitions are connected to decisions and actions, which are situated in the moment and are related to a specific teaching domain (Berliner, 2004; Chi, 2006). Studies from Berliner and colleagues (1988) in the tradition of the expert-novice paradigm have verified these characteristics, as it was shown that the apparently effortless performance of experienced teachers is situation-specific and that experts do not have superior cognitive processes in general, rather gained much more domain-specific knowledge.

In sum, teacher knowledge includes various forms and taps diverse knowledge areas, which have to be developed and orchestrated in order to teach effectively (Eraut, 1994). Related to

pre-service teachers' learning in university-based teacher education, the development of formal (declarative/conceptual) knowledge acquired in diverse and situated contexts as well as the avoidance of inert knowledge are of particular importance. In this context, the following questions arise now: How is teachers' domain-specific declarative knowledge represented and what characterizes the specific declarative knowledge representation in a complex domain, such as generic teaching and learning components? The following section summarize the state-of-art in this field.

2.2.2 Characterization of teachers' complex knowledge representations

So far, relevant types of teacher knowledge have been targeted. Besides, it was outlined that the acquisition of declarative knowledge is in the focus of university-based teacher education. In order to provide a more detailed insight into the nature of pre-service teachers' declarative knowledge and find indicators for the analysis of their cognitive processes, assumptions about the structure of the mental representations are drawn.

In order to reconstruct pre-service teachers' development towards professional knowledge structures, models on knowledge representation (Mandl, Friedrich, & Hron, 1988), research focusing on the expert-novice paradigm (Boshuizen, Bromme, & Gruber, 2004) and its transfer to the teaching profession (Berliner, 2001) are considered to be helpful.

First of all, there is a general consensus that the representation of appropriate conceptual knowledge is not characterized as a basket of single facts, rather it is characterized by an integrated network of concepts (Aebli, 1988; Anderson, 2007; Mintzes, Wandersee, & Novak, 1997). Despite that, there is no coherent single cognitive theory on how knowledge is stored or represented in long-term memory. Secondly, studies on expertise in the domain of teaching have contributed to the analysis of professional knowledge structures as characteristics that seem to differentiate experts' and novices' knowledge representations have been provided (Berliner, 1987;1988; 2004). Besides, as expertise is recognized as a cognitive competence, research emphasizes the performance orientation and the use of suitable criteria for measuring expertise development (Sternberg & Frensch, 1992).

In this light, three knowledge representation models are presented, which are helpful for analyzing pre-service teachers' cognitive learning processes. S*emantic network models* deal with semantical features of related concepts, *schema theory* focuses on the structure or organization of related concepts, and the *theory of macrostructures* takes an even more global view about the organization of complex information and relates it to social interactions. Overall, they all show some kind of interrelatedness. The theoretical assumptions from the

knowledge representation models will be added by expertise-centered findings in the domain of teaching.

Semantic models of knowledge representations (Collins & Quillian, 1969; Kintsch, 1972; Quillian, 1968; Rumelhart, Lindsay, & Norman, 1972) suggest that the nature of knowledge can be best characterized through propositional representations of semantical features or information (Stracke, 2004). A proposition is defined through concepts, which include words and sentences. According to the semantical network approach, propositions express facts about relationships among elements or words, which can be true or false (Anderson, 2007). When learning takes place, propositions are added and integrated in semantical proposition networks (Mandl, Friedrich, & Hron, 1986). They are stored in semantic and/or in episodic memory, the two information processing systems in long-term memory.

Based on earlier semantic network models (Collins & Quillian, 1969; Quillian, 1968; Rumelhart et al., 1972), Klix (1976, 1984b) defines in his work concepts and their relationships, the so called "semantically links", more precisely. Based on experimental findings, the model proposes two different types of relationships about which is assumed, that their existence are indicators for the semantical complexity of the knowledge structure (Klix, Kukla, & Klein, 1976). These two types are defined as *intrarelated* and *interrelated concepts*.

An essential characteristic of concepts, which are *intrarelated*, is their somehow hierarchical structure as links between them are found through comparisons of properties between the concepts (comp. Collins and Quilian's model). Intrarelated links can consist of relations, which indicate similar or different properties of the linked concepts. For example, the superordinate-subordinate concept relation ("is part of" or "consist of") is the ability to answer the question, if concept A is a subordinate concept of concept B. This is the case, when concept A possesses all properties of concept B and also has properties above the similar properties. In contrast, intrarelated links regarding differences between two concepts are characterized through the fact, that the relevant properties cannot be compared immediately; instead properties have to be made firstly comparable through special procedures, in order to contrast them. The difficulty of this procedure depends on two aspects: numbers of necessary procedures and numbers of properties, which have to be proceeded (Van der Meer, 1984). In order to create an intrarelated link between two concepts, a specific kind of processing is necessary. Thereby, comparisons of similarities and differences indicate that cognitive processes have been activated.

According to Klix (1984a), *interrelated* links characterize relations between concepts, which are basically determined through time and space. Interrelated relations define concrete events or actions, or better relations between subjects, objects and activities. For example, water and swimming or teacher and teaching. Subsequently, comparisons of properties and the decision, if concepts are similar or different regarding their property, are not relevant within interrelated links. Interrelated relations are considered to be descendent from individuals' perceptual world and their experience. Therefore, knowledge about situations is much more individually biased than knowledge about properties. Furthermore, interrelated concepts are assumed to be stored fixed and being activated through search processes in long-term memory, instead of being produced through cognitive processes. These aspects are assumed to be one reason, why an expert chess player retrieves a situation on the chess board much faster (De Groot; 1965). The expert possesses amounts of interrelated concepts, which are activated through the perception of a chess board. In contrast, a novice player just recognize single chess pieces, as he has not developed interrelated concepts to notice a special constellation on the chess board. Hence, crucial for the activation of interrelated links is the steering of search processes and their detection.

Research found out, that interrelated links can be also characterized according to their *difficulty* to activate them (Klix, 1984a). One influencing factor is seen in the complexity of the interrelated relations. Depending on how much additional information is at least necessary to characterize the semantically relationship between the concepts, following interrelated relations can be separated:

One-place interrelated links do not need a further element to describe the property and are therefore, assumed to be the easiest one to be activated. To this category, *relations among an actor and an activity* without an object, like fish – swim; student – learn, belong. Furthermore, *location- relations*, which characterize a spatial relationship (e.g. deer – forest) are part of it.

Two-place interrelated links need one more element (actor or object) to being described properly and are therefore, more difficult to activate. Following types of relation are considered to be part of: *relations among an actor and an activity* with an object (e.g. horse – pull), *instrument-relation* (e.g. brush – paint), and *object-relation* (e.g. teaching – student).

The *finality-relation* (e.g. bet – win; clean – shine) is perceived as a *three-place interrelated link*, as three additional information, such as the actor, an objective and an activity, are necessary to describe the relationship. This kind of interrelated relation can be seen as most difficult. Experiments from Klix, Van der Meer, and Preuss (1984) confirmed that an

increasing number of additional information increased significantly the time to activate the interrelated concepts.

In sum, two types of semantical relations between concepts characterize according to Klix (1984a), how knowledge or information pieces are connected. Both, intra- as well as interrelated concepts consist of different complexity degrees, which are indicated by their creation or activation and have influences on cognitive processes. It can be assumed, that the complexity to develop intrarelated concepts is higher than for interrelated concepts (Van der Meer, 1984).

As already indicated, research on expertise in different domains refer to, and confirm these assumptions on how semantical knowledge is acquired and stored: Studies found out that knowledge structures from experts consist of a different nature, and are organized differently. In the domain of physics, Chi, Feltovich, and Glaser (1981) studied qualitative knowledge differences between experts (professors and advanced graduate students) and physics novices (college students), and the impact on their problem solving. The experts categorized problems on a deeper level according to major physics principles applicable in the problems' solution. In contrast, the novices tent to organize them according to salient objects and features in the concrete problem situation and therefore, according to surface characteristics. A related interpretation of these findings is characterized by the integratedness or hierarchical representation of expert knowledge, as the identified features are all related to each other in a meaningful way through the integration into higher-order principles (Chi, 2006). Patel and Arocha (2001) studied physicians' diagnostic knowledge represented in terms of hierarchy levels. Their physical observations were interpreted in terms of significant observations or findings on the lowest level, followed by facts – clusters of findings – on the intermediated level, and diagnoses on the highest level. Novices and experts physicians differed in the way that the novices missed the intermediate knowledge level and based their decisions on the findings level rather than on the facts level, like the experts did. The different reasoning chains in diagnosing reveal the integrated nature of experts' knowledge and pointing out that novices' knowledge representations are more like lattices than hierarchies (Chi, 2006). These results might be also transferable to the domain of teaching, as Schwindt (2008) found expertise differences between pre-service teachers and school inspectors in the classification of events observed in a classroom situation. Pre-service teachers mostly categorized the observed events on a surface level by not integrating them into higher order principles. School inspectors used to a great extent higher order principles to categorize their observations in their written protocols.

Referring to these findings, the semantic network approach seems to provide a suitable framework for analyzing how pre-service teachers' declarative knowledge is semantically organized, and where the proposed kinds of semantical links indicate the complexity of their knowledge structure. This is also related to the fact, that semantic network models deal with linguistic knowledge representations (Wender, 1988) and scientific language plays an essential part in the acquisition and development of declarative teacher knowledge. Besides, research in this tradition provides with the concept mapping tool also a promising way to elicit and study pre-service teachers' semantical knowledge structure.

Concept maps are considered as external representations of how central concepts in one subject area are mentally organized and linked to each other by learners (Renkl & Nückles, 2006). Joseph D. Novak, foundational for the development of the concept mapping technique, defines a concept map as followed: *"A concept map is a schematic device for representing a set of concept meanings embedded in a framework of propositions"* (Novak & Gowin, 1984, p. 15).

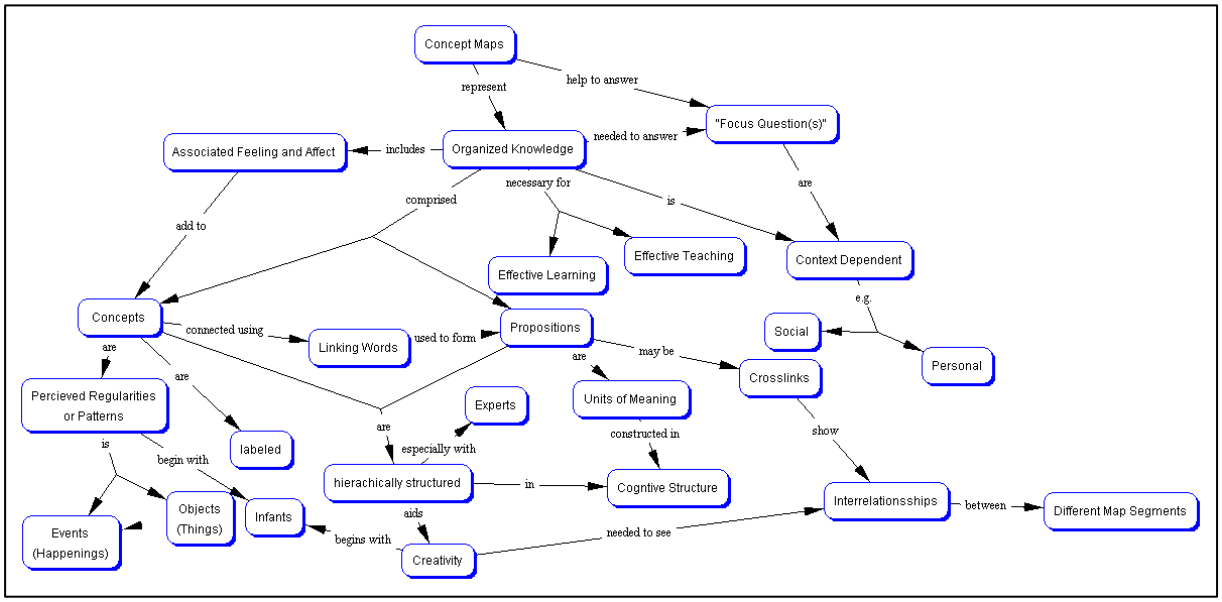


Figure 2. Example of a concept map (adapted from Novak & Cañas, 2008).

As figure 2 illustrate, a concept map includes *nodes* representing concepts, linking lines between nodes representing *relations*, and *labels on the lines* that specify the relationship between nodes. The linkage of two nodes through a labeled line is called a *proposition*. A proposition is the smallest unit within a concept map that can be used to judge the relevance and correctness of the relation drawn between two concepts. Concept maps, thus, are associated to elicit learner's understanding of a knowledge domain. These definitions show

that the theoretical roots of concept mapping lie in semantical models of knowledge representations.

Originally, concept maps were developed in the course of Novak's and his colleagues work on investigating and fostering children's knowledge of science, grounding in Ausubel's theory of meaningful learning, proponing a hierarchical cognitive knowledge structure. This position is in congruence with the earliest semantical model (Collins & Quillian, 1969; Quillian, 1968). The hierarchical structure arises as "new information often is related to and subsumable under more general, more inclusive concepts" (Novak & Gowin, 1984, p. 97). Thereby, an increase of meaning is defined as learners recognizing new links between propositions at the same hierarchy level, because these *cross-links* connect different subdomains of the knowledge structure (Novak & Cañas, 2008).

As the view on the cognitive structure changed towards a semantic network of concepts linked by labeled lines over time (Klix, 1984a; Rumelhart et al., 1972), concept maps can have a hierarchical structure with one main concept at the top, but not necessarily. Based on semantical network approaches and related to Ruiz-Primo and Shavelson (1996, p. 572), then, "(a) concept maps are networks with concept nodes linked directionally by labeled lines (arrows) to produce propositions, (b) the lines between the nodes represent various relations, (c) any number of lines may connect two nodes, and (d) the network may divide nodes into subsets and indicate the link (crosslink) between these subsets".

Schema theories

Approaches, which build on semantic network models and provide a description of knowledge representation in terms of a more relational organization of concepts, refer to *schema* (Mandl et al., 1986). In the context of knowledge acquisition, schemata can be characterized as prerequisites or as results of knowledge acquisition processes, both are very closely related to each other (Mandl et al., 1986). A schema is defined as an organized network of elements, which represents an area of interest and includes information about relations to other schemata. Knowledge about frequently common and standardized situations or sequences of actions, for example the knowledge underlying of what happens during homework-control, is also represented through a schema. This kind of schemata is called *skript* (Schank & Abelson, 1977).

Schemata can be interrelated and hierarchical organized: Low level schemata can be integrated in higher level schemata, as for example the schemata of a "steering wheel" and of "wheels" can be part integrated into the higher level schema "car". Through the combination

of low level schemas and the integration into high level schemas, skilled information-processing can take place for example. Sweller and colleagues (1998, p. 255) explain this phenomenon within the domain of reading:

> "In early school years, children construct schemas for letters that allow them to classify an infinite variety of shapes (as occurs in hand writing) into very limited number of categories. These schemas provide the elements for higher order schemas when they are combined into words that in turn can be combined into phrases, and so forth. Ultimately this process allows readers to rapidly scan a page filled with hugely complex array of squiggles and derive meaning from it".

Thus, schemata are not only assumed to provide a mechanism to store and organize knowledge in long-term memory, but also to help to reduce working load in working memory (Sweller et al., 1998). Due to the fact that there are limits on the number of elements what working memory can process, but not on the complexity of each element, huge amounts of knowledge organized in one schema can be retrieved effortless (see section 2.1). Therefore, schemata are often addressed in research on learning and knowledge acquisition, especially in models of data-driven and schema-driven information processes (Mandl, et al, 1988). As it is assumed that new information is perceived and being up taken based on specific schemata (bottom up process), one function of schemata is their steering of attention on schema-related or schema-unrelated information. This in turn, determines how the information is processed further (top down process), which relates to Piaget's (1976) understanding of how cognitive structures develop. When new information is incorporated within an existing schema, assimilation takes places. The existing schema provides a frame, in which the new information can be integrated, what in turn, fosters the understanding of the new information (Kopp & Mandl, 2006). When new information is perceived, which does not fit a schema, accommodating is necessary. Accommodation is being interpreted as creating a new schema that will fit better with the new information, or modifying the prior schema according to the new information. Hereby, it is proposed that the reorganization of higher level schemata is more difficult than the reorganization of a lower level schema, as all schemas below have to be changed as well (Sweller et al., 1998).

Nevertheless, with the advantages of such schemas as prerequisites for knowledge acquisition come disadvantages which should not been underestimated, as schema also can restrict and distort information or causes that crucial information is overlooked. This is especially the case with schema based on personal experience (case knowledge), what is a relevant issue for teacher education as pre-service teachers enter university-based teacher education with many personal experiences as students (Kagan, 1992).

Several studies in the tradition of the expert-novice paradigm suggest, that knowledge organization around specific schemata explains differences in experts and novices' thoughts and actions (Chi, 2006, Feltovich, Prietula, & Ericsson, 2006, Ropo, 2004). In the domain of teaching, Berliner and his colleagues conducted in this line various studies with three different expertise groups (e.g. Carter et al., 1988). Expert teachers were chosen by nomination after classroom observation, novice teachers were first year teachers, and the group of postulants were individuals with subject matter knowledge but without knowledge in pedagogy. Data were obtained by showing the different groups slides of classroom scenes and asking them to discern and interpret relevant events. Findings revealed that experts have schematically organized knowledge categories, which guided their viewing. Through this well-developed knowledge structure, they were able to monitor both visual and auditory cues and seemed less confused; thus, were also better able to interpret the noticed classroom events. They did not only make more comments on what was happening, but their comments were more detailed and included conclusions, evaluations and suggestions about the classroom phenomena. Furthermore, the expert teachers attended towards instructional significant aspects (e.g. teaching/learning activity) and did not turned towards literal characteristics and static features of the shown classroom situation, which indicate their ability to distinguish between important and unimportant aspects. By contrast, novices and postulant teachers, even more, do not have developed complex and connected knowledge structures, what in turn affected their ability to process relevant information. For example, both groups showed difficulties in making sense of the shown classroom slides, indicated by contradictory statements about what was happening within the classroom. Besides, novices and postulants seemed to show no particular pattern in what they noticed. But especially physical objects, like classroom equipment or desks, as well as instruction-irrelevant information, like postures and gestures, attracted their attention. Overall, the findings from the Berliner group contribute to the assumption that knowledge organization around specific schemata explains differences in expert teachers and novices' thoughts and actions.

The relationship between teachers' integrated knowledge representation in terms of schemata and their teaching as a "complex cognitive skill" within the teaching domain was investigated by Leinhardt and Greeno (1986). Within their study, they analyzed a small group of expert and novice teachers' teaching mainly under the aspect of their teaching agenda or lesson plan. For this purpose, they used observation protocols, videotapes and stimulated recall interviews as instruments. According to Leinhardt and Greeno (1986), teaching can be compared with solving an ill-structured problem where the task environment can change constantly. Within

this ill-structured problem situation, they argue that expert teachers' actions are organized around a set of schemata with differing levels (e.g. global/content-non-specific and local/content-specific schemata), which help them to structure incoming information and to reduce complexity in the classroom. As expert teachers have a large repertoire of such schemata, their actions became routinized, which allow them to teach more effectively and efficiently. Furthermore, expert teachers do not only conduct these schemata but also seek and take care of situation-specific information, which become incorporated in their schemata for similar future activities. These assumptions could be verified through their findings. Experts' lessons were structured around core activities (e.g. presentation), which were usually quite short as they were able to save time through a repertoire of many routines that can be applied flexibly to new situations. Because the novice teachers have not gained routines, their activities within one lesson and over lessons changed constantly, and they were not able to focus all the time on reaching their goals. This study underpins that schematically organized teaching knowledge, in terms of applying routines to ill-structured classroom situations, is an indicator of teaching expertise.

The findings on knowledge differences between experts and novices make the relevance for analyzing pre-service teachers' knowledge representation in terms of schemata obvious and provide thus, a second important theoretical basis.

Theory of macrostructures

A further related, but still different concept within research on knowledge representation, has been introduced by Van Dijk (1980) in his *theory of macrostructures*. His theory incorporates research from cognitive psychology and other disciplines of humanities and social sciences, such as linguistic and sociology. More specifically, this conceptualization integrates aspects from the above presented understanding of knowledge representation and discusses them in the context of information processing in complex social interactions. *Macrostructures* are defined as "higher level semantic or conceptual structures that organize the 'local' microstructures of discourse, interaction and their cognitive processing" (Van Dijk, 1980, p. V). The difference between macrostructures and schema is pointed out as followed: "It appears that they [schema] are important in the formation or comprehension of macrostructures, but it should be emphasized here that they should not be confused with macrostructures, which are higher-level structures in processing and representation" (Van Dijk, 1980, p. VII). The basic idea of macrostructures is that complex information (*microstructures*), which is involved in discourses and social interactions has to be organized

and reduced through the construction of higher level and global structures (*macro-operators)*. Within a particular social discourse situation, the organizing macrostructures may then not only consist of knowledge, but also of beliefs, tasks, purposes or attitudes and so forth. These factors are summarized by Van Dijk (1980) as *cognitive set*, what implies that people with different cognitive sets create different macrostructures to reduce complexity in social discourses. Another concept, introduced by the author, is related to *superstructure* which organizes and orders the global content (macrostructures) schematically and thus, characterizes a specific discourse genre or type of knowledge domain.

Once more, expertise research contributes to the assumptions that macro-operators have to be developed in order to retrieve, process and apply knowledge efficiently and effectively to various situations of the domain (e.g. Feltovich et al., 2006; SEEK-Modell from Holding, 1985). The need of such problem solving and organizing operators during teaching were observed by Livingston and Borko (1989), called "improvisational performance". Their cognitive analysis of teaching of novice and expert teachers showed again that expert teachers have more elaborated and accessible macro-operators than novice teachers, which help them to flexibly accomplish the different teaching activities. For example, the three participating expert teachers were able to follow their lesson structure, while also being open to new input (e.g. from students). When there was an unexpected problem, they were able to flexibly adapt to them and getting back on the track. These interactive teaching skills were not visible in novice teachers' classrooms.

In sum, the theory of macrostructures provides a third suitable theoretical basis for analyzing cognitive representations required to master complex teaching situations, even if less empirical work is available, so far. As teacher knowledge is situated and related to complex social interactions with students, pre-service teachers have to develop macro- and superstructures which may help them to reduce complexity and to organize dynamic teaching actions. Especially for future teaching situations which are companied with stress, e.g. expectations from students, the use of such macrostructure processes is important (Wahl, 1991).

2.2.3 External representation of pre-service teachers' knowledge

This section aims to synthesize and transfer the presented theoretical assumptions and findings on complex teacher knowledge to teacher education. The outline include following two aspects, which are relevant for the current study:

- Relevance of expertise research to study the development towards complex teacher knowledge
- Relevant components in the analysis of complex knowledge representation

Relevance of expertise research to study the development towards complex teacher knowledge

A popular and helpful research strategy in describing the development of complex teacher knowledge, as outlined, refers to the identification of typical differences between experts and novices in quasi-experimental experts-novice comparisons or through the comparison of quasi-longitudinal sample groups, for example postulants with pre-service teachers and expert teachers (Berliner, 1987; Bromme, 1992; Gruber, 1994; Gruber, 1998). Hereby, the tasks measuring expertise vary and in turn, expertise differences are found. Over all studies, it can be summarized that complex teachers' knowledge is domain-specific and closely related to teaching performance. Furthermore, it is organized through networks with higher-order groupings and meaningful, complex relations among. In addition, it is combined with cognitive search and control processes. The development of an organized knowledge representation can be achieved through a stepwise linkage of fundamental propositions related to that network, and through integrating low level concepts into high level concepts. These complex knowledge characteristics allow teachers a fast recognition of meaningful patterns through immediate and integrated access to relevant knowledge, a flexible adaptation to the demands of the current situation, and an efficient problem solution.

These summarized characteristics imply that pre-service teachers' acquisition of expert-like knowledge structures needs time to develop and includes different qualitative stages, which can be supported by individual cognitive learning activities and learning opportunities in teacher education. This is in line with Berliner's (2004) proposed five stage model of teacher competence development, which builds on the work from Dreyfus and Dreyfus (1986).

Relevant components in the analysis of complex knowledge representation

So far, research, analyzing teachers' conceptual knowledge, predominantly studied the nature of teachers' knowledge representation in terms of specific schemata and refers to schema theories, when explaining experts and novices' thoughts and actions. This is in line with

assumptions that the organization of available small pieces of information into larger and more integrated cognitive units indicates the size and extent of teacher knowledge. Nevertheless, concerns about the rather general and vague character of schema theories and the hardly falsifiable impact of schema have been raised (Mandl et al., 1988). Specifically, research in this tradition often make inferential leaps from teachers' performances to their cognition and give no detailed insight on how concepts of the domain are related to each other, and how information is structured to reduce complexity.

Therefore, it seems promising to use criteria and indicators from diverse cognitive approaches to study pre-service teachers' cognitive processes. In the context of the present work, the integration of higher order principles and concepts is used as one indicator for the complexity of pre-service teachers' knowledge structure in Study 1. Additionally, in Study 2, this indicator is combined with the analysis of semantical relationships based on Klix' semantic network approach and the investigation of pre-service teachers' macrostructure and superstructure based on the outlined theory on macrostructures (Van Dijk, 1980). Hereby, concept maps are regarded as useful to make different cognitive components explicit.

2.3 Cognitive learning activities during information processing

In the previous section, the characterization of complex knowledge structure was in the focus. In this context, it can be asked, what are supporting processes during knowledge acquisition phases in teacher education to develop integrated and complex teacher knowledge.

Research on cognitive learning processes or activities are closely related in this context to the *approach* of *cognitive learning strategies*, which analyzes the effectiveness of cognitive learning activities during information processing (Biggs, 1993; Mandl & Friedrich, 1992; Weinstein & Mayer, 1986). The word *strategy* implies goal-oriented actions and behaviors in order to achieve a specific aim, in this case meaningful learning (Weinstein & Mayer, 1986). Originally, most of the research has been conducted in the field of text comprehension by analyzing the occurring cognitive information processes (Van Dijk & Kintsch, 1983). Over time, these cognitive processes became in general prominent for comprehension and knowledge acquisition processes and strategies (Ballstaedt, 2006; Weinstein & Mayer, 1986). Thus, there are also studies now, which successfully transferred the approach of deep-level processing to the use of oral language and its comprehension in classrooms (Hugener, 2008; Lehtinen, 1992; Seidel, 2003). Although, most of the empirical findings, so far, relate to the model of information processing (e.g. Pintrich, Smith, Garcia, & McKeachie, 1993; Weinstein & Mayer, 1986), there is also a second theoretical tradition in research on learning

strategies (Biggs, 1993). The "approaches-to-learning" include more context-oriented work and are more of qualitative nature, and have contributed to the analysis of deep level processing (Entwistle & Entwistle, 1991; Marton & Säljö, 1976a; Marton & Säljö, 1976b).

According to Weinstein and Mayer (1986), cognitive learning strategies are defined as behaviors, which are intentionally activated by the learner, to manage and control all phases of information processing (see section 2.1). Research in this tradition distinguishes learning strategies related to surface- and deep-level-processing (Craik & Lockhart, 1972; Marton & R. Säljö, 1976a; Wild, 2000). On a surface-level, the learner processes the learning material in a way that is rather similar to the presented form and replicates only the new information, without integrating or transforming them. For example, applying rehearsal strategies is considered as surface level processing, where oral repetition, underlining or copying are examples for such strategies.

In contrast, deep-level processes are related to meaningful cognitive activities, as the learners try to reach a deep understanding for the learning material by understanding the intentional content of the learning material. Deep level processes integrate according to Steiner (2001) three pairs of activities: a) *composing and decomposing*; b) *condensing and unfolding*; c) *structuring and restructuring*. Rumelhart and Norman (1978) describe deep level processes of *accretion*, *tuning* and *restructuring* as necessity for integrated knowledge acquisition. *Chunking* as the summarization or compression of small information pieces to higher level concepts and schema as described above is also interpreted as a deep-level process (Chase & Simon, 1973). It is obvious that cognitive research does not use the same terms for deep level processes, nevertheless they agree that one specific deep-level activity is not only related to one specific information process (e.g. information encoding); instead they influence all phases (Weinstein & Mayer, 1986). In sum, all researchers emphasize elaboration and reduction or organization processes as being central to knowledge acquisition and problem-solving (Mandl et al., 1986; Van Dijk & Kintsch, 1983). Elaboration processes are assumed to foster the assimilation or accommodation of knowledge. Organization processes are considered to help condensing and organizing the new cognitive structures. As both deep-level processes are essential for pre-service teachers' learning, I will refer to them more detailed in the following sections.

2.3.1 Elaboration processes

The major goal of elaboration processes is relating new information to prior knowledge, what can be understood as transferring knowledge from long-term memory to working memory and to select and integrate new information to the existing knowledge base (Friedrich & Mandl, 2006). Mandl and colleagues (1986) distinguish between two different types of elaboration processes or strategies: *necessary elaboration strategies* and *facultative elaboration strategies*.

Necessary elaborations relate to the activation of prior knowledge in order to select and understand new information. This elaboration process becomes especially important in complex problem situations, where much information has to be processed and the understanding for the presented information is not that easy as in everyday life situations. For (pre-service) teachers, necessary elaboration processes can be very helpful, as they often have not gained scientific correct knowledge (Kagan, 1992) and show difficulties when entering the complex classroom life after teacher education. *Facultative elaborations* go beyond the necessary elaborations strategies, as new information is processed on a broader knowledge base and integrated in several ways into the existing knowledge structure. Comparisons with personal experiences or critical questions are examples for facultative elaboration strategies.

(Experimental) studies in the field of text comprehension have revealed a significant impact of (the quality of) elaboration on information processing (e.g. Schiefele, 1996). It could be shown that a group with more prior knowledge in the relevant domain was firstly, better in remembering and retrieving information from the text and secondly, used more elaboration strategies than the group with sparse prior knowledge (Bobrow & Bower, 1969). It was also investigated that students with better prior knowledge focused on specific presented features and used more sophisticated elaboration strategies (Bransford, Stein, Shelton, & Owings, 1980). Findings from expert-novice comparison in the field of teaching suggest that pre-service teachers might not generate elaboration that easy as teachers with years of experience, indicated by remembering less and different information. In a study from Carters, Sabers, Cushing, Pinnegar and Berliner (1987), expert and novice teachers participated in a simulated teaching task in which they were given extensive information about a class which they should take over. One task included the recall of information about students. The analysis showed that novices (like pre-service teachers) were less discriminating in the types of information, they remembered in comparison to expert teachers, as they believed they should have remembered all of the information presented. Besides, novices found different information more obvious and helpful than experts, e.g. they remembered more individual information

about one specific student, whereas expert attended more to information about the class as a whole.

Overall, empirical findings reveal that elaboration strategies facilitate the understanding of the new learning but also the later retrieval:

> "The depth of processing and its elaboration are important because deeper, more elaborate processes leave more traces that can later be recovered. Variable encoding leaves traces that can be matched by more retrieval cues. Thus, the nature of the encoding processes makes a great deal of difference of how well some experience will be recalls later: Elaborate, semantic, meaningful encoding and the embedding of experiences in a rich, accessible matrix ensure memorability" (Van Dijk & Kintsch, 1983, p. 335).

Thus, elaboration determines the kind of information being processed in working memory, as it influences the selection process through attention allocation (Brünken & Seufert, 2006; Krause & Stark, 2006). Through the activation of prior knowledge, relevant information can be distinguished from irrelevant information and new information from already known information, which facilitates the transfer of only relevant information to working memory. This underlines the importance of elaboration for developing a complex knowledge base; nevertheless, elaboration strategies are often not well enough applied (Mandl et al., 1986), and pre-service teachers often consider them as minor important (Oosterheert & Vermunt, 2001). However, it was also shown that students are able to adapt and develop their learning strategies during higher education (Vermetten, Vermunt & Lodewijks, 1999). Hereby, (self-) questioning (Diekhoff, Brown, & Dansereau, 1982) and using vivid imaginations (Kulhavy & Swenson, 1975) have be shown in experimental studies as well as in field studies (e.g. Glogger, Holzäpfel, Schwonke, Nückles, & Renkl, 2009; Nückles, Hübner, & Renkl, 2009) as successful strategies to support elaboration processes.

2.3.2 Organization processes

Beside elaboration processes, necessary to extend and modify existing knowledge, learners also have to reduce and structure the amount of incoming information in order to understand and memorize relevant information (Mandl et al., 1986; Vermunt & Verloop, 1999). In this context, research underlines the importance of organization processes. It could be shown that people, structuring incoming information according to specific categories, remember them better (e.g. Bousfield, 1953). This classification phenomenon is known as "clustering" and helpful due to limited capacity of working memory. Organization processes become even more obvious within complex learning situations, such as learning from a textbook or taking

part in a lecture, where much information is presented (Mandl et al., 1986; Anderson, 2007). Mandl and his colleagues (1986) refer to the importance of macro-operators, proposed by Van Dijk (1980), to organize complex information (see section 2.2.2). An analysis of research literature on cognitive processing activities showed that researchers used different expressions for these macro-operators and applied it to different fields (e.g. Dörner (1976) on complex problem solving; Ballstaedt (2006) on text summarization; Vermund & Verlopp (1999) on student learning in school). However, the processes, which are necessary to organize and structure complex information, are always the same (Vermunt & Verloop, 1999). Overall, supportive macro-operators refer to the processes of *omission and selection of information* and *abstraction and construction*.

Omission and selection of information

Central prerequisites for every kind of knowledge organization is the awareness towards main ideas of the presented material and to select such information, and in turn, to omit irrelevant information. These macro-operators are also known as copy-delete-strategy, which has with an appropriate use a significant impact on the later retrieval of the main ideas (Ballstaedt, 2006). According to Ballstaedt (2006), the awareness towards relevant information is biased by prior-knowledge and experience and can thus, be diverging from the main ideas seen by the presenter or author of the learning material.

Abstraction and construction

These kinds of macro-operators go beyond the learning material and are therefore, more complex than the omission and selection of information (Ballstaedt, 2006). Abstraction is defined as bringing together single information pieces into an organized whole, trying to impose structure, and integrating new information into already known ones. Examples of "abstraction" activities are, that learners think about analogies, examine similarities and differences, and compare the presented information with knowledge they already have acquired (Klix, 1984a; Vermunt & Verloop, 1999).

The procedure of construction takes place when information is seen as relevant, but sub-ordinate to a more general concept and is therefore, being omitted on the sub-ordinate level, but still integrated in the super-ordinate concept. Examples of "construction" activities are that learners bring the main concepts of a presented material and their interrelations into a clearly arranged scheme, try to form an overview of the topic, and order super-ordinate principles or themes to this topic (Klix, 1984a; Vermunt & Verloop, 1999).

Furthermore, the macro-operators of abstraction and construction relate to two organization processes, a *structure-related* and a *content-related* one (Ballstaedt, 2006).

The first organization process drives the way how the selected information is organized in relation to the structure of the presented material. For example, organizing it more on the surface (the material per se indicated by details) or on the intentional content (underlying meaning indicated by main principles and facts). This refers to Van Dijk's (1980) concept of superstructure. It could be shown that the acquaintance to the way how complex information is presented is an influencing factor to the organizing operators of abstraction and construction, and thus, on the later retrieval (e.g. Glynn & Di Vesta, 1977; Lorch & Lorch, 1985). Studies on text comprehension have found that people, who were not familiar with the presented text structure (e.g. cultural reasons), showed less informative summarizations of the text than the other, more familiar group (Kintsch & Greene, 1978). Identification of the current text structure provided the better solving group with the appropriate information needed for organizing the content and integrating relevant propositions. Furthermore, it can be assumed that a certain way of information presentation may affect the organization processes of individuals differently. For example, Schnotz (1982) studied the interaction between prior knowledge and different types of text organization, and found interaction effects.

This leads to the second, content-related organization process, which includes prior knowledge in the field of the presented material and gets activated through the presented learning material.

From the perspective of supportive aids on the application of organization activities, research on teaching and learning in school suggests instructional activities such as "presenting an outline", "providing examples" and "highlighting main points" (Vermunt & Verloop, 1999). The presentation of analogies is seen as a further aid for the organization activity of "abstraction". Also written or oral summarizations of the learning content are known to be helpful for organization processes (Steiner, 2001). Another impact on the organization of incoming information is seen in the modality of presentation (e.g. visually through written text or video, auditory through listening to a lecture). Studies from Mousavi, Low and Sweller (1995) showed that a mixed-mode presentation of visual and aural information on geometry worked examples, rather than a single mode, increased students' learning. This was explained that working memory capacity was increased by having an auditory system organizing incoming language information, and a visual system handling visual presented information. Consequently, complex information that may be difficult to process purely through one

system (e.g. visual or system) may be easier to handle, if it can be organized partially by both systems.

However, the empirical findings are mostly from experimental designs and school settings and might be thus, not transferable to the setting of teacher education. Hence, it seems promising to study pre-service teachers' organization processes in a learning setting, which combines different presentation forms. Nevertheless, these studies provide promising hints, how to support organization processes efficiently and effectively. In this line, the use of different kinds of representations of the learning material is assumed to address the needs of many pre-service teachers, and also may help to increase the amount of information processed by working memory. Furthermore, the better information is structured and presented according to the main concepts of the learning material, the better new information can be organized and integrated in the existing knowledge structure (Ballstaedt, 2006).

2.3.3 Assessment of cognitive learning activities

As learners have to be actively engaged in cognitive learning processes to foster meaningful learning (Weinstein & Mayer, 1986, Steiner, 2001), it can be assumed that their engagement affects learning outcomes in terms of integrated knowledge structure and successful problem-solving. The theoretical assumption that deep-level cognitive learning strategies (in this case elaboration and organization strategies) mediate learning processes and thus, effect learning positively, have been replicated in experimental research studies (Willoughby & Wood, 1994) and also in field studies. For example, Kardash & Amlund (1991) explored learning strategies which university students used to process information from course-related material, and analyzed their effects on learning from expository text. Participating students filled out the questionnaire on learning strategies directly after they studied the expository text material. Factor analysis revealed two types of cognitive learning processes during their information-processing. Covert cognitive processes included internal elaboration and organization and strategies, like summarization, contrasting, and combination of information to be learned. Overt cognitive processes included observable encoding strategies, like writing a list, making charts or diagrams, underlining or copying main ideas. The covert cognitive processes predicted the recall of two expository passages and were related to students' achievement as measured by grade in an academic test, whereas the overt cognitive processes did not. This highlights the importance of covert "inside the head" cognitive strategies for learning.

Another study from Alexander, Murphy, Woods, Duhon, & Parker (1997) examined changes that occurred in pre-service teachers' use of learning strategies together with their domain

knowledge and interest over the course of one term of formal instruction in educational psychology. The learning outcome was measured through a domain-related recall task. Their learning strategies were assessed through a questionnaire, whithin pre-service teachers have been told to write down what kind of learning strategies they used during their reading, or immediately following their reading task of the domain-related text passages. Results indicated that beside knowledge and interest, the use of learning strategies developed positively. For example, pre-service teachers' used at the beginning more surface cognitive processes (e.g. re-reading) and in the end more deep cognitive processes (e.g. determining the main ideas). Furthermore, the strategy use was a significant predictor for their domain-related learning, and pre-service teacher's learning activities were significantly impacted by their interest and knowledge of the domain. Alexander et al. (1997) see these results also as a confirmation that (research on) academic learning and development has to consider the domain-specific perspective.

However, there are also field studies reporting different results, as Artelt (2000a) pointed out in her work. Reasons for the diverging findings are seen in the methods used for assessing learning strategies (Artelt, 2000b; Wild, 2000). In most of the studies, questionnaires are used due to the fact that the implementation for bigger sample sizes is much less time consuming than interview studies, for example. However, they are considered to be abstract and to measure more learning styles or dispositions than learning processes (Krapp, 1993). Within questionnaires, learners have to release their learning strategies from a concrete situation to estimate their learning behavior or process. This requires elaborated abstraction and reflection skills, which is highly challenging – not only for novices – and thus, may contribute to contradictions between self-assessment and the task-specific strategy use (Lind & Sandmann, 2003). Studies in school and university settings, using self-assessments through questionnaires, showed therefore, less positive and significant relationships between cognitive learning strategies and learning/knowledge acquisition than studies assessing cognitive learning strategies in concrete learning situations (Baumert, 1993; Blickle, 1996; Lehtinen, 1992; Marton & Säljö, 1976a; Marton & Säljö, 1976b; Pintrich & Garcia, 1994; Schiefele, Wild, & Winteler, 1995). Findings from the diverse studies underpin the importance of measuring deep learning processes in relation to a concrete learning task and to take a domain-specific perspective into account.

The dissonance between strategy use in a real learning task and the self-assessment within questionnaires was prominently addressed by Artelt (2000a). She came to the conclusion that self-assessment of learning strategy use via questionnaire has limitations in validity and is

influenced by many constructs, such as self-concept, knowledge about learning strategies, social desirability and so on. To similar conclusions came Lind and Sandmann (2003), who compared the strategy use of students with different knowledge in the domains of physics and biology during (think-a-loud protocol) and out of a concrete learning situation (self-assessment with a questionnaire). A significant correlation was found between the learning strategy use in the learning situation and the learning outcome (problem solving task), but not for the self-assessed learning strategy use and the learning outcome. Furthermore, students overestimated their learning strategies during self-assessment. Another interesting result was that students' knowledge determined their use of learning strategies. Expert students applied more strategies which foster a deeper understanding of the learning material, whereas novice students used mostly weak content-related strategies.

Another critical aspect using self-assessment through questionnaires is addressed by Leopold and Leutner (2002), who report that questionnaires do not take the quality of students' learning strategy use into account. Questions are tapping, if and how often a certain strategy is used (e.g. self-questioning); however they do not include information on how well a learner is able to apply this strategy in a real task. Against this backdrop, the authors developed a questionnaire with whom the quality of the two deep learning strategies "finding relationships between concepts" and "generating images of the learning content" was assessed by integrating content-related strategy items. These items indicated, if students really think about relevant concepts or, if they just use domain-irrelevant information. Results revealed differences between students from lower and higher grades regarding the quality of their strategy use, which underlines that also the quality, and not only the use of deep learning strategies counts for learning. However, the authors did not assess the quality for all learning strategies within the questionnaire.

In sum, studies assessing learning strategies in a specific and concrete situation showed higher correlations between strategy use and learning outcome than studies using questionnaires as a self-assessment tool.

In the following, I will present studies using a more contextualized way of assessment, especially as my work is doing so as well. These studies base predominantly on qualitative work, such as interviews and observations. Another issue, which is better analyzed within the qualitative work, relates to descriptions of the quality regarding learning strategy use and learning outcome. Whereas in quantitative studies the learning outcome is commonly described in "how much is learned", the question of "what is learned" cannot be answered

properly. However, this is seen as even more essential for the understanding of "what it takes to learn", as Marton and Säljö (1976a, p. 4) pointed out.

In two prominent qualitative experimental studies, Marton and Säljö (1976a, 1976b) investigated qualitative differences in cognitive learning processes and learning outcomes from Swedish university students. In the first study, students had to read passages of prose and received questions, which allowed the identification of learning processes and outcome related to the content of the learning material. It was found that the students showed different ways of understanding the intentional content or the author's argument, which were categorized along four qualitative different levels of outcome. Corresponding differences were also found on the level of information processes according to deep-level and surface-level processing. These results show that learning takes place in various ways, indicated for example by the diverse ways in which the same material was processed and comprehended. In their conclusion, Marton and Säljö (1976a) highlight therefore, the importance to describe the learning content in order to understand learning and knowledge acquisition. Based on the results of their second study, Marton and Saljö (1976b) define the learning outcome also as a function of the learners' conception of the task. These results are in line with quantitative findings on the impact of the assessment tool on the level of students' processing (e.g. Souvignier & Gold, 2004). It has to be critically added, however, that despite the fact that the assessment was very close to the task, it shows strictly speaking also some kind of retrospectively self-assessment.

Another study, which assessed qualitative differences between good and poor students on their use of five different learning strategies during a lesson in the context of two concrete learning situations, was done by Lehtinen (1992). This study is even more special, as it is one of the few studies which analyzed cognitive learning processes in the context of language comprehension. Beside, video was used as one assessment method for students' learning strategies. A lesson was videotaped and individually shown to students who have not participated in this lesson before. At specific passages, the video was stopped and the student should comprehend the statements of the teacher based on questions, the researcher asked. Within the other assessment condition, the lesson took part in a language laboratory. Every student was equipped with headphones and a microphone in order to assess their comments. The lesson was also stopped at specific points, where the researcher asked the same questions as in the video assessment. Afterwards, the teacher continued until the next break. Both methods resulted in similar findings: The use of cognitive learning strategies indicated by students' answers to the questions had impact on students' learning outcome indicated by

their grades. Students with high grades used more deep-level strategies, such as prior knowledge activation or reduction and abstraction of information, than students with low grades. However, there were exceptions to that rule, as also "good" students used overall more surface-level strategies. This shows that non-specific criteria, as an indicator for learning outcome, do not necessarily say something about the quality of the occurred learning process. Furthermore, it can be assumed that external factors, such as the learning environment or teachers' instruction, are not always able to support "good" students' deep-level processing when the students themselves are not willing to engage in a deeper understanding of the content of the lesson.

Summarizing, qualitative research on the effectiveness of learning strategies reveals positive impacts on the learning outcome. Good learners or problem solvers can be distinguished from poor learners or problem solvers with regard to the quality of strategies they use, and in turn, also with regard to their learning outcome. Overall, the numbers of studies, which analyze learning strategies within a concrete learning situation, are fewer than studies using questionnaires; even if they are recommended by research. This is might be caused by the fact that it is methodologically more challenging and time consuming to implement contextualized studies. Nevertheless, a reconstruction of the learning process is still visible, as all studies use some kind of retrospective self-assessment tools (Artelt, 2000a). Furthermore, it has to be mentioned that these studies are related to school students and are not the latest ones.

Against this backdrop, it seems promising to explore a new assessment approach in the context of pre-service teacher education, which is characterized through 1) a close temporal and contextual connection to the learning situation; 2) a well-defined description of the structure of the learning material and the learning conditions; 3) the assessment of learning processes in "action"; and 4) the use of dynamic, but not too complex problem situations. All these aspects are according to Wirth (2005) essential to receive reliable and valid results when assessing learning processes.

Summarization of the first theoretical paragraph

The present work investigates pre-service teachers' cognitive learning activities during information processing when learning about general teaching and learning components in university-based teacher education. In this chapter on "learning, knowledge and information processing", it was outlined that the deep-level cognitive processes of elaboration and organization are important for the development of complex (declarative) knowledge. They impact the selection and processing of relevant information as well as their understanding and

later retrieval. In this line, knowledge representation models, findings from cognitive research, and the expert paradigm provide a fruitful basis and tools for identifying relevant criteria to describe pre-service teachers' cognitive processes and characterizing the development of complex knowledge structures. So far, however, studies in this tradition are often experimental and not related to teacher education. Thus, they cannot be directly related to pre-service teacher's learning in university-based teacher education. A more context-oriented analysis of cognitive learning processes is provided by research on learning strategies, which build another relevant theoretical basis for this work. Overall, there are several studies reporting the effectiveness of deep cognitive learning processes on the learning outcome. In this line, cognitive learning activities in the context of elaboration are considered to be meaningful, when pre-service teachers activate prior knowledge based on content-related schemata instead of grounding on personal experiences and naive assumptions necessary to select specific information and to process them in accordance to the content of the learning material. With regard to pre-service teachers' engagement in the deep-level cognitive process of organization, the quality of their structure-related and content-related organizing macro-operators is essential. In this context, meaningful organization processes on the structural level take place, when pre-service teachers select and organize information from the presented material according to its underlying meaning and organize information pieces represented in single nodes into more complex macrostructure units. Content-related organization processes reveal to be meaningful, when pre-service teachers are able to create semantical complex relationships between the selected information pieces and integrate higher order principles based on content-specific knowledge.

Nevertheless, there also studies revealing diverse results regarding the effectiveness of elaboration and organization strategies. These discrepancies are often attributed with the assessment methods which do not consider the context and content specifity of the knowledge domain. In this regard, research underlines to analyze learning strategies within a concrete learning situation, instead of using retrospective methods (mainly within a questionnaire); specifically as studies in this venue reported positive effects on the learning outcome the most. A promising approach to assess learning strategies during a concrete learning situation without any kind of self-assessment, is the analysis of learners' performance during a concrete and dynamic learning task (Artelt, 2000a; Wirth, 2005). This has the advantage that the learners do not have to engage in thinking processes about their strategy use, which may affect their cognitive processing related to the task. As such studies are still very scarce in this field, this thesis will make a first attempt to assess the cognitive learning activities of

elaboration and organization in a concrete, dynamic and well-defined learning task in relation to a specific topic and domain in teacher education.

Overall, research on learning strategies has provided important information about the activation and impact of cognitive deep-level activities on information processing and learning in school settings. Thus, students' cognitive learning processes and learning environments in schools are mostly in the focus. In contrast, much more uninvestigated is the assessment of (future) teachers' cognitive learning processes, when they are learners at universities. Therefore, the assessment of pre-service teachers' cognitive learning processes in the context of university-based teacher education is a relative unexplored research area, however, it can be expected that results from this work may provide new information for the design of learning environments in teacher education at universities.

3 Knowledge about Teaching and Learning Components as an Integral Part of University-Based Teacher Education

A main interest of this thesis is to analyze, how knowledge about effective teaching and learning components as a relevant part of general pedagogical knowledge is applied and linked to real classroom situations within pre-service teachers' elaboration and organization processes. Thus, a prerequisite for the analysis of pre-service teachers' cognitive learning processes is, to present the content of the learning material (Marton & Säljö, 1976a). The acquisition of this kind of general pedagogical knowledge in teacher education is a prerequisite for pre-service teachers' future job demands of implementing an effective instructional practice which foster student learning (Hattie, 2009; Seidel & Shavelson, 2007).
In line with this, I will summarize in the following paragraph the theoretical background and empirical findings on the acquisition of knowledge about teaching and learning components in (German) teacher education. First, I introduce models of teaching and learning, which build the theoretical basis for general pedagogical knowledge about relevant teaching and learning components (section 3.1). As goal clarity and learning climate are two relevant teaching and learning components under study in this thesis, I will address them in a separate section afterwards (section 3.2). Lastly, I will summarize findings on pre-service teachers' knowledge about teaching and learning components, and how it is fostered and assessed in (German) teacher education so far (section 3.3).

3.1 Models about teaching and student learning

As addressed in the context of pre-service teachers' learning (section 2.1), recent teaching and learning models are based on ideas of constructivism and characterize learning as a self-directed and social process of knowledge construction (Bransford, Brown, & Cocking, 2000; Reusser, 1998). This conceptualization builds not only the theoretical basis for the investigation of pre-service teachers' learning processes in this thesis, but also for the knowledge they should acquire. In this line, I present in the following a current teaching and learning model, proposed by Seidel & Shavelson (2007), and empirical findings from teaching effectiveness research, integrated in this model and highlighting the role of specific teaching components for student learning.
Overall, studies in this tradition and taking the cognitive learning processes into account, interpret students' learning not any longer as directly influenced by the teacher and the learning environment, as it was proposed by earlier work based on the process-product

paradigm (Brophy & Good, 1986; Fraser et al., 1987; Gage, 1963; Scheerens & Bosker, 1997). Rather, teaching is considered as the implementation of learning environments, which provides opportunities for students to actively and intentionally engage in cognitive activities relevant for knowledge acquisition (Seidel & Shevelson, 2007). Thus, students have to use these learning environments as a source for their learning and construct knowledge by themselves, where the teacher supports their higher order learning through effective learning conditions (Reusser, 1995). These assumptions are integrated in Seidel and Shavelson's (2007) proposed teaching and learning model (figure 3), which is based on Bolhuis (2003) work and can be used for the empirical investigation of the relationship between teaching and learning.

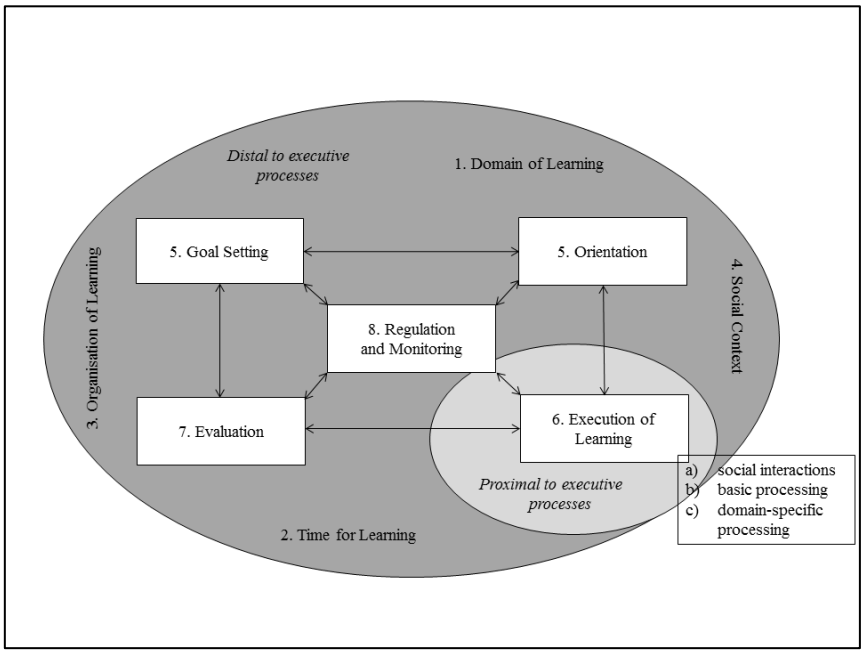


Figure 3. Teaching and learning model (proposed by Seidel & Shavelson, 2007).

Within this cognitive process-oriented model, learning is considered as a cognitive, motivational-affective process, which can be facilitated and fostered by components of teaching. Elements of teaching are integrated into components of learning. These components include both, components of teaching that are assumed to have proximal effects on knowledge building processes and distal components that "cover the instructional context and provide the necessary frame for students to engage in learning" (Seidel & Shavelson, 2007, p. 461). The four proximal interrelated teaching and learning components refer to *goal setting/orientation*, *execution of learning activities*, *evaluation*, and *regulation and monitoring*. The first component of goal setting and goal orientation involves teaching activities like clarification of goals and student orientation towards the achievement of those learning goals. The second

component refers to the execution of learning activities, which impact students' (internal and external) knowledge-building processes. Evaluation refers to classroom activities that provide possibilities to judge the development towards the learning goals. The last component of regulation and monitoring is considered as the central integrative component, as it involves classroom activities that stimulate, monitor and regulate the process of learning. Overall, the model builds on the assumption that the more and better these components are integrated in teaching, the better and more student learning takes place.

Knowledge domain, time for learning, organization of learning, and *social context* are the four distal components which are included in Seidel and Shavelson's (2007) process-oriented model on teaching and learning. The component of knowledge domain takes the domain specifity of teaching and learning into account (e.g. language, history, math), whereas time for learning builds the limited frame for students to engage in learning tasks. Through the component of organization of learning, the teachers provides the instructional context for learning (e.g. components such as classroom management). Finally, the component of social climate refers to the degree, to which teachers establish a social climate in their classrooms that build a positive and supportive frame for learning processes, for example by taking students seriously.

These proximal and distal components functioned for Seidel and Shavelson (2007) as categories to classify teaching variables, in order to test teaching effect sizes on student learning. Thereby, student learning outcome was related to learning processes, cognitive and motivational-affective outcomes. The authors could show that more studies on teaching effectiveness research fit within this new proposed framework on teaching and learning, as within traditional process-product models (e.g. Scheerens & Bosker, 1997), and was better able to account for effect sizes. This result is one reason for the strength of their meta-analysis, displaying the current state of research on the influence of teaching and learning. Overall, the effects of teaching components on student learning show differential effects. However, the execution of domain-specific activities consistently represented within all analysis (e.g. domain; stage of schooling) the teaching component with the most important influence on student learning. The results of their meta-analysis for secondary education (the stage of schooling, for which pre-service teachers in this thesis are educated for) point out that students' learning outcome in this stage of schooling is supported best, when the teacher provides opportunities to execute domain-specific learning activities, defines and communicate learning objectives and requirements to the students, and provide a positive and supportive learning climate. These findings provide one empirical reason, why this thesis

focuses on goal clarity as one important proximal component and social climate as one important distal teaching and learning component for learning processes in teacher education for secondary education. The execution of domain-specific learning activities is so far neglected in this work, as the main focus is on general pedagogical knowledge which is applicable in a wide variety of subjects. In the following, I will elaborate on the two teaching and learning components under study more in detail – nevertheless I am aware of the importance of other teaching components for student learning.

3.2 Teaching and learning components

It was outlined, so far, that goal clarity and social climate have been shown in the meta-analysis from Seidel and Shavelson (2007) as important teaching and learning components for learning processes of students. Also other reviews and meta-analyses have indicated their relevance for student learning (Brophy & Good, 1986; Fraser et al., 1987; Hattie, 2002; Scheerens & Bosker, 1997). In this line, analyzing pre-service teachers' knowledge about these components, the next paragraph aims to define goal clarity and social climate more precisely by pointing out their role for student learning and introducing the central concepts, indicating later on knowledge about these components. Furthermore, I address empirical findings on the execution of the teaching and learning components under study in classrooms.

3.2.1 Goal clarity and coherence

Research in teaching instruction has pointed out that high goal clarity and coherence is one of the main predictors for high learning outcomes, and has positive effects of students' competence development, cognitive learning activities and motivational regulation of learning (Helmke & Weinert, 1997a; Herweg, 2008; Kunter, Baumert, & Köller, 2007; Rakoczy et al., 2007; Seidel, Rimmele, & Prenzel, 2005). Against the backdrop of empirical findings from teaching effectiveness research (e.g. Seidel & Shavelson, 2007) linked with theories of knowledge acquisition (Steiner, 2001), cognitive load (Sweller et al, 1998) and the quality of learning motivation (Deci & Ryan, 1985; Prenzel, Kramer, & Drechsel, 2002), the component goal clarity and coherence refers to instructional lesson elements implemented by the teacher to foster students' goal-oriented learning (Herweg, 2008; Seidel, Rimmele, et al., 2005; Seidel & Stürmer, 2014). This conceptualization builds also the basis for the definition within the *Observe* project, in which this thesis is embedded in. Based on Herwegs' (2008) summarization of the current research, goal clarity and coherence can be defined as *teachers' clear and transparent communication of learning goals at the beginning of a lesson, a*

structured orientation of the lesson towards the stated teaching and learning goals and also to a coherent, goal-oriented presentation and integration of the learning content, where the use of advance organizers, structured overviews and summaries and contextualized anchors are supportive instructional elements. Furthermore, it relates to teachers' clear and transparent communication of tasks and requirements as a scaffold for students' cognitive and motivational learning.

In the following, I will outline the specific characteristics of goal clarity, identified by Herweg (2008), more precisely.

Goal clarity and coherence matches characteristics of direct instruction (Rosenshine, 1979), where teachers specify goals and tasks, organize lessons step by step and regulate and monitor students' learning processes. Current research points out that students' learning outcomes are essentially influenced by their occurring learning activities in classrooms (Bransford et al., 2000). In order to engage in meaningful learning activities, it is highly relevant that students know what they should learn (Herweg, 2008). The importance of communicating and clarifying learning goals at the beginning with respect to what students have to expect in the following lesson and what content they are expected to know after the lesson, is also pointed out by research on information processing and its implication on instructional design (Klauer & Leutner, 2007). Information about the learning goals drives students' attention towards relevant information for reaching the learning goals and helps students to focus on the main concepts what in turn, reduces cognitive load (Sweller et al., 1998). A clear and transparent communication of the learning goals supports also students' elaboration during information-processing, as the activation of prior knowledge is possible. Furthermore, students can integrate and organize new information into existing knowledge structures in a better way, when they know what they are expected to have learned in the end of the lesson. Empirical studies confirm these assumptions: For example, Herweg (2008), analyzing goal clarity and coherence as a scaffold for student learning in 82 physics classes in Germany and in the German speaking part of Switzerland, found a significant positive relation between the communication of learning goals and students' engagement in elaboration and organization learning activities.

A clear communication of learning goals is also considered to support students' self-determined learning motivation, which plays an essential role for the regulation of cognitive learning processes (Ainley, Hidi, & Berndorff, 2002; Krapp, 2002a; Seidel, Rimmele, et al., 2005). Self-determination theory from Deci and Ryan (1985) postulates three necessary conditions for students to develop self-determined learning motivation, which is related to

support of competence, *support of autonomy* and *social relatedness*. Furthermore, theories on interest in pedagogy (e.g. Prenzel, Krapp, & Schiefele, 1986) underline the importance of *personal commitment* and *interest*, indicated by seeing the relevance of the learning content for the development of a self-determined learning motivation (Prenzel, Kramer, et al., 2002). By making the learning content transparent, students get supported to see the relevance for their learning and are thus, more likely to be personally involved, as they may find connections between their own learning goals and the goals set by the teacher, what in turn, fosters a self-determined motivation towards the learning content (Bolhuis, 2003; Prenzel, 1997). Theories of learning motivation and interest point out that a frequently experienced learning motivation in actual learning situations, indicated by a high degree of self-determination, is highly related to the development of a stable interest in the relevant domain (Krapp, 2002a). Although, it was theoretical assumed that high goal clarity and coherence may contribute to such a long-term motivational effect, Seidel and colleagues (2005) could not confirm this hypothesis on the development of students' individual interest in physics within one school year. From a theoretical point of view, it is argued that individual interest develops very slowly and has to be fostered frequently. Nevertheless, in classes with high goal clarity short-term motivational effects were found, as students were more likely to experience self-determined motivation. Thus, teachers' clarification of goals contributes to students' quality of learning motivation.

It can be pointed out that there are different ways, how teachers can communicate lesson goals (Herweg, 2008). However, stating the topic of the lesson is not sufficient at all for students to identify with the learning content and to integrate the teaching goals into own learning goals (Krapp, 2002b; Prenzel, 1997; Seidel, Rimmele, et al., 2005). Rather, giving an elaborate and explicit explanation about aspects of the learning content on which students have to work on and which they have to know in the end, combined with underlining the relevance of the learning content, is considered as a clear and transparent clarification of goals. With respect to students' cognitive learning processes, instruction research has pointed out the importance of integrating the learning content into a superordinate context, when clarifying the learning goals of the lesson (Herweg, 2008). This helps the students to activate prior knowledge and to relate it to the actual learning content, what in turn facilitates later retrieval and transfer to new learning situations (Bransford et al., 2000). Overall, it also contributes one time more to show students the relevance of the learning content, as it is not regarded as a single learning aspect rather as an integrated part of a superordinate topic (Prenzel, Drechsel, Kliewe, Kramer, & Röber, 2000).

Communicating the lesson goals in an elaborative and transparent way and to integrate them into a superordinate context is a necessary prerequisite to structure the lesson towards the learning goals and to present the learning contents in a goal-oriented way (Herweg, 2008). Lesson structuring is another aspect of goal clarification. Only if the teacher recourses during the lesson several times to the stated learning goals, students are able to follow the lesson in a way that fosters their knowledge acquisition process, as they can select information relevant to the learning goals and get supported to store and reflect the learning content in the context of the learning goals (Bolhuis, 2003). Besides, a repeated explication of learning goals is necessary for creating supportive conditions for students' self-determined learning motivation, because the relevance of the learning content is frequently shown to students (Prenzel, 1997).

Effective elements of structuring the lesson towards the learning goals are seen in the use of organizing cues, such as *advance organizers*, *overviews*, *outlines* and *periodic summaries* (Bransford et al., 2000; Helmke & Weinert, 1997b; Herweg, 2008; Mayer, 1983). Teachers' use of *advance organizers* (Ausubel, 1974), for example, fosters students to activate their prior knowledge and to integrate the new learning content into existing knowledge structures and is thus, a supportive aid of elaboration and organization learning processes (Helmke & Weinert, 1997b). *Periodic summaries* and therefore, *repetitions of relevant information* increase students' opportunities to select, process and to store relevant information in long-term memory more effectively, what affects the later retrieval positively (Mayer, 1983; Wild, Hofer, & Pekrun, 2006). The use of *contextualized anchors*, while presenting the learning content, is another supportive aspect for students to individually elaborate on new learning contents (Barron et al., 1998). Based on the "Anchored-Instruction Approach", introduced by the Cognition and Technology Group at Vanderbilt (1992), contextualized anchors refer to authentic and interesting problem situations related to the learning content. The use of contextualized anchors might induces students to activate their prior knowledge to solve the problem, and might compels them to realize what kind of knowledge or skills they are still missing and in turn, see a personal relevance of the lesson and the learning goals (Reinmann & Mandl, 2006). Furthermore, the use of contextualized anchors support the transfer to other phenomena of the daily life and problem situations, fosters the understanding of the practical relevance of the learning content for students, and helps to see the learning content from different perspectives (Marks, 2000; Renkl, 1996). However, in order to avoid too much cognitive load and to guarantee that the use of contextualized anchors functions in deed as supportive conditions for motivational processes, students need some kind of structural

guidance and information on how to solve the problem situation and tasks in order to achieve the learning goals (Mayer, 2004; Reinmann & Mandl, 2006).

Against this backdrop, the clarification of tasks and requirements is a further component of goal clarity and coherence (Herweg, 2008; Trepke, Seidel, & Dalehefte, 2003). When students get supported through a clear and transparent communication of the tasks and on how they are expected to be processed, students can focus on the central aspects of the tasks necessary for knowledge building processes. In contrast, a vague verbalization contributes more likely to a disorientation regarding relevant working steps as well as students do not really know at what point of the knowledge building process, they actually are, and neither can they see the relevance of the learning task (Prenzel, 1997). With regard to cognitive-load-theory (Sweller et al., 1998), it also seems crucial to communicate the relevant strategies and steps on how to solve the task to the students, especially when the learning content is totally new to them. Through this instructional aid, extraneous cognitive load can be minimized and in turn, working memory has more capacity to work on the relevant learning content (Renkl, Gruber, Weber, Lerche, & Schweizer, 2003).

Summarizing the outlines above and related to the issue of what pre-service teachers should know about goal clarity and coherence, this teaching and learning component refers to one important instructional condition created by the teacher for students to engage in meaningful cognitive learning activities and self-determined learning in the classroom. Within this definition, it is necessary for pre-service teachers to know the indicators of goal clarity and coherence (clarification of learning goals including a structured orientation and presentation towards those goals; use of organization cues and contextualized anchors as supportive instructional elements; clarification of learning tasks and requirements), and to explain them with regard to student learning processes based on cognitive and motivational theories related to instructional design principles and teaching effectiveness research.

3.2.2 Learning climate

Research findings reveal that students learn best within cohesive and caring learning communities, as a supportive social climate is considered as a necessary prerequisite for productive and motivational-affective learning (Brophy, 2004a; Helmke, 2004; Seidel & Shavelson, 2007).

Although the concept of social climate is somehow elusive, a social climate in class features teacher/student and student/student interactions and is influenced beside many other sources (e.g. general school situation, context beneath school) by individual characteristics (e.g.

gender, race), as well as by learning background and prior experience and build an important frame in learning situations (Brophy, 2000; Hascher, 2003; Meyer, 2011). Thus, the social climate within in a class is highly specific and may not only influence learning, but also the individual perception of it may contribute to well-being of students – considered as another educational objective (Hascher, 2004; Meyer, 2011).

With regard to a supportive learning climate for student learning, the importance of social interactions between teachers and students has been pointed out (Boekarts, 2001). Thereby, the roles of teachers as well as specific teaching behaviors have been emphasized in particular. For example, Hascher (2003) showed that a teaching practice that relied on care, fairness and high quality teaching contributes to students' positive attitudes towards school, their joy and their academic self-concept, and could partly even help to reduce worries and problems in school. She and also other researchers (e.g. Oser, 1998) conclude that it is not enough for teachers just to be friendly and to care about some students, rather teachers have to develop professional competencies to integrate dimensions like fairness, joy and care in their teaching practice, and to implement a student-oriented learning environment. This is in line with Deci and Ryan (1993), who postulate that social integration is one *basic need* for the development of motivation. Teachers' care taking behavior towards all students is one major source for students feeling socially integrated and thus, for the development of intrinsic learning motivation. Through a student-oriented learning environment, the needs of students can be taken seriously. This influences in turn, the other basic needs of *support of autonomy* and *support of competence*, as it fosters students' self-perception of respected individuals and competent learners. Brophy (2000, p. 8) summarizes research on teachers' competencies for a supportive classroom climate as followed:

"To create a climate for moulding their students into a cohesive and supportive learning community, teachers need to display personal attributes that will make them effective as models and socializers: a cheerful disposition, friendliness, emotional maturity, sincerity, and caring about students as individuals as well as learners. The teacher displays concern and affection for students, is attentive to their needs and emotions, and socializes them to display these same characteristics in their interactions with one another."

Beside respectful, care taking and fair teaching practice, teachers' use of humor is regarded as another indicator for a supportive learning climate (e.g. Meyer & Bülter, 2004; Rissland, 2002). Humor provokes laughter and provides amusement, however, has to be distinguished from satire and irony which can be very offending sometimes (Rissland, 2002). Using the right portion of humor is seen as a prerequisite for a good social interaction with students,

helps to keep students' attention, and supports the connection between learning content and positive emotions, what in turn, facilitates the development of cognitive and motivational-affective learning (Rissland, 2002).

Nevertheless, it is not sufficient for students' learning processes, when teachers show such supportive, care-taking behavior only sometimes, rather it is necessary that it appears over various teaching and learning situations (Hascher, 2003; Seidel & Prenzel, 2003). Especially the handling of situations, critical for students' learning, for example when mistakes occur, is seen as an indicator for the quality of a supportive learning climate (Althof, 1999). In this regard, achievement and learning situations are distinguished (Seidel & Prenzel, 2003): Achievement situations are defined by obligatory requirements and explicit evaluations criteria. Students have to show their knowledge or skills and are evaluated according to them. In such situations, students are motivated to show their best and try to avoid mistakes. Thus, mistakes in achievement situations are related to negative attributions, such as embarrassment or anxiety and in turn, to avoidance. In contrast, learning situations aim to foster students' exploration and understanding of the new learning content and do not include explicit criteria for right or wrong answers. Even more, making mistakes during situations, where new knowledge is acquired or applied, is considered as very productive for learning as occurring mistakes help to identify misconceptions, wrong interpretations in knowledge acquisition processes and false ways of problem solving. It is assumed that such "negative knowledge" helps to avoid the same mistake in the future again (Oser & Spychinger, 2005). Furthermore, research on mistakes underline the positive effects on learning motivation (Seidel & Prenzel, 2003). When students have identified and overcome their own mistakes, they have a feeling of competence, have positive emotions and feel intrinsically motivated. This intrinsic motivation is in turn, again necessary to engage in deep and meaningful learning activities (Schiefele & Schreyer, 1994). It was predominately Oser and his colleagues (Oser & Hascher, 1997; Oser, Hascher, & Spychinger, 1999), who contributed to this new interpretation of mistakes. They point out that teachers should encourage their students to engage in learning situations without anxiety to make mistakes, as they provide a great chance for their learning. Reasons, why mistakes in learning situations are still most of the time regarded as negative and tried to be avoided by students through non-participation in lessons, relates to teachers' handling with mistakes in learning situations (Althof, 1999; Seidel & Prenzel, 2003). Negative comments on students' statements or the ignoring of mistakes, for example, can be perceived as an indicator for specific requirements or criteria which have not been reached. In worst cases, students feel afterwards embarrassed and ashamed by their teacher and do not

participate any longer or only when they are sure that they know the "correct" answer. This blending of learning and achievement situation contributes to a negative development of intrinsic motivation and knowledge acquisition (Meyer et al., 2006). In order to overcome this negative issue and to encourage students to contribute without fear, research suggest that teachers have to create opportunities and learning arrangements where students can make mistakes (working on authentic problem situations, group work). Furthermore, teachers have to create a mistake culture, where empathy and social support are features of it, and where mistakes are not ignored rather being addressed through objective and constructive feedback. Studies, which analyze the relationship between a positive mistake culture and student learning not exclusively from students' individual perception of it, rather taking an external perspective, are rare. So far, it was shown that mistakes appear very scarcely in (German) classrooms, what in turn has methodological restrictions on the analyses of teachers' handling with mistakes (Althof, 1999; Heinze, 2004; Meyer et al., 2006).

Overall and nevertheless, the above outlines may show that research on learning climate in classrooms has not worked out a specific concept, but instead, has analyzed specific teaching actions and behaviors in specific teaching and learning situations which contribute to the creation of a supportive learning climate. In this strand, cognitive research, research on motivational-affective learning and classroom research proved to be useful as a theoretical background and have addressed relevant indicators for the genesis of a positive and supportive learning climate (Krapp, 2002a; Krapp & Ryan, 2002; Meyer et al., 2006; Weinert, 1999). *Based upon that, it can be summarized that teachers promote a positive and supportive learning climate, when mistakes are handled as natural parts of learning processes, students are taught and encouraged to ask and contribute to lessons without embarrassment and anxiety, and when respect, care and enthusiasm indicated by taking students' needs seriously and using humor are integral parts of their teaching practice* (Helmke, 2012; Meyer, 2011; Oser & Hascher, 1997).

Against this background, it is necessary for pre-service teachers to know what are elements of supportive teaching behavior necessary for a positive learning climate in diverse, and especially in critical teaching and learning situations against the backdrop of indicating the effects on student learning based on motivational and cognitive learning theories and models.

The implementation of a supportive positive climate was also captured within the IPN Video study (Prenzel, Seidel, et al., 2002) through analyzing the constructive handling with mistakes and conceptual change as one basic element of science learning. It was analyzed, to what

extent physics classrooms are turned from learning situations into achievement situations, as the blending of learning and achievement situations are an intensively discussed problem area in the culture of teaching in Germany (Meyer et al., 2006; Schulmeiß, Seidel, & Meyer, 2003; Seidel et al., 2007). The implementation of a positive learning climate was rated through analyzing the three conditions of self-determined learning (support of competence, support of autonomy and social relatedness) based on Deci and Ryans' theory of self-determined learning (Deci & Ryan, 1993). For example, support of autonomy included, whether students' behavior indicated avoidance of wrong answers, and the extent to which students obviously hesitated or seemed anxious. Overall, the analysis of a constructive handling with mistakes indicating a supportive climate for learning are similar to previous research, as also very few situations have been found where mistakes occurred (Heinze, 2004). The findings from the IPN video study underline its importance for learning motivation, as analyses of extreme cases of embarrassment and anxiety revealed negative effects on students' intrinsic learning motivation. This is in line with previous research on individual perception of support and its impact on self-determined motivation (e.g. Rakoczy, Klieme, & Pauli, 2008).

To summarize, given the state of the art in research on teaching and learning, goal clarity and learning climate have been pointed out as effective teaching components for students' cognitive and motivational learning. As teaching practice is influenced to an essential part by theoretical knowledge acquired during teaching education, it seems relevant to analyze the acquisition of knowledge about effective teaching and learning components in (German) teacher education. Especially, since first empirical findings reveal that general pedagogical knowledge is positively associated by students with indicators of instructional quality (Voss et al., 2011) and professional knowledge about teaching and learning components positively affects teachers' classroom practice (Kobarg, 2009). Thus, I will outline this issue in the following section more in detail.

3.3 Teaching and learning components in (German) university-based teacher education

With regard to the widespread and international debate about university-based teacher education regarding the development of knowledge and skills proximal to teachers' classroom practice, the support of pre-service teachers in acquiring knowledge about what constitutes effective teaching and learning, is seen as one important objective. Besides, enabling them to apply this knowledge to classroom situations is also part of these discussions (Cochran-Smith, 2003; Darling-Hammond & Bransford, 2005; Koster et al., 2005; Voss & Kunter, 2011). In

the same vein, the assessment of their processes of knowledge acquisition and competence development in order to make statements about the level of their competencies necessary for their future job demands, is called for (Seidel, Schwindt, Kobarg, & Prenzel, 2008; Voss et al., 2011). In reviews on university-based teacher education, however, it is often claimed that general pedagogical university courses do not link theory with practice and thus, this kind of knowledge is not available for pre-service teachers in the practice of classroom situations (Blomberg, Stürmer, & Seidel, 2011; Cochran-Smith & Zeichner, 2005; Mandl & Gerstenmaier, 2000). Besides, the available distal measures and instruments are part of critical discussions, which do not allow conclusions on pre-service teachers' competence development (Baumert & Kunter, 2006; Desimone, 2009; Voss & Kunter, 2011). In the following, I will address instructional approaches and elements of teaching and learning courses in (German) university-based teacher education to support pre-service teachers' learning processes towards applicable knowledge (section 3.3.1). Furthermore, I will refer to assessment approach of pre-service teachers' learning gains (section 3.3.2). In the end, I will integrate both sections and transfer it to the current work (section 3.3.3).

3.3.1 Knowledge acquisition and its support in university-based teacher education

With regard to fostering applicable knowledge and meaningful learning in teacher education, pre-service teachers should be taught in the same way than it is expected from them to teach their future students (Vermunt & Verloop, 1999). A focus on specific aspects of teacher education (e.g. instructional tools) and pre-service teachers' learning can thus, help to examine whether, how, and why teacher education programs work or not.

In Germany, teacher education consists of two phases. The first phase is designed mainly for formal learning processes and is implemented by teacher education programs at universities. This first, academic phase cover subject matter courses (content knowledge), subject matter courses in education (pedagogical content knowledge), and courses in education and psychology (general pedagogical knowledge). After four till five years of knowledge acquisition at university, pre-service teachers enter the second phase, which completes after (usually) two years of practical training at school. The teacher education programs are – as well as the school systems – authorized by the federal states of Germany and thus, vary from state to state. The variety of teacher education programs within university-based teacher education is also caused by the implementation of the Bologna Declaration of 1999, where traditional state examination programs have successively been replaced by various forms of modularized or consecutive programs (Bauer, Diercks, Rösler, Möller, & Prenzel, 2012;

Bauer et al., 2010). Therefore, the following outlines are not intended to be exhaustive, rather give an overview about common practice and developments of instructional activities in courses on teaching and learning.

Although university-based teacher education courses in the field of general pedagogical knowledge are much more under-investigated than in the domains of content knowledge and pedagogical content knowledge (König & Seifert, 2012; Stürmer, Könings, et al., 2013), research has pointed out that university education courses tend to have a relatively low impact on pre-service teachers' deep knowledge structures as pre-service teachers are very often not able to transfer their acquired knowledge to classroom practice (Cochran-Smith & Zeichner, 2005) – and show thus, a lack of practical relevance (Kennedy et al., 2008). Results from one of the few studies on pre-service teachers' development of general pedagogical knowledge over the course of university based teacher education from König and Seifert (2012) may contribute to this assumption, as pre-service teachers – even if they acquired general pedagogical knowledge from the beginning till the end of their study – still had difficulties at the end of university-based teacher education with tasks, where they had to connect their theoretical knowledge with practical situations. Explanations why knowledge acquired through formal university settings might tend to be of inert quality are related to the learning processes that underlies the acquisition of knowledge and to the situatedness of cognition (Renkl et al., 1996). According to the situated cognition point of view, knowledge is bound to an application situation, and the interaction between individuals' cognition and the context of situation. Thus, transfer of knowledge acquired in university is only possible, if the instructional setting do not differ too much from the problem situation, where knowledge should be applied to. Given that traditional learning in university and teaching in classrooms differ in many aspects, such as in their problem complexity, pre-service teachers' lack of knowledge application to classroom situations is not surprising (Renkl et al., 1996). In response to these problems, much emphasis has been given in the last decade to situational teaching approaches within university-based teacher education courses, which try to overcome the development of inert knowledge by providing meaningful, rich and authentic application contexts for pre-service teachers (Borko, 2004; Darling-Hammond & Bransford, 2005; Grossman et al., 2009; Grossman & McDonald, 2008). For example, Stürmer, Könings and colleagues (2013) could show that pre-service teachers, who acquired general pedagogical knowledge within a situated video-based approach, showed higher gains in applying knowledge to authentic classroom situations in comparison to pre-service teachers, who were not instructed with a situated teaching approach.

In line with expertise research (Ericsson, 1996), teacher education research argues that university education courses including instructional elements relating to *representations*, *decompositions* and *approximations of practice* (Grossman et al., 2009) foster knowledge application and transfer to classroom settings (e.g. Berliner et al., 1988; Grossman et al., 2009; Seago, 2004; Van Es & Sherin, 2002). These are key concepts of a theoretical framework for fostering and analyzing teaching practice in university-based teacher education, suggested by Grossman and her research group from Stanford University.

Representations of practice include examples of the teaching practice, such as videotapes of classroom situations, observation protocols or lesson plans, which provide pre-service teachers opportunities to develop "ways of seeing and understanding professional practice" (Grossman et al., 2009, p. 2065).

The principle of *decompositions of practice* is related to the aspect that novices first need opportunities to engage in the different components of complex teaching practice before dealing with the overall and complex practice of teaching. Thus, decomposing or breaking down the complex practice into its different components supports pre-service teachers in attending to and enacting the critical elements of teaching. For example, focusing on elements of reflection on teaching is only one small aspect in teachers' work, however crucial in the full cycle of teaching.

The third principle of *approximations of practice* includes opportunities of enactment and experimentation with particularly challenging components of teaching practice. Although or because approximations are not entirely authentic (e.g. missing of real students), they allow for more mistakes, support and feedback than actual teaching practice. Grossman and colleagues (2009) distinguish between different activities with regard to the level of authenticity, from less complete and authentic (e.g. analyzing a written case) to more complete and authentic approximations (e.g. observation of videotaped classroom examples, role plays). Grossman and colleagues (2009) conclude in their study, that pre-service teachers have very few opportunities to engage in approximations so far.

Video reflection

Nevertheless, one prominent way to integrate approximations of practice into teacher education occurs so far, through the use of classroom video (Brophy, 2004b; Goldman et al., 2007). Video supports pre-service teachers' learning through secondhand experience of complex and subtle classroom teaching, and which allow more authenticity and richness than writing cases but without having the pressure to interact like in real classroom teaching

(Miller & Zhou, 2007; Sherin, 2004). These video features are useful for bridging the gap between theory and practice in university-based teacher education for several reasons (Gomez, Sherin, Griesdorn, & Finn, 2008). First, through illustrating particular theories on teaching and learning, video can help to acquire theoretical knowledge in a situated way (Seidel et al., 2013). Secondly, video provides opportunities to apply knowledge to authentic classroom situations and to experience the complexity of making sense of classroom practice (Borko, Jacobs, Eiteljorg, & Pittman, 2008). For example, after introducing the principle of goal clarity and coherence, pre-service teachers can be encouraged to encode and interconnect the theoretical principles with the videotaped teaching situation, in which it is shown how this kind of knowledge is applied (Renkl, 2011). Additionally, observing a wide range of classroom videos gives insight into diverse teaching styles, student populations and classroom interactions, which can help pre-service teachers to develop a sense of the practice to be learned (Grossman et al., 2009).

Against these advantages, it is not surprising that pre-service teachers' learning by means of video-based approaches has been investigated in various research studies designs in the past (Blomberg, Sherin, et al., 2013; Ling Wong, Wai Yung, Cheng, Lam, & Hodson, 2006; Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008; Santagata & Angelici, 2010; Seidel et al., 2013). One part of studies analyzed effects of video analysis on pre-service teachers' learning, mostly on knowledge application and reflection. Research shows that when pre-service teachers are provided with opportunities to observe teaching through video, they become more reflective over time and provide more elaborated analyses of classroom situations (Santagata, Zannoni, & Stigler, 2007; Star & Strickland, 2008; Stürmer, Könings, et al., 2013; Van Es & Sherin, 2002). Van Es and Sherin (2002) found that teachers, who watched and discussed video-cases, learned to analyze classroom interactions in a more expert way. In particular, they had greater attention to the details of specific classroom events rather than attention to more general features of a classroom. Furthermore, Santagata and Guarino (2010) successfully implemented the online video platform "Lesson Analysis Framework" (Santagata et al., 2007) into an teacher education course for fostering pre-service teachers' productive video-based reflections on mathematics teaching. During the lessons, pre-service teachers' viewing of videotaped lessons (including different kinds of clips like teachers interviewing individual students, sequences of clips from mathematical lessons in one classroom, clips showing pre-service teachers' teaching) was guided through a set of specific questions. The focus was on identifying lesson and learning goals, analyzing student thinking and learning, constructing hypotheses about effects of teaching and student learning and

proposing alternative teaching strategies. The findings suggest that their video-based teaching approach facilitates pre-service teachers' reflections with respect to elaborate on what they observe and to propose alternative teaching strategies.

Some studies provide specific knowledge on how to integrate video into university-based teacher education courses, in order to foster pre-service teachers' learning (Santagata & Angelici, 2010; Seidel et al., 2013). For example, Blomberg, Sherin and colleagues (2013) explored pre-service teachers' learning within two different learning environments, incorporating video and based on different instructional strategies (cognitive vs. situative). The authors analyzed the effects on pre-service teachers' reflection skills over the intervention of three months and found distinct impacts of the two learning environments. Findings reveal that the video-based learning environment designed according to the cognitive approach better fitted to derive expert-like reflections within a short period of time. In contrast, the video-based learning environment using situated principles fostered pre-service teachers' reflections in the long run. Their findings highlight on time more that video is a technology for delivering content and must therefore, be employed with clear objectives and learning goals in mind (Van Es, 2009).

Based on these research findings, it can be assumed that the well-considered integration of video in university-based teacher education fosters pre-service teachers' deep learning processes according to Weinstein and Mayer (1986) (see section 2.3) through providing authentic examples of classroom practice, where main concepts and principles of teaching and learning can be related and applied to. First results already show positive effects of learning with video on the use of elaboration strategies, like the activation of prior knowledge to reason about classroom situations (Stürmer, Könings, et al., 2013). However, effects on organization activities, also necessary for the acquisition of integrated knowledge, are so far under-investigated. Against this backdrop, one aim of this thesis is to analyze pre-service teachers' organization activities within a video-based learning environment in university-based teacher education.

Journal writing

Another prominent tool within the framework of professional teacher learning is related to journal writing as a means of decomposing practice through reflection (Dyment & O'Connell, 2011; Gläser-Zikuda, 2010; Hascher, 2010). Since Dewey (1910) first introduced his idea of reflection and advocated the development within pre-service teachers, the concept of reflective teaching and learning has been widely adopted in teacher education, especially on

its promotion through journal writing (Calderhead, 1989; Dyment & O'Connell, 2011). Thus, not surprisingly, journal writing occurs in various forms and varies in terms of their content and purpose for supporting reflection (Dyment & O'Connell, 2011; McCrindle & Christensen, 1995). In this thesis, reflective journal writing is assumed to support cognitive learning processes as defined by Weinstein and Mayer (1986) that constitute expert-like knowledge structures, knowledge transfer and problem solving in the field of instructional quality. By introducing pre-service teachers to the task of writing down a text and to reflect on the relevant content, for example in this thesis on instructional quality, pre-service teachers are supposed to identify effective principles of teaching and learning, find relationships between the main concepts as well as to interconnect abstract principles and concrete situations and experiences. Such reflective, cognitive activities foster a deeper processing of the learning content, and lead to long-term retention and knowledge transfer to actual teaching practice (see also section 2.3) (Berthold, Nückles, & Renkl, 2007; Glogger et al., 2009; Nückles et al., 2009; Schäfer et al., 2012). Meanwhile, there are several studies revealing the positive effects of journal writing on cognitive learning processes in different university settings (Berthold et al., 2007; Gläser-Zikuda, Rohde, & Schlomske, 2010). For example, McCrindle and Christensen (1995) found that journal writing significantly induce more sophisticated cognitive learning strategies (application of elaboration and organization strategies) and reduce surface processing (application of rehearsal strategies) within university students in biology. Furthermore, these students demonstrated better structuring of knowledge and the development of more comprehensive semantic relationships within their knowledge bases than the control group, who wrote scientific reports.

However, recent research results also show that writing in general does not automatically lead to learning gains and the use of sophisticated learning strategies, especially not within novices like pre-service teachers (Bangert-Drowns, Hurley, & Wilkinson, 2004; Berthold et al., 2007; Nückles, Schwonke, Berthold, & Renkl, 2004). In this strand, an effective method to support learning is seen in the use of prompted journal writing (Berthold et al., 2007; Hübner, Nückles, & Renkl, 2007; King, 1992b). Prompts refer to questions, which help to induce productive learning activities, like creating links between the new learning contents, and help to reflect on the main ideas. It is supposed that pre-service teachers already hold certain deep processing strategies, however, lack the spontaneous application of them (Hübner et al., 2007). Therefore, prompts provide scaffolds to overcome this so-called "production deficiency" (Flavell, 1978), as they suggest specific cues for the desired learning activities. In the study from Berthold and colleagues (2007) cognitive prompts within journal writing

successfully functioned as strategy activator as they helped psychology students' to engage in cognitive learning strategies. First empirical studies in the field of teacher education show that learning environments which use prompted journal writing enhanced the quality of pre-service teachers' cognitive processing (Picard & Imhof, 2010), and especially the use of elaboration strategies (Schäfer et al., 2012). However, little research has investigated specifically the quality of pre-service teachers' organization strategies within educational courses using prompted learning journals as a learning tool. First results from a study within school settings (Glogger et al., 2009) showed that fostering the application of organization strategies in learning journals with prompts has a positive impact on the coherent and clearly structured presentation of main concepts and their interrelations – one indicator for the structural quality of students' organization strategies. Nevertheless, it remains an open question whether and how pre-service teachers' organization processes develops in the complex setting of initial teacher education, more specifically within a learning environment using prompted writing journals as an element of decomposing practice through reflection.

In a nutshell, learning environments in teacher education that include elements of decomposition, representation and approximations of practice are considered to foster pre-service teachers' learning processes regarding the integration of theory and practice (Grossman et al., 2009; Korthagen & Kessels, 1999). Ideally, pre-service teachers' deep learning processes (i.e. organization strategies) are prompted. If sophisticated learning strategies are shown, learning outcomes such as deep and integrated knowledge structures are enhanced as some studies point out (e.g. Berthold et al., 2007; McCrindle & Christensen, 1995; Stürmer, Könings, et al., 2013). The development of knowledge toward expertise may in turn, help to bridge the perceived theory-practice gap in teacher education (Brouwer & Korthagen, 2005) – especially as pre-service teachers in this early stage of their professional career have not gained much practical experiences.

Thereby, educational researchers still see a research gap in analyzing connections between specific aspects of teacher education and pre-service teachers' learning processes in order to make statements, if teacher education programs help to avoid the development of inert knowledge within pre-service teachers (Brouwer, 2010; Kennedy et al., 2008; Vermunt & Verloop, 1999). Therefore, this thesis seeks to investigate pre-service teachers' learning processes with regard to organization strategies within a video-based learning environment using prompted learning journals as a learning tool. In this line, questions with regard to valid assessment methods and tools for pre-service teachers' learning processes and knowledge

acquisition arise (Zeichner, 2005). In the following section, I will outline these aspects more in detail.

3.3.2 Assessment of knowledge acquisition and learning gains

Although a shift within educational research towards focusing on teachers' general pedagogical and psychological competencies is visible (Blomberg, Seidel, & Prenzel, 2011; Terhart, 2000), so far only limited conclusions about initial processes of knowledge acquisition and competence development in university-based teacher education can be drawn (König & Seifert, 2012; Seidel & Stürmer, 2014). Causes for that are often attributed to the measurement approaches for assessing pre-service teachers' general pedagogical knowledge, considered as very procedural and contextualized in nature (Baumert & Kunter, 2006; Cochran-Smith, 2003; Voss & Kunter, 2011). In the following, I will give an overview about current research activities overcoming these perceived research gaps in the field of teacher education and present findings from these projects.

For a long time, (pre-service) teachers' general pedagogical competencies were assessed through questionnaires, including self-judgments of knowledge and abilities, numbers of courses taken, degrees or certifications attained (Frey, 2006). These references were then used to draw conclusions about (pre-service) teachers' underlying knowledge structures and competencies in the field of general pedagogical knowledge (Darling-Hammond, 2000). As it was already outlined in section 2.3.3 (assessment of cognitive learning activities), self-assessments have from a methodologically point of the view the advantage of being very time efficient as a huge sample size can be tested within a short time period. Furthermore, it is also assumed that competencies are best-known by the individuals themselves. However, this requires highly self-reflected competencies of pre-service teachers in order to give a realistic judgment in the retrospective and being not biased by social desirability (Frey, 2006). Therefore, conclusions that are drawn from such "soft" measurements and proximal indicators are often criticized. Results have to be interpreted with caution, as they do not include information about pedagogical competencies and knowledge assessed in a concrete situation (Voss & Kunter, 2011).

Against this backdrop, an afford has been made in the last years to develop more standardized tests, as one solution to overcome the problems of self-assessments within the field of general pedagogical knowledge as Kunina-Habenicht and colleagues (2012) have been pointed out in their Delphi study on educational topics relevant for teacher education. A prominent instrument in this strand has been developed in the context of the *Cognitive Activation in the*

Classroom-Referendariat (COACTIV-R) study, which investigated beside subject and pedagogical content knowledge also general pedagogical knowledge of pre-service teachers in the second phase of German teacher education (practical training) (Kunter et al., 2011; Voss & Kunter, 2011; Voss et al., 2011). Voss and colleagues (2011) developed a standardized questionnaire, which taps different dimensions of general pedagogical knowledge including knowledge of classroom management, knowledge of teaching methods, knowledge of classroom assessment and students' heterogeneity. Three different item formats are used: multiple-choice items, short-answer items and video-based items for the assessment of knowledge about classroom management, as it is considered to be more procedural and contextualized in nature than the other three dimensions of general pedagogical knowledge. In a study with N = 746 pre-service teachers, Voss and colleagues (2011) assessed pre-service teachers' general pedagogical knowledge within their first and second year of practical training in four different federal states of Germany. Additionally, they collected information on the instructional quality of pre-service teachers' teaching by administrating a short questionnaire to their students in order to make statements about the relationship between their knowledge and the quality of their teaching. The instrument was proven to be sensitive to differences and developments as the findings reveal that pre-service teachers' general pedagogical knowledge increased during the second phase of teacher education, and it was shown that their learning gains (so far only analyzed with regard to the dimension of classroom management) were influenced by the organization system of the practical phase. Finally, pre-service teachers' test scores were positively related with students' rating on instructional quality, what underlines that general pedagogical knowledge in fact matters for teaching. As the standardized instrument was developed to test general pedagogical knowledge within the second phase of teacher education, assumptions about pre-service teachers' knowledge base in the first phase cannot be drawn from.

In this regard, a similar paper-pencil instrument, which includes 16 standardized rating items and 34 open answer questions with varying difficulties, has been developed in the context of the *Teacher Education and Development Study – Learning to Teach Mathematics* (TEDS-M). Within the main TEDS-M study, mathematical content knowledge and mathematical pedagogical content knowledge of future mathematics' teachers from 17 different countries were compared to each other (Tatto, Schwille, Senk, Ingvarson, Peck, & Rowley, 2008). Additionally, three participating countries (Germany, Taiwan, and USA) aimed to investigate pre-service teachers' general pedagogical knowledge with regard to lesson structuring, classroom management, student motivation, classroom assessment and students'

heterogeneity. The standardized test was developed in cooperation with international experts from the field of teaching and learning research and from general didactics, which showed in a German pilot study a good reliability (König & Blömeke, 2009). Furthermore, the results indicate like Voss and colleagues' study (2011) that general pedagogical knowledge cannot be regarded as one dimensional rather being divided into several knowledge aspects, what makes it necessary to investigate the diverse knowledge dimensions. König and Seifert (2012) used this instrument in their study (*LEK –Längsschnittliche Erhebung pädagogischer Kompetenzen von Lehramtsstudierenden)* on the development of general pedagogical knowledge within German university-based teacher education and compared four different university settings in Germany. Also here, similar findings to the study from Voss and colleagues (2011) on teacher education in the second phase were found. Pre-service teachers' knowledge base developed over time of university-based teacher education and differed between the different teacher education programs. Furthermore, pre-service teachers showed the lowest gains within the most difficult questions (relating theoretical knowledge to practical situations).

In the light of these activities, it can be stated that research progress with regard to the development and implementation of direct and proximal measures of pre-service teachers' general pedagogical knowledge had been made in the last years. The standardized instruments focus on the assessment of pre-service teachers' competencies (declarative and procedural knowledge) related to concrete tasks and situations; especially the instrument from Voss and colleagues (2011), which includes short video sequences (23-78 sec.) as item prompts. The results indicate also that pre-service teachers successfully acquire general pedagogical knowledge within German teacher education (first and second phase).

3.3.3 Assessment of pre-service teachers' learning about specific teaching and learning components in the context of university-based teacher education courses

In this final section, the above outlined conceptualizations and empirical findings are transferred to the assessment of pre-service teachers' learning processes about specific teaching and learning components in the context of university-based teacher education courses. Following aspects will be addressed:

- Relevance of teaching and learning courses in university-based teacher education
- Suitable approaches for the assessment of knowledge acquisition processes about teaching and learning components

Relevance of teaching and learning courses in university-based teacher education

Previous studies, investigating pre-service teachers' learning within the formal phase of German teacher education, could show that pre-service teachers gain general pedagogical knowledge when taking part in specific university courses (König & Blömeke, 2009; Stürmer, Könings et al., 2013; Voss et al., 2011). However, they also point out that pre-service teachers have difficulties to activate their acquired knowledge in actual classroom settings (König & Blömeke, 2009). Regarding the acquisition of knowledge about teaching and learning components, empirical findings highlight therefore, the role of situated teaching approaches providing authentic application contexts and reflection elements (Grossman et al., 2009). A meaningful integration of the instructional tool of videotaped classroom examples has been specifically proofed to be effective for later knowledge application and transfer (Blomberg, Sherin et al., 2013; Seidel et al., 2013; Stürmer, Seidel et al., 2013; van Es & Sherin, 2002). The activation of elaboration and organization processes is also positively associated with prompted journal writing (Bertold et al., 2013; McCrindle & Christensen, 1995; Schäfer et al., 2012). Thus, it seems promising to study pre-service teachers' organization processes and changes within a teaching and learning course that combines these two effective instructional tools for knowledge acquisition processes.

Suitable approaches for the assessment of knowledge acquisition processes about teaching and learning components

In the context that teachers require knowledge about teaching and learning components to create effective learning opportunities (Darling-Hammond & Bransford, 2005; Seidel & Shavelson, 2007), progress has been made in developing standardized tests to measure competencies in this knowledge domain in the first and second phase of German teacher education (König & Blömeke, 2009; Kunter et al., 2011; Voss & Kunter, 2011). Although these paper-pencil instruments assess pre-service teachers' knowledge about effective teaching and learning components as one relevant part of general pedagogical knowledge under standardized conditions, an in-depth insight into pre-service teachers' capacities to activate and apply knowledge in real teaching situations rarely can be given. Thus, it seems promising for this work to follow a new development in this research strand, which focuses on a video-based assessment of general pedagogical knowledge. The advantage of this approach is that the core aspects of the teaching profession – situativeness, authenticity, complexity, and the real teaching context – can be taken more into account (Oser, Salzmann, & Heinzer, 2009; Seidel et al., 2009). Main assumption of video-based assessment approaches

is that pre-service teachers' general pedagogical knowledge becomes visible through their competence in observing and analyzing classroom situations targeting this knowledge aspect (Brophy, 2004; Carter et al., 1987; Goldman et al., 2007). This is in congruence with the expertise paradigm, where the effect of professional knowledge is defined as a shift in teachers' categorial perception of classroom situations (Bromme, 1992). In this regard the concept of professional vision (Goodwin, 1994), defined as attending and interpreting relevant classroom situations (Van Es & Sherin, 2002) can serve as an indicator for assessing pre-service teachers' cognitive learning in the field of effective teaching and learning components in a proximal and contextualized way. The next paragraph addresses the concept of professional vision more in detail, as this thesis investigate pre-service teachers' cognitive learning processes with regard to goal clarity and learning climate in this context.

Summarization of the second theoretical paragraph

In the previous section, the theoretical basis of the learning content, in which pre-service teachers' cognitive learning processes are investigated, has been presented. Empirical findings based on current teaching and learning models show that proximal teaching components, such as goal clarity, and more distal teaching components, like a supportive learning climate, have positive effects on students' cognitive and motivational learning. Empirical studies point out that knowledge about instructional quality matters for the quality of teaching. Hence, the support and the assessment of pre-service teachers' knowledge acquisition and competence development in this knowledge domain in university-based teacher education can be considered as highly relevant. With regard to supporting pre-service teachers' learning processes towards applicable knowledge, research suggests instructional elements related to *representations, decompositions and approximations of practice*, like video and prompted learning journals. So far, very limited empirical findings with regard to pre-service teachers' changes in their cognitive learning processes during such settings exist, specifically not with regard to changes in their organization processes. As information on that is relevant for the design of teacher education courses on teaching and learning, this thesis attempts to investigate changes in pre-service teachers' organization processes during a course, which uses a video-based instructional approach combined with reflective elements. An even more important research gap is related to the assessment of pre-service teachers' learning activities and knowledge acquisition processes about general pedagogical knowledge. It is argued that distal indicators, such as degrees and courses taken, cannot be used as criteria for successful learning processes and in turn, conclusions on the effectiveness of teacher education programs

cannot be made. Advancements in this regard are seen in the development and implementation of more proximal assessment tools (Baumert & Kunter, 2006; Cochran-Smith, 2003; Frey, 2006; Voss & Kunter, 2011), and where a video-based assessment approach seems to be a promising method.

This thesis takes the current discussion about measurement tools in teacher education up and investigates pre-service teachers' deep-level learning activities through direct and contextualized measures. The investigation of pre-service teachers' knowledge about the effective teaching and learning components of goal clarity and learning climate is based on cognitive and motivational learning theories and findings.

4 Professional Vision as a Proximal Indicator for Investigating Pre-Service Teachers' Cognitive Learning Processes in the Context of Teaching and Learning Components

According to cognitive science research and research on teacher expertise, the quality of teachers' knowledge structure – and hence, the development of knowledge towards greater expertise – determine the ability to apply declarative knowledge flexibly and effectively to various teaching situations (Anderson, 1996; Leinhardt & Greeno, 1986). In order to acquire such expert-like knowledge structures, it was outlined above that initial teacher education at universities provide an important baseline as it can support the development through integrating theoretical knowledge with practice (Berliner et al., 1988; Darling-Hammond & Bransford, 2005). In this regard, identifying indicators of pre-service teachers' knowledge application in authentic situations and assessing their learning processes towards "integrated" teacher knowledge is of particular importance (Cochran-Smith & Zeichner, 2005). Thereby, a promising indicator for "integrated" knowledge about effective teaching and learning components is seen in the concept of professional vision, originally introduced by Goodwin (1994) and applied to the teaching profession by Sherin and Van Es (Sherin, 2001; Van Es & Sherin, 2002).

In the following sections, I will define the conceptual framework of professional vision, introduce empirical findings and state-of-the-art analysis approaches, and show some of their limitations. To address the stated critical issues, I present in the last section new analysis aspects, which might be very fruitful to consider when analyzing cognitive processes in the context of professional vision. In order to move the research field with regard to the use of diverse methodologies approaches forward and to meet the claim of analyzing also organization processes in the context of professional vision (Seidel & Stürmer, 2014), I will introduce concept mapping as a new and promising methodology approach for measuring organization processes in the context of professional vision.

4.1 Modell of professional vision

Teachers' professional vision describes the ability to direct attention to relevant classroom elements and respond flexibly to events that influence student learning based on conceptual knowledge (Berliner, 2001; Star & Strickland, 2008; Van Es & Sherin, 2002). As classrooms are highly dynamic, where interactions among multiple persons and events occur simultaneously and change constantly, professional vision is a crucial vehicle for enhancing the development towards effective teaching (Eilam & Poyas, 2006; Kersting et al., 2010).

Research shows that the development of professional vision helps to avoid inert knowledge (Blomberg et al., 2011), equips teachers with knowledge and skills to reflect teaching as an element of life-long learning (Santagata & Guarino, 2010), and provides settings for "approximations of practice" (Grossman et al., 2009) and "lessons as experiments" (Santagata & Yeh, 2013).

Current literature points out that professional vision does not mean to focus on superficial events, such as the speech patterns of students or the interior design of the classroom, instead being aware of situations and pedagogical strategies that are especially relevant to student learning (Kobarg, 2009; Schäfer & Seidel, accepted). As significant events for student learning often occur in underlying classroom structures and only can be inferred from a more in-depth analysis of the complex teaching situation, professional knowledge about teaching and learning is required (Berliner, 2001). Thus, professional vision is defined as a knowledge-based process (Goodwin, 1994) that draws in the teaching profession on generic and subject-specific knowledge (Shulman, 1987), and can be differentiated into the two processes of noticing (attention to relevant situations) and reasoning (interpretation of noticed events) (Van Es & Sherin, 2002). Before I refer to both processes in the field of general pedagogical knowledge – as this thesis focuses on this knowledge facet – I will shortly revisit the original conceptualization of professional vision, defined by Goodwin (1994).

Definition of Professional Vision related to Goodwin

Professional vision according to Goodwin, a linguistic anthropologist in the field of discursive practice, refers to *"socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group"* (p. 606). In his article, Goodwin describes within two examples of professional settings – archaeological field excavation and legal argumentation of expert police in a criminal trial in court – that the way how professionals look at phenomena in their field of expertise can be analyzed in their use of three practices: *highlighting*, *use of coding schemes* and *graphic representations*. *Highlighting* refers to "methods used to divide a domain of scrutiny into figure and a ground, so that events relevant to the activity of the moment stand out" (p. 610). The *use of established codes* is used to describe the complex practice and transform it into categories relevant to the professional work. Through the use of *graphical representations*, professionals can articulate their ways of seeing to others and where the produced artifacts are defined as embodied practice.

Within the example of archaeology, Goodwin demonstrates how these three practices can be used to support novice archeologists to develop experts' way of seeing. It becomes visible

that professional vision includes *specialized knowledge*, necessary to see and discuss phenomena in a specific area of expertise.

Within the second example, where the use of excessive force from four policemen to arrest an African-American motorist, stopped for speeding in Los Angeles, was legally defended in court despite video-recorded evidence, Goodwin illustrate how professionals' way of seeing becomes socially recognized as not only different but also better than those of lay persons. Thus, professional vision implies for him also the aspect of *power* or *authority*, what he illustrates with the fact that an expert witness interpreted the beating on the video only from the perspective of police profession and what influenced in turn, lawyers' way of looking as they trusted on the expert's view.

Teachers' Professional vision

Goodwin's concept has been influentially up taken by research on the teaching profession in the past decade, and particularly applied to the field of teacher learning (e.g. Sherin, 2001). In this regard, however, Lefstein and Snell (2011) critically point out that the political dimension – in the sense of power and authority – has been kind of overlooked, as professional vision in the context of teacher learning is often defined as a "singular, cognitive ability" (p. 513). The consequence of such a conceptualization is regarding to the authors that the plurality of professional visions (e.g. different perspectives between educational researchers and teachers) is replaced through a position, where only one correct way of seeing is defined as professional, and mostly the researchers' ones. Against this backdrop, I want to highlight that I do not mean to imply that researchers' professional vision is the only right way of seeing, when I refer to aspects from a research point of view and define professional vision as *the* ability to notice and interpret relevant classroom features. However, I also argue that attending to and interpreting relevant situation based on theories and empirical findings from teaching and learning is a constituent component in the way of developing "professional vision". This is also consistent with Sherin's position (2001), who suggested that researchers also learn from teachers' way of seeing. She and her colleagues crucially framed professional vision in the teaching context and have conducted several research studies in the last decade (e.g. Sherin, 2007; Sherin & Han, 2004; Sherin & Van Es, 2009; Van Es & Sherin, 2008).

In this regard – although some researchers have adopted a somehow different definition in the study of teachers' professional vision – the differentiation between noticing and reasoning has proved useful for studying pre- and in-service teachers' professional vision (Star & Strickland, 2008; Van Es & Sherin, 2002).

Noticing

The term *noticing* used in everyday language for general observations clearly has to be distinguished from teachers' noticing, what encompasses the ability to direct the attention to classroom situations that are crucial for teaching and learning in classrooms, for example, events that influence student learning in a positive or negative way (Seidel et al., 2010a; Van Es & Sherin, 2002). In line with Endsley's theory on situational awareness(1995), data-driven (bottom-up) and goal-driven (top-down) information processing mechanisms are important for noticing, and which name more alternating processes rather than a static concept. Teachers' professional knowledge in terms of schemas influences both mechanisms, allowing to be more sensitive to relevant aspects of classroom situations and their classification against the background of theoretical concepts (Palmer, Stough, Burdenski, & Gonzales, 2005; Seidel & Stürmer, 2014). As teachers' professional knowledge is made up of a combination of content knowledge, pedagogical content knowledge, and general pedagogical knowledge (Shulman, 1987), and significant advancements already have been made in the study of domain-specific areas (mostly in teaching mathematics), this research focuses on pre-service teachers' noticing with regard to generic pedagogical principles and strategies; more specifically on knowledge about the components of goal clarity and learning climate. Both, as outlined have been repeatedly proofed to be relevant to students' cognitive and motivational learning (e.g. Seidel & Shavelson, 2007). As Kobarg (2009) studied teachers' noticing of effective teaching and learning components and showed that teachers, who intuitively noticed them, also were more likely to have incorporated them into their own classroom teaching, this study context seems to be promising for pre-service teachers' noticing as well.

In the model of professional vision, noticing is not regarded as an isolated process, rather it is interrelated and cyclical with the second process of professional vision – reasoning about noticed events. Both are considered to be influenced by teachers' knowledge (Bromme, 1992; Sherin, Jacobs, & Philipp, 2011). For example, on what situations teachers attend to have an impact on their reasoning and interpretation about them, what in turn affect further noticing processes and so on (Bromme, 1992; Endsley, 1995; Van Es & Sherin, 2002).

Reasoning

With regard to the second component of professional vision, *reasoning* involves the process of making sense of what has been noticed by linking observed situations to knowledge, in this case about teaching and learning. Whereas pre-service teachers' noticing provides insight the quality of teachers' knowledge structure during selection and attention processes, reasoning

describes their quality during information processing and transfer to the classroom context (Borko, 2004; Borko et al., 2008). Thus, reasoning means linking the noticed situation to existing knowledge – often described as *integration* and in this case, activation of knowledge about teaching and learning – in order to explain the noticed situations as well as to predict further learning processes. Findings from expertise research and studies on modelling the structure of reasoning distinguishes three qualitatively different facets of reasoning, which are nevertheless highly interrelated (Berliner, 1991; Seidel & Prenzel, 2007; Seidel & Stürmer, 2014; Sherin & Van Es, 2009): *description*, *explanation*, and *prediction*.

Description reflects teachers' ability to focus on the noticed events and differentiate between them without making any judgments. With regard to goal clarity, this implies that one is able to state that the teacher refers to what the students should learn or how the lesson is structured without a subjective note (e.g. I like, in my opinion).

Explanation defines teacher's ability to relate theoretical knowledge to the noticed classroom events and classify the situations according to the components of teaching involved. To do this well with regard to goal clarity, it involves linking the observed event to professional concepts and the use of professional terms and indicators of goal clarity. For example, stating that the teacher is communicating the learning goals not transparently, however uses an advanced organizer as a supportive instructional element shows the presence of professional concepts in this knowledge area.

The ability to make *predictions* requires teachers to draw inferences about what might be happening with regard to student learning by linking broader concepts about teaching and learning to the noticed situation (Seidel & Stürmer, 2014). With regard to goal clarity this dimension involves the use of knowledge about the cause and effects of the teaching component of goal clarity on student learning (e.g. application of concepts derived from motivational theories or from empirical findings) in order to make predictions about possible consequences. The nuanced difference between explanation and prediction might make visible, why some researchers treat the two higher-order knowledge application processes as one facet (e.g. Van Es & Sherin, 2008).

In figure 4 the cyclic and interrelated noticing and reasoning processes of professional vision and the impact of professional knowledge on them are illustrated:

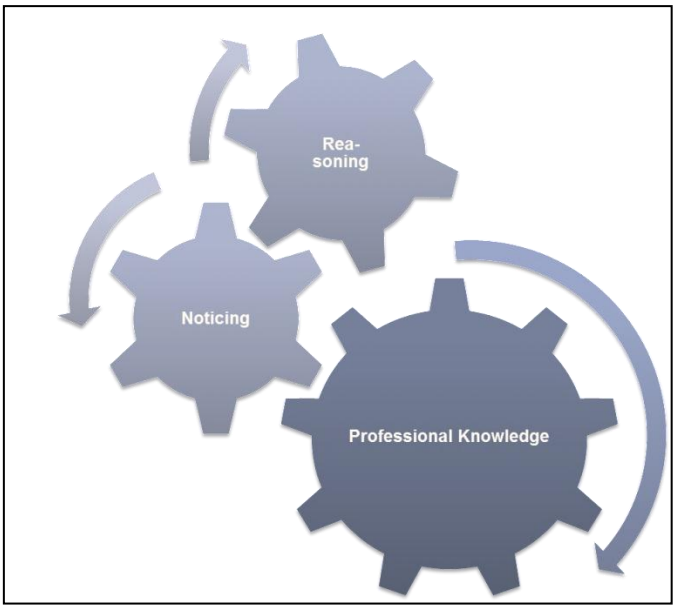


Figure 4. Interplay of the knowledge-driven processes of noticing and reasoning.

When noticing and reasoning processes are applied to pre-service teacher education, it can be assumed that pre-service teachers do not yet have acquired knowledge that is much elaborated, rather still determined by naive assumptions and subjective theories about teaching and learning (Carter et al., 1987; Lampert & Ball, 1998). Therefore, it seems not surprising that that their ability lays behind that of experienced in-service teachers (Oser, Heinzer, & Salzmann, 2010; Seidel & Prenzel, 2007). For example, Oser and his colleagues (2009) studied expertise differences in their project *VET – Vocational Educational Training* by using video vignettes about concrete teaching behaviors in classroom situations and a subsequent criterion-based questionnaire, where the teacher in the video had to be evaluated according to standard quality criteria of instructional processes (e.g. giving feedback). Results from their study in the field of vocational education reveal in fact competency differences between different expertise groups of vocational school teachers (5 groups defined on the basis of Berliners' (2004) proposed five stage model of teacher competence development) and non-teachers with regard to noticing and reasoning about the effective teaching behavior of giving feedback. However, it has to be remarked that the authors used no expert norm as reference, instead compared a single teacher's evaluation with the mean competency profile of the given sample of vocational school teachers and thus, no general conclusion on pre-service teachers' knowledge structure can be made. In contrast, in the project *LUV – Learning from classroom videos* from Seidel and Prenzel (2007), a criterion-referenced norm was used and differences between three expertise groups (20 pre-service teachers, 86 experienced teachers and 19 school inspectors) with regard to noticing and reasoning about effective

teaching and learning components have been found. As an assessment tool, the authors integrated authentic video recordings of classrooms in the computer-based learning environment LUV and connected them in the first part of LUV to standardized rating items, which combined questions on teaching and learning components (e.g. goal clarity and learning climate) on three different quality levels indicating different knowledge structures. In summary, school inspectors scored over all teaching and learning components the highest, indicating that general pedagogical knowledge is applied to teaching situations. In contrast, pre-service teachers showed the lowest abilities. In the second part of LUV, participants analyzed a representative recording of a 45-minute lesson and were asked to reflect about the lesson with regard to teaching and learning components. All written teacher comments were analyzed concering the extent to which teachers noticed the relevant components (Kobarg, 2009) and the depth of their reflections (Schwindt, 2008). The results, again, showed systematic differences between pre-service teachers, experienced teachers, and school inspectors, who were for example the most differentiated in their evaluations of the 45-minute lesson (Schwindt, 2008). It is also known that pre-service teachers have difficulty focusing on students' (rather than on teachers') actions and tend to view lessons merely as chronological but disconnected sequences of events (Borko et al., 2008; Kersting, 2008; Sherin & Van Es, 2009; Star & Strickland, 2008).

In a nutshell, this indicates that novice teachers are less able to notice and interpret situations against the background of limited knowledge. Nevertheless, it seems likely that knowledge structures required can be developed over time, as experienced teachers are more able to differentiate and integrate knowledge and apply it flexibly to various teaching situations (Berliner, 2001; Jacobs, Lamb, & Philipp, 2010; Seidel & Prenzel, 2007). In the following section, I will refer to state-of-the-art measurement approaches of pre-service teachers' noticing and reasoning abilities and cognitive learning processes, that might lead to the proposed expert knowledge structure.

4.2 State-of the art measurement approaches in the context of professional vision

As pointed out, professional vision is regarded as a situational and contextualized indicator for teachers' knowledge activation and learning (Hammerness et al., 2002; Putnam & Borko, 2000). Thereby, video has become a prominent tool for eliciting this kind of knowledge (Blomberg, Sherin, et al., 2013; Brophy, 2004b; Krammer, Ratzka, Klieme, Lipowsky, Pauli, & Reusser, 2006); both for studying pre- and in-service teachers' learning (Star & Strickland, 2008; Van Es & Sherin, 2002), and for designing learning environments (Santagata &

Angelici, 2010), as outlined in section 3.3.1. Besides, the development of knowledge structures required has been studied by qualitative and quantitative approaches so far. According to that, this section targets the aspect of "activation of cognitive learning processes" and "measurement approaches for eliciting cognitive processes".

4.2.1 Activation of cognitive learning processes

A deeper look into teacher education research reveals that the use of video has achieved a stable position across the last decades, however, the purposes for what video has been used in teacher education has changed over time (Sherin, 2004). In particular, advancements in digital videography, software development, and hypermedia technologies have led to higher quality videos and to a greater accessibility and flexibility to video, what in turn lead to a substantial increase in the use of video (see also section 3.3.1) (Brophy, 2004b; Goldman et al., 2007). Just as the technological developments stimulated a variety of uses, the shift in the perspective from behaviorism to cognitive views on teaching and learning was also followed by new innovations on video as a cognitive research tool (Kersting, 2008; Seidel & Stürmer, 2014). But what makes video also valuable as an assessment approach for teachers' cognitive learning processes?

First of all, expertise research in teaching has shown that expert teachers systematically perceive and interpret classroom events in a different way than novice teachers when viewing videotaped classroom situations, like providing more coherent and richer interpretations or offering alternative teaching approaches (Carter et al., 1987; Carter et al., 1988). These findings do not only confirm different knowledge structures between experts and novices (Bransford et al., 2000), but also underline that using videos of classroom situations can serve as stimuli to elicit and activate teacher knowledge (Kersting, 2008). Video makes it possible that pre-service teachers can connect knowledge that they have learned in teacher education courses to the classroom context, in which they will apply that knowledge in the future (Santagata et al., 2007). This is one advantage of video since for diagnosing cognitive learning processes it is necessary to bring (pre-service) teachers into situations, where the application of knowledge is required (Reusser, 2005). Furthermore, video gives the opportunity to capture and conserve the complexity of real classroom situations and thus, takes the situated and contextual nature of teacher knowledge into account (Kersting, 2008). In addition, videotaped lessons give pre-service teachers the possibility to observe classroom situations without the necessity to decide for prompt reactions. Finally, each lesson presents a number of different challenges of teaching strategies on student learning for an external

observer. This makes it possible to select a range of videos as stimuli for the assessment of pre-service teachers' knowledge and competence development (Seidel et al., 2009; Wiens, Hessberg, LoCasale-Crouch, & DeCoster, 2013).

Within the use of video as a promising tool for elicting and investigating pre-service teachers' knowledge representation, however, the kind of video material has to be considered and chosen carefully with the study objectives in mind (Blomberg, Renkl, Sherin, Borko, & Seidel, 2013; Sherin, Linsenmeier, & Van Es, 2009). This assumption is based on empirical findings revealing differential effects on teachers' knowledge activation depending on the implemented video material used as stimuli (Brophy, 2004b; Kleinknecht & Schneider, 2013; Seidel, Stürmer, Blomberg, Kobarg, & Schwindt, 2011). In the following, I will outline three issues particularly relevant for knowledge activation in this study, and on which I thus, had to decide on.

Own video material or external video material?

The first issue concerns effects of showing pre-service teachers their own videotaped instruction, if they have had practical experiences, or the teaching of others on the activation of their cognitive processes. In this context, Kleinknecht and Schneider (2013) investigated whether it makes a difference, if teachers observe a video showing their own teaching or that of others for the activation of the cognitive processes of noticing and knowledge-based reasoning. In a quasi-experimental research approach, they analyzed the written comments on a shown video clip from 10 in-service mathematics teachers, which have been equally divided into two groups ("Own Video Group" vs. "Other Video Group"). In terms of the cognitive process of noticing, the five teachers who observed their own teaching focused slightly less attention on students and students' learning processes than the teachers from the other group. With regard to the activation of knowledge-based reasoning, the "Own Video Group" tended only to perceive, describe and evaluate situations. In contrast, teachers watching the video from someone else engaged more in the three step analysis of description, explanation and prediction. Both groups differed also in terms of dealing with negative events, whereas the members of the "Other Video Group" showed more reflections on alternatives ways of dealing with critical events. These results are in line with a previous experimental research study from Seidel et al. (2011), where teachers who analyzed their own teaching also commented less critically as well as identified fewer critically incidents. These (preliminary) findings lead to the conclusion that the use of video from others' teaching might be more useful for activating deeper reflection processes. However, watching someone else teaching

will not necessarily ensure that pre-service teachers will activate professional knowledge and reflect on own beliefs because video may feel too distant to them (Seidel et al., 2011). On the other side, viewing videotaped classroom situations from unknown teachers may provide a safer environment to explore teaching and learning, particularly for novice teachers (Sherin, 2004).

Best-and worst practice or typical classroom practice?

The second issue to consider is, whether pre-service teachers view examples of good/bad teaching practices or videos from typical classroom situations. Given the situated and contextualized nature of teacher knowledge, it is generally emphasized that the selected video sequences should be real enough to pre-service teachers and to be believable (Seago, 2004). In research on teacher learning, it is highlighted that "the most useful video clips were based in situations where there was some elements of confusion (either the students' or teachers') that typically arises in classrooms" (Seago, 2004, p. 267). This assumption is in line with model-based learning (Bandura, 1986), where the most effective models are not those that represent especially good performers instead those in which performers initially have difficulties and model how to overcome the barriers. Other researchers, on the contrary, suggest the use of "good practices" to elicit, develop, and track novice teachers' awareness of alternative teaching methods and approaches (Yung, Wong, Cheng, Hui, & Hodson, 2007). As to my knowledge, so far, no empirical study has systematically explored differential effects of typical versus best/worst practice video examples on knowledge activation for assessment purposes, the use of representative classroom situations where different kinds of quality teaching (positive, negative, ambiguous examples) are visible, is related to the study objective more appropriate. Especially, as different types of teaching approaches and learning situations might be more stimulating and challenging to pre-service teachers (Lampert & Ball, 1998). In this regard, however, it is important that the video clips involve not too much complex and unfamiliar instruction (e.g. teaching situation from another country or culture), which would lead to increased cognitive load (Renkl, Hilbert, & Schworm, 2009).

"Raw" classroom lessons or "edited" selections of classroom sequences?

The third issue that guides the choice of video is related to whether, video excerpts should be unedited versions of classroom lessons or selected and shorter classroom sequences. The advantages of a "raw" version of a videotaped lesson is the real character of teaching maintains (Santagata et al., 2007) and thus, teachers do not need further information about the

context from which it is derived from, what in contrast is necessary when using a segmented video clip (Sherin et al., 2009). Furthermore, the idea is that through the use of an entire unedited lesson more can be learned about teachers' knowledge activation and competence than when using a short sequence of for example 5 minutes, as teachers will comment on much more (Seidel et al., 2009). Although some studies have used a total lesson as knowledge activation stimulus successfully with pre-service teachers (e.g. Rosaen et al., 2008; Santagata et al., 2007; Schwindt, 2008), researcher also caution that unedited and too long videotaped examples may overload pre-service teachers (e.g. Brophy, 2004b). For Seago (2004) another disadvantage of using an entire lesson is related to the ""couch potato" syndrome, e.g. the habit of television viewers to watch a TV screen passively and take in the content in a linear fashion" (p. 268). Segmenting and editing the video into smaller units and providing background information may in contrast prevent such overload and passive behavior (Brophy, 2004b). The next question, which arises then, is what lesson parts should be selected and even more important on what basis should the selection take place.

Beside the widespread consensus that the selected clips should represent authentic teaching and learning situations as well as common happenings during instruction and thus, interesting prompts, the chosen segments should base on a theoretical framework in order to identify sequences that are particular relevant to the study context (Seidel & Stürmer, 2014). Most of the research, so far, has drawn on Shulman's conceptualization of teacher knowledge and learning theories, especially on pedagogical content knowledge in the domain of mathematics (e.g. Kersting, 2008; Jacobs et al., 2010; Roth, 2009; Seago, 2004; Star & Strickland, 2008; Sherin & Van Es, 2009). In this domain-specific research area, dimensions like the mathematical importance of the unit, the extent to which a clip provides insight into students' mathematical thinking, teaching strategies, and interactions between teaching and students' mathematical learning, played key roles in the video selection process (Sherin et al., 2009; Sherin, 2004; Seago, 2004). In the field of general pedagogical knowledge, sequences are chosen on the basis, if teaching instructions that are particular relevant for student learning are shown, either in the way that a positive example is shown or in the way that the videotaped teacher lacks to foster student learning by considering also the grade of teaching (Gold, Förster, & Holodynski, 2013; Seidel & Stürmer, 2014; Wiens et al., 2013).

Within the selection of video sequences, a last important aspect with regard to the later analysis of pre-service teachers' comments on the video clip has to be considered. Given the fact that pre-service teachers' responses are based on subjective comments on the observed video clip and that the theoretical framework, which is suitable for the choice of situations

related to the study objective, do not provide information, if pre-service teachers' knowledge activation is right or wrong in a specific classroom situation, it seems necessary to have information on the content of the video clip from a more objective point of view. For example, a pre-service teacher might notice an event involving goal setting and reason that student learning was encouraged in the video (which would be classified as activation of knowledge), but an expert in the field of teaching and learning viewing the same video would reason that student learning actually was not being encouraged. Thus, a criterion-referenced norm, which provides details what actually can be noticed and reasoned from an expert point of view may be suitable in this context. This issue is mostly not taken into account in current video-based approaches so far. To address this issue, I choose for this research study videotaped classroom sequences, which experts in the field of teaching and learning research analyzed with regard to the implementation of the specific teaching and learning components of goal clarity and learning climate. In the method sections of this thesis, I will provide further information on that.

In sum, several features of video has to be carefully considered when selecting video material for the use with pre-service teachers' knowledge activation, and the choice should depend on the study objective in mind (Kane, 1994). For this research study, external, typical-practice, and edited video clips eliciting situations related to the effective teaching and learning components of goal clarity and learning climate seem suitable, as the aim is to activate a reflective stance and to provide pre-service teachers with video material that stimulates, but do not cognitively overloads them.

4.2.2 Elicitation of cognitive learning processes

In the previous part I referred to the aspect, that the choice of video material matters for activating pre-service teachers' knowledge. Now, I will turn to methodology approaches, applied so far for studying pre-service teachers' cognitive processes indicated as knowledge activation during noticing and reasoning in the context of professional vision.

Overall, the methodology approaches applied build upon the same understanding, that pre-service teachers' abilities to notice and reason about the chosen videotaped classroom situations give insight into pre-service teachers' knowledge structure in the domain of interest (Wiens et al., 2013). Although, the current analysis approaches applied vary between research studies with regard to qualitative and quantitative methods, the developments in this field indicate that the task of noticing and reasoning about video clips of teaching and learning situations is becoming an accepted proxy for studying cognitive learning activities and

knowledge application during instruction, critical for teaching and student learning (Kersting et al., 2010). In the following, I present a selection of video-based research attempts, assessing pre-service teachers' cognitive processes in the field of professional vision through different qualitative and quantitative methods.

One qualitative video-based approach was applied by Santagata and Guarino (2010) to explore pre-service teachers' learning with regard to attending to relevant elements of teaching and to reasoning about teaching within a mathematics teacher preparation course based on the "Lesson Analysis Framework". To examine pre-service teachers' learning processes, they were asked at the beginning and the end of the lesson analysis course to watch a videotaped lesson and to describe and comment on interesting events with regard to teachers' actions, students' learning, and mathematical content. Based on an former study (Santagata et al., 2007) and on previous research on teacher noticing (Van Es & Sherin, 2002), the authors coded the *quality of descriptions* (vague vs. detailed) indicating pre-service teachers' noticing abilities, as well the *commentary* of each pre-service teachers was coded along *different quality levels* (descriptive, separate elements, integrated) indicating their reasoning abilities. The analyses replicated findings from previous studies with Italian pre-service teachers (Santagata & Angelici, 2010; Santagata et al., 2007) and showed that pre-service teachers significantly improved their noticing and reasoning abilities. Despite the fact that the 'Lesson Analysis Framework' provides a promising approach to measure pre-service teachers' learning process, it becomes clear that the theoretical distinction between noticing and reasoning is given up in their analyses. Besides, no conclusions can be drawn if pre-service teachers' noticing and reasoning abilities are based on professional knowledge necessary to develop professional vision.

Star and Strickland (2008) used video to study pre-service mathematics teachers' 'observation skills', as they call it, particularly pre-service teachers' ability to notice or attend to instructional features. The authors investigated also the impact of viewing videotaped classroom situations on their noticing abilities. In a pre-post design, pre-service teachers' were asked to observe a classroom video (two different videos per measurement time), while they were able to take notes during watching. Afterwards, they should answer questions developed by the research team and targeting noticing of *classroom environment*, *classroom management*, *tasks*, *mathematical content* and *communication.* These noticing categories served also as framework for the teacher education course. One special feature of the study is that Star and Strickland implemented a criterion reference norm to validate the questions and to have a reasonable approach what pre-service teachers could notice. Therefore, six

experienced teachers answered the questions with regard to the specific video clips. Questions on which only two or less of the six experts got the correct answer, were eliminated. The results on the pre-assessment show that pre-service teachers have not well-developed noticing abilities when they enter teacher training. However, they can be developed over time as the post-assessment indicated, particularly with regard to noticing static features of the classroom environment, mathematical content of a lesson, and teacher and student communication. In sum, this study adds new information to what different kinds of classroom events pre-service teachers focus their attention when observing a lesson, and it provides a new and valid recall methodology for studying pre-service teachers' noticing. Unfortunately, the development of pre-service teachers' noticing was studied with two different video clips, as well as the interaction with the component of reasoning has not been investigated.

In contrast, the study from Schwindt (2008) investigated through a video based approach the quality of pre-service teachers' reasoning abilities in more detail. One of her research interests was to explore the impact of experience and knowledge on reasoning abilities. Thus, the sample included beside pre-service teachers, in-service teachers, and school inspectors. It was assumed that pre-service teachers have a differentiated level of knowledge and little experience, in-service teachers vice versa, and school inspectors possess an integrated knowledge base and extensive practical experience. Differences to the two reported studies above are that the domain of study was subject-independent and thus, not related to mathematics teaching, as well as the assessment was not part of an intervention study. During the assessment task, pre-service teachers observed an entire Physics lesson and were asked to analyze the classroom interactions based upon questions targeting specific teaching and learning components. For example, pre-service teachers should reflect upon the way in which goals were addressed and clarified, how teachers interacted with students, whether students were willing to admit a lack of understanding or misconceptions, and the way in which experiments were embedded in the lesson. Afterwards their written comments were analyzed based on a coding scheme, which included the five categories of *analysis process ('Analyseprozess'), focus on specific events ('Fokussiertheitsgrad der Analyse'), classification of events against the backdrop of knowledge ('Umgang und Art der Klassifikation'), quality of written comments ('Qualität der schriftlichen Dokumentation'), dealing with critical incidents ('Umgang mit Wertungen')*. Each category was furthermore divided into different quality levels. Overall, the findings reveal that pre-service teachers' comments are characterized by detailed descriptions and explanations of relevant events and enriched by much additional information on irrelevant aspects. Furthermore, subjective

beliefs and theories are integrated as well as pre-service teachers are not yet able to comment on critical incidents and to propose teaching alternatives. The other two expertise groups provided a more global analysis of the videotaped classroom lesson. This study adds another valuable contribution to the description of the quality of pre-service teachers' reasoning abilities and gives insight into their ability to activate and apply professional knowledge to the authentic classroom situations. Nevertheless, it would have been interesting to apply the coding scheme to the different teaching and learning components individually in order to make also statements about the first component of professional vision (noticing), as it can be assumed that attention processes drive their reasoning.

There are additional research studies, which implemented standardized video-based approaches to examine pre-service teachers' cognitive learning processes in the context of professional vision.

For example, Wiens and colleagues (2013) developed the online tool "Video Assessment of Interactions and Learning: VAIL" to measure pre-service teachers' knowledge of effective teaching, when they were analyzing videotaped pre-kindergarten English language arts lessons. After watching a video clip, pre-service teachers were asked in an open-ended format to identify five effective teaching strategies and provide for each a specific example taken from the video. The videos and questions focused on the following three dimensions of effective teaching: emotional support indicated by regard for student perspective, classroom organization represented through instructional learning formats, and instructional support through the indicator of quality of feedback. The tool was originally developed for in-service teachers and firstly applied to the context of teacher education in order to analyze its usefulness for assessing pre-service teachers' learning. With regard to the analysis approach, pre-service teachers' responses were coded for naming a strategy indicating knowledge of effective strategies, and for the example indicating pre-service teachers' ability to identify effective teaching behaviors in authentic classrooms against a master code list. Additionally, it was coded whether the example was an accurate example of the strategy identified, as well as the number of unique applied strategies to each dimension of effective teaching was analyzed. The findings revealed that pre-service teachers showed consistent abilities over all three video clips with regard to identifying effective teaching behaviors measured by the example category. With regard to the three dimensions of effective teaching strategies, pre-service teachers gave the most examples related to classroom organization than to emotional support or instructional support. But with regard to articulating an effective strategy indicating their understanding and knowledge behind, the dimension of instructional support

showed the highest means. Overall, pre-service teachers were better able to identify effective teaching behaviors by giving examples than to name the effective teaching strategy behind. These results indicate that pre-service teachers may know what effective teaching looks like, however, fail to understand why those teaching actions are effective or demonstrate only a superficial understanding of effective teaching. These results give promises that the VAIL instrument can be used as a standardized tool to diagnose the development of pre-service teachers' cognitive learning processes with regard to knowledge about effective teaching in pre-kindergarten English language arts lessons. Nevertheless, its sensitivity to changes over time has to be tested beforehand. Furthermore, it should be tested if video clips showing pre-kindergarten lessons are appropriate for testing pre-service teachers pursuing teaching licenses for elementary or secondary education.

Similarly, Kersting (2008) developed a standardized video-based assessment approach to measure teachers' knowledge of teaching mathematics indicated by their ability to notice and reason about events along the four dimensions of mathematical content, student thinking, alternative teaching strategies, and quality of interpretation. Despite that this measure has not been tested in teacher education so far, Kersting's findings contribute again to the assumption that the standardized use of video clips is a valid approach to assess teachers' professional vision indicating their knowledge structure. Furthermore, as Kersting and colleagues (2010) could confirm the predictive validity of this instrument for the success of teachers' students in a mathematics achievement test, the usefulness of examining pre-service teachers' competence development and knowledge growth that will lead to effective teaching practice becomes one time more visible.

In the context of German pre-service teacher education, standardized video-based measurement tools also have been developed recently in order to diagnose pre-service teachers' cognitive learning processes in the context of professional vision (Jahn, Stürmer, Seidel, & Prenzel, accepted; Seidel & Stürmer, 2014) and to design and evaluate interventions (Gold et al., 2013). For example, in the study from Stürmer, Seidel and colleagues (2013) the computer-based online instrument, the *Observer Tool* (Seidel, Blomberg, & Stürmer, 2010b) was used to examine pre-service teachers' changes in knowledge-based reasoning over a theory-practice term. Within this special term pre-service teachers had practical experiences in schools combined with theoretical courses held at the university. One of these courses was a video-based course focusing on effective teaching and learning components. At the beginning and the end of this course, pre-service teachers had to take part in the video-based

assessment. The *Observer Tool*[1] combines six video clips of classroom situations from secondary education featuring two of three teaching and learning components (goal clarity, learning climate, teacher support). These clips function as prompts for the following standardized rating items tapping the two components and varying in their difficulty with regard to the three knowledge-based dimensions of reasoning (description, explanation, prediction). The mean of three expert answers to the rating items with a 4-point rating scale (*disagree; disagree somewhat; agree somewhat; agree*) are used as criterion reference norm. Overall, pre-service teachers reasoning abilities changed over the course of the theory-practice term positively, especially with regard to predicting consequences on students' learning process indicating that higher order knowledge structures have been developed. Detailed analysis, however, revealed differential effects of changes with regard to pre-service teachers' entry level in their reasoning ability. Pre-service teachers with a low entry level indicated by a low agreement with the expert rating seemed to benefit the most, as their reasoning ability improved over all three dimensions with strong effect sizes. Pre-service teachers, who had already at the beginning a better matching with the expert rating, remained stable within their reasoning abilities. Different conclusions can be drawn from these results: First of all, it seems possible to develop and implement standardized video-based assessment tools that are sensitive to changes in teacher education. Secondly, it indicates that pre-service teachers cannot be assumed as a homogeneous group regarding the quality of their knowledge structure and in turn, in their competence development. However, nothing can be said about if pre-service teachers would have been able to identify the teaching and learning components by themselves, like it is for example assessed with the VAIL instrument, as rating items direct their attention towards them. Thus, questions with regard to changes in their noticing process remain open. Furthermore, it would have been interesting to learn more about the reasoning abilities in the different dimensions, as results from Wiens and colleagues (2013) suggest differential knowledge structures and skills.

A similar standardized approach was developed by Gold and colleagues (2013) to evaluate a video-based training, fostering pre-service teachers' professional vision in the context of classroom management. The instrument includes seven short video clips showing lessons from primary education and tapping the classroom management facets of withitness, organizational structuring and group focus, which are followed by content-related standardized rating items. The video clips have been edited from entire videotaped classroom

[1] More information will be provided in the specific method sections of this thesis, as parts of the *Observer Tool* are included in this research study.

lessons and were validated by primary education teachers with regard to their authenticity and representativity of the chosen classroom management facets. Responses to the rating items from three research experts in the field of classroom management build in this approach also the norm, to which pre-service teachers' answers are compared to. Despite that, the video selection procedure differ to those of Seidel's research group in the way that each video clip represents three classroom management facets under investigation. Furthermore, the rating items in the instrument from Gold and colleagues (2013) differ between the video clips as well, as they are dichotomous (*disagree*; *agree*). In this context, the authors examine knowledge activation within the component of noticing as pre-service teachers have to decide if a specific and effective teaching behavior is visible or not. Whereas in the *Observer Tool,* pre-service teachers have to activate knowledge in order to describe, explain and predict the impact of a specific teaching behavior on student learning. Significant differences at the end of the intervention could be measured between the participating and non-participating pre-service teachers with regard to noticing the facets of organizational structuring and group focus, but not for withitness. Thus, this study shows one time more that professional vision is a knowledge-guided process and that elements of relating theory to practice examples can foster the acquisition of professional knowledge and transfer to classroom situations. However, it remains an open question, why the participants have not outperformed in all three studied classroom management facets. One possible reason could lie within the assessment approach itself, as the items targeting the classroom facets are dependent from the video clip. As the authors pointed out, that one video clip (No. 1) was rated as less representative than the other video clips by the teachers and as this clip represents specifically the facet of withitness, further studies should prove the validity of the instrument.

Overall, qualitative and quantitative methods have contributed to the investigation of pre-service teachers' knowledge activation in the context of professional vision. Noticing and reasoning studied with an open-format as qualitative state-of-the-art approach focus on descriptions about the quality of teacher knowledge and teacher learning over time, taking individual as well as group conditions into account. Thereby, the content of the noticed elements and the reasoning that ensued are put into categories, which include aspects of active persons (teacher, students), content (pedagogical or general), or student thinking processes. These categories are developed based on the context of the subject under investigation (e.g. mathematics education). Findings from these qualitative studies have contributed to characterize (pre-service) teachers' professional development in the light of Berliner' s (2004)

five stage model of expertise development. However, data analysis is time consuming and thus, most of the times not applicable to a large sample group.

In contrast, quantitative measurements, where (pre-service) teachers are faced with classroom video clips and are asked to evaluate the clips based standardized rating items, aim to empirically model and test the descriptive knowledge gained from qualitative research (Kersting, 2008; Seidel & Stürmer, 2014). Findings indicate that the use of video and standardized rating items is a valid approach to measure pre-service teachers' abilities to notice and reason about classroom situations, and to assess their knowledge. Research in this strand sees potential to integrate such standardized measures of professional vision in a longer run as formative assessment instruments into teacher education, as they are from a time-benefit-analysis more appropriate than qualitative measures (Seidel & Stürmer, 2014; Wiens et al., 2013).

4.2.3 Issues and problems in assessment approaches

So far, research in the area of professional vision has provided up to now a valid basis for investigating the quality of (pre-service) teachers knowledge structures and learning processes (Seidel & Stürmer, 2014). However, and as it was already partly addressed in the section above, some study aspects have to be critically discussed and leave room for improvement and future research. For example, the analysis approaches in research on (pre-service) teachers' professional vision have not been applied in combination to allow the results gathered using the different methods to be compared. Given the advancements in the field, it can be argued for future research to validate findings on the basis of mixed-method approaches.

Neither do previous studies, using video as prompt, provide detailed information about the reasons for their video selection; and do not provide specific information on the content of the videotaped classroom situation. For example, by stating what actually could be noticed and reasoned from an expert point of view.

Furthermore, some studies have analyzed pre-service teachers' noticing process, some studies focused on their reasoning, and still others did not separate between noticing and reasoning in their operationalization and investigation. Thus, it remains an open question whether pre-service teachers show different abilities in activating knowledge for noticing and reasoning or and how their abilities are interrelated. Taken the study from Stürmer, Seidel and colleagues (2013) into account, where pre-service teachers showed different entry levels and learning paths with regard to their reasoning ability, it also seems possible that different interrelated

noticing and reasoning abilities exist. In investigating the interrelation of pre-service teachers' noticing and reasoning, it can be assumed that whether the events noticed indeed are relevant to teaching and learning has to be taken into account, as well as whether pre-service teacher's reasoning about the noticed events is adequate – meaning pre-service teachers use their knowledge correctly to interpret their observations. Pre-service teachers, for example, might notice events involving goal setting, but their interpretation of whether goals have or have not been set might be inadequate (e.g. about what constitutes learning goals and how they might differ from merely telling students how the lesson will be structured). Knowledge about these kinds of interrelations could advance the design of learning environments in university-based teacher education to support pre-service teachers in developing professional vision and applicable knowledge structures. Therefore, analyzing pre-service teachers' professional vision in the interrelation of noticing and reasoning as a proximal indicator for their elaboration processes in the context of specific teaching and learning components should be targeted.

In the context that a coherent and integrated knowledge representation is essential for professional vision, also pre-service teachers' knowledge structure or organization, and not just the pre-service teachers' knowledge activation indicating their elaboration processes, is an important component of knowledge acquisition to measure. However, attempts to investigate processes of pre-service teachers' knowledge organization in the context of professional vision by using video as stimulus have not been made so far. In this regard, research in the broader area of cognitive psychology suggests, based on theoretical models of knowledge representations (see chapter 2.2.2.), the use of concept maps as a valuable tool for exploring learners' knowledge structure and learning defined as change in their knowledge organization (McClure, Sonak, & Suen, 1999; Novak, 1990a; Ruiz-Primo & Shavelson, 1996). As learners have to reduce complex information and to construct relationships between concepts as well as to label the semantical relationships within the task of concept mapping, learners' deep cognitive information process of organization is encouraged (Renkl & Nückles, 2006). Hence, the technique of concept mapping might provide also a new successful assessment method for tapping into pre-service teachers' conceptual knowledge structure with regard to teaching and learning components, and their organization processes in the context of professional vision. Thus, I will refer to this methodology in the next section more in detail.

4.3 Concept mapping as a new assessment tool in research on professional vision

Despite that concept maps are far more used as a learning tool (e.g. Novak, 1990a, 1990b; Horton, McConney, Gallo, & Woods, 1993), their potential to use them as an assessment tool have been recognized as well, mostly in the field of science education (e.g. Kinchin, Hay, & Adams, 2000; Lang & Olson, 2000). This issue has led to the fact that a variety of concept-mapping techniques have emerged. On the one hand, it is a great chance to adapt techniques flexible to various assessment situations. On the other side, the diverse definitions of concept maps and operationalization make the comparison and interpretation of the diverse research results difficult. Hence, it is helpful to integrate the concept mapping technique developed in this study into existing frameworks. In this context, also critics have been raised about the technical qualities of concept mapping techniques for assessment purposes (Kagan, 1990). Thus, it is also important to address this issue and to provide findings from teacher education, where concept maps have been used as an assessment tool for pre-service teachers' knowledge organization. All aspects are targeted in the following chapters.

4.3.1 Classification system and technical qualities of concept maps

Ruiz-Primo and Shavelson (1996) propose a framework, which characterizes a concept map used as an assessment tool as a combination of a *task*, a *response format*, and a *scoring system*. Each category is further divided into three components. It is pointed out by the authors that without these three categories, a concept map cannot be regarded as an assessment tool. In the following, I will refer to each category and its dimensions in more detail.

Assessment task

The concrete assessment task for eliciting knowledge organization can vary with regard to following three components. The task includes firstly *demands* given to the learners for constructing their concept maps. The task can, for example refer to filling in a concept map, constructing a concept map by themselves, or responding to an interview. Additionally, *task constraints* lead to different assessment conditions and can vary widely. Such constraints may refer to asking learners only to construct a hierarchical concept map, or to provide them the concepts, or links to use in the task. The third component of *task content structures* refers to the aspect of carefully considering the task demands and constraints with the structure of the knowledge domain to be mapped. For example, a specific knowledge domain may propose a

hierarchical map structure while in many other domains different map structures are more suitable.

Response format

The response format refers to the responses, learners make, and is closely related to the characteristics of the task. Three different types of responses have been identified:

The *response mode* describes the tool used for constructing the concept map. Generally, learners are asked to draw a concept map (paper-pencil method), to orally give their response (e.g. interview), or to create a concept map on a computer using a special concept-mapping software. The *format characteristics* reveal how the response is given in relation to the task. For example, if learners are asked to draw a concept map without concepts provided, the response format only included a piece of paper, whereas a list of concepts is included in the response format when the task provides specific concepts. The *mapper* defines the person or group, who construct the concept map. Beside the individual learner, mappers can be a group of learners or other persons, like teachers or researchers, who are interested in the field of concept mapping.

Scoring system

With regard to evaluating learners' concept maps, a variety of scoring systems can be found. Overall, they can be differentiated into three general scoring strategies. *Scoring components* of a concept map refers to the first strategy and evaluates the concept map, for example with regard to numbers and accuracy of concepts, links, propositions, or hierarchy levels. The second strategy, the *use of a criterion map*, compares learners' concept map with a concept map generated by an expert in the knowledge domain. For example, the expert map can be defined through individual experts, like the course instructor or teacher, as well as by an average of experts or top learners. The degree of overlap is then used as an indicator for the quality of learners' knowledge structure in that domain, what implies the existence of an "ideal knowledge organization". Finally, a scoring system consisting of a *combination of components and a criterion map* can be applied. For example, learners' as well as experts' maps are scored parallel and afterwards, the score of learners' map score is divided by the criterion map score to give a percentage for comparison. Another combination could be to count the number of presented or absented concepts, links or propositions in learners' concept maps in comparison to the criterion map.

Overall, the framework from Ruiz-Primo and Shavelson (1996) reveal that concept mapping techniques can vary widely with regard to tasks, response formats and scoring systems applied. Thus, the way how learners' knowledge organization is elicited differ between the many studies enormous. This fact, lead for the authors, to the conclusions that a cognitive theory is needed which can drive the preference for one or another technique.

A theoretical framework is also necessary for providing information on the psychometric characteristics of concept maps, especially as the quality criteria of *objectivity*, *reliability* and *validity* (Bortz & Döring, 2006) are critical for appropriate concept mapping techniques used as alternative assessment forms. However, in their review article on concept maps used as assessment tools, Ruiz-Primo and Shavelson (1996) summarized information on the technical qualities available from research, and came to the conclusion that only very few studies have addressed these issues. Also McClure and colleagues (1999), and Kagan (1990) point out that many study results gathered by concept mapping have to be discussed with caution and circumspection. In the following, I refer to each test criteria and summarize issues that need to be addressed, when using concept maps for assessment. This information build another basis for exploring and discussing concept mapping as a potential assessment tool for pre-service teachers' organization processes about specific teaching and learning components in the context of professional vision.

Objectivity

The objectivity of a concept mapping task describes, if the concept mapping scores are independent from the tested person (Bortz & Döring, 2006). An objective concept mapping assessment is ensured, when its task, analysis, and interpretation are independent from the learner, and when it provides the same results for the same learners. The use of standardized instructions and assessment conditions, for example, help to ensure a high objectivity. The use of a coding manual is necessary to obtain a high analysis objectivity, and a criterion norm can be useful for the interpretation objectivity. This first quality criteria is addressed by very few research studies explicitly, as Stracke (2004) points out. Reasons for that are seen in the fact, that it is more or less "easy" to fulfill this first quality criterion.

Reliability

Reliability refers to the consistency or generalizability of the concept mapping responses. In the context of concept mapping, the indication of interrater agreement or reliability is a

common procedure. In studies indicating this quality criteria, most of the time high reliability coefficients (r = .80 and above) are reported (e.g. Barenholz & Tamir, 1992; Herl, O'Neil, Chung, & Schacter, 1999; Lay-Dopyera & Beyerbach, 1983). However, these studies do often not specify the procedure used to establish agreement or the number of raters involved. Furthermore, a high inter-rater agreement is also assumed, even if only a small selection was coded by more than one rater. Beside, a high inter-rater agreement is also found over various scoring systems, independently if the number of specific components is counted, or if the responses were analyzed with regard to their validity (Ruiz-Primo & Shavelson, 1996). In the first case, a high interrater agreement can be more easily assumed. Research indicates that raters also can score complex data reliably, however, have to be trained properly. How stable map scores are across time is another aspect of reliability (Bortz & Döring, 2006). Against the backdrop that concept maps are often used to assess learning regarded as changes of knowledge structures within a specific learning environment, it is often not possible to address this issue. Thus, only a small number of studies have reported test-retest-reliability of concept mapping (Lay-Dopyera & Beyerbach, 1983; Stracke, 2004).

Validity

Another essential criterion is validity, which refers in the context of concept mapping, according to Ruiz-Primo and Shavelson (1996) to "the extent to which inferences to students' cognitive structures, on the basis of their concept map scores, can be supported logically and empirically" (p. 592). One aspect, which should be considered is *content validity* indicating based on a theoretical framework, whether the concept map provides a sensible representation of the knowledge under study. The use of experts in that domain is regarded as one criterion to evaluate the representativeness and accuracy of maps within that knowledge domain. So far, when experts were involved, they provided information which concepts and relations necessarily should be included in a representative concept map (Anderson & Huang, 1989; Stracke, 2004; Wallace & Mintzes, 1990). *Instructional sensivity* of concept maps – another relevant criterion – is given, if the structure and organization of concept maps differ after learners have received instruction. For example, some studies counted concepts (e.g. Lay-Dopyera & Beyerbach, 1983), others focused on the complexity and on organizational patterns (e.g. Wallace & Mintzes, 1990). Despite the various analysis methods, the studies using a pre-post design mostly show a knowledge increase or revealed a knowledge restructuring process. Thus, it can be assumed that concept maps are sensitive to measure changes in pre-service teachers' knowledge structures. Another validation form of concept

mapping is related to *known group differences* (Ruiz-Primo & Shavelson, 1996). Studies examined so far, if concept maps can differentiate among groups with different expertise in the content domain under study. Previous studies indicate that concept maps are sensitive for group differences, and showed that the structure from high-achieving students is more complex and shows more connections within and between levels than the structure of low-achieving students. Similar results are found in comparisons between advanced and beginning students at university and novices and experts (Koponen & Pehkonen, 2010). For example, Acton, Johnson and Goldsmith (1994) compared three expertise groups in the field of physics (course instructor, individual experts, top graduate students) and found, that the map mean scores were higher for experts than for top students, as well as the experts' map varied substantially among themselves, however were more similar than the group of students' map. Although this study reveals that concept maps can differentiate different expertise groups, it also indicates that using a criterion map to evaluate learners' concept map score might be problematic. Due to the fact, that experts' maps are not as similar as expected, different conclusions about learners' knowledge structures are drawn depending on the expert selected. Finally, some studies reported results with regard to the *concurrent validity* of concept mapping, by comparing concept mapping scores with other achievement tests, like multiple-choice tests, standardized achievement tests, or degrees. Overall, diverse findings ranging from moderate, negative till highly significant positive correlations have been reported. Reasons for that are seen in the fact that concept maps are considered to measure a somehow different type of knowledge than the so far, applied achievement tests. The study from Stracke (2004) provides a first evidence that designing both, concept mapping task and achievement test, according to the same underlying theoretical framework (e.g. Bloom's learning taxonomy) may help to overcome this barrier and provide valid concept mapping results.

In a nutshell, concept map assessments are characterized as a task, response format, and scoring system, which can vary widely in the way they elicit the organization processes. In order to provide reliable and valid results, an underlying theoretical framework as well as empirical findings, which help to narrow the number of possible techniques to manageable alternatives, should guide the development of the concept mapping technique (Ruiz-Primo & Shavelson, 1996). The underlying theoretical basis, which guided decisions about the concept mapping technique developed for Study 2, has been already presented in previous chapters, specifically with regard to the assumed knowledge representation (paragraph 2), the content domain (paragraph 3) and the application context (paragraph 4).

Nevertheless, empirical findings providing information on the four criteria of *"appropriateness of the cognitive demands required by the task, appropriateness of a structural representation in a content domain, appropriateness of the scoring system for evaluating the accuracy of the representation, and practicality of the technique*" (Ruiz-Primo & Shavelson, 1996, p. 595) are also absolute for eliminating concept mapping techniques due to the study aim (Yin & Shavelson, 2008). In this context, experimental studies already have been made success in comparing different concept mapping techniques in the field of science education with regard to these criteria. Despite the fact that the studies have not been conducted in the field of teacher education, following results are nevertheless important to this study context (Acton et al., 1994; McClure et al., 1999; Ruiz-Primo, Schultz, Li, & Shavelson, 2001; Yin & Shavelson, 2008; Yin, Vanides, Ruiz-Primo, Ayala, & Shavelson, 2005):

- Within the comparison of different assessment tasks, the demand of filling in concepts is not equivalent to the demand of filling in semantical links into a presented concept map. It is stated that both tasks assess similar, but not identical aspects of learners' knowledge and understanding.
- The "construct-a-map-by-yourself" task is assumed to better reflect differences among learners' knowledge structure than the "fill-in-a-presented-map" task, as analysis revealed in general more low performance on constructing a map. Whereas learners' scores with the "fill-in-a-presented-map" task was generally very high. Correlations with scores from multiple-choice tests confirmed the difference between both tasks/techniques.
- Within the comparison of six scoring systems, the scoring method, which evaluated the semantical relations between concepts in comparison to a criterion map, yielded the most reliable scores.
- The use of a criterion map can also be problematic as even experts vary in their concept map construction.
- With regard to the practicality of the scoring method, the "construct-a-map-by-yourself-with-preselected-semantical-links" task is easier to score and produces higher reliability than the "construct-a-map-with-preselected-concepts" task, however, lead to a decrease of validity.

In the following, I will present studies in the field of teacher education, in order to have an empirical basis related to the specific target group of this study.

4.3.2 Empirical findings on using concepts maps in teacher education

Whereas concept maps have been used frequently to identify students' misconceptions in knowledge, their conceptual understanding and change in science education (e.g. Jegede, Alaiyemola, & Okebukola, 1990; McClure et al., 1999; Rice, Ryan, & Samson, 1998; Wallace & Mintzes, 1990), the number of studies assessing (pre-service) teachers' knowledge structure and learning are limited. A few studies, which used concept maps as assessment tools in pre-service teacher education, are addressed in the following.

Ferry, Hedberg and Harper (1997) studied pre-service teachers' use of concept mapping in organizing their curriculum content knowledge over the run of tutorial sessions on concept mapping. The pre-service teachers had to plan science-based instruction for an elementary school class using a computer-based concept mapping tool, as well as a selection of the participants were interviewed and wrote reflective journal's to trace the change process. In their analysis approach, the authors counted the frequencies of linked concepts (propositions) and hierarchical links, as well as they analyzed the concept and link notes. Concept notes were examined with regard to the mean number of words, and the mean frequency of teaching strategies mentioned in the notes. The link notes were coded with regard to their accuracy. Results reveal that in the end of the tutorial session, pre-service teachers' concept maps included a higher number of linked concepts and hierarchical links, as well as the quality of the notes increased. The authors concluded that once the process of concept map construction has been experienced, the use of computer-based concept-mapping tools assisted pre-service teachers to focus on the cognitive processes to organize their knowledge into integrated knowledge frameworks. However, how reliable the results are, has to be questioned, as nothing is said about the analysis process more in detail and the interrater reliability.

In contrast, other studies found decreases in the complexity and organization of pre-service teachers' knowledge structure. In the study from Winitzky and Kauchak (1995), pre-service teachers had to construct a concept map of their own conceptions of classroom management without any concepts provided over four measurement points within a course in an elementary teacher education program, including practical experiences in schools. For the analysis procedure, the qualitative scoring system form Winitzky, Kauchak and Kelly (1994) was adapted as reliability and validity for this scoring method had been established already. Maps were scored for the number of concepts, number of levels, number of chunks (number of groups of superordinate and linked subordinate concepts), width (number of chunks at widest point), and hierarchical structure (levels and width). Beside the quantitative analysis, which revealed a reduction of the complexity with regard to the number of concepts, chunks

and hierarchical structure between the four time points, the authors report a "turbulent" qualitative change in the content and form of the maps. In the beginning of the course, pre-service teachers' constructed more dichotomous maps emphasizing effective versus ineffective management strategies. By the time, concept maps had more a wheel structure, indicating for the authors that they have learned that classroom management is more than "black-and-white, control vs. chaos enterprise" (p. 17). Furthermore, a thematic shift from teacher activities to students learning was visible, as well as the labels became more precise. Similar patterns of knowledge growth have been found by other researchers, using varying methodologies in different knowledge domains. Winitzky and colleagues (1994) found in their study on long-term changes in cognitive structure during pre-service teacher education a gradually increasing complexity from time 1 to time 2, and then between measurement points 3 and 4 a reduced complexity. In the domain of teaching reading, Roehler and Duffy (1986) and Roehler, Duffy, Herrmann, Conley and Johnson (1988) reported similar restructuring processes, and concluded that changes in the knowledge structures are not always linear and continuous rather than characterized by diffusion, stagnation, or regression. Interestingly, practical experiences might contribute to this kind of knowledge change. In the study from Winitzky and Kauchak (1995) pre-service teachers reported in interviews – additionally implemented to get more insight into their memory – that real teaching situations influenced their concept map construction most. Lang and Olsen (2000) also found in maps, drawn before teaching about the same topic, a greater variability of concepts and relations than in the maps created afterwards. Overall, pre-service teachers in these studies have been deeply engaged in knowledge restructuring processes, but this lead to the consequence that concept maps became smaller and simpler over time rather than more complex. Explanations for the different findings from studies, who found an increasing knowledge organization can be related for Winitzky and Kauchak (1995) to the expert paradigm and Anderson's ACT-theory. Morine-Dershimer (1993) used pre- and post-concept maps to study pre-service teachers' conceptual change with regard to teacher planning. She targets in her study the criteria of practicality of concept mapping. She developed a fairly simple scoring system that enabled her to identify knowledge growth, as well as group differences associated with pre-service teachers' certification level and particular features of the learning environment (course instructor). Positive quantitative and qualitative shifts from the beginning of the course on curriculum, instruction and assessment to the end have been identified, which indicate for Morine-Dershimer (1993) the potential of concept mapping for teacher program evaluation.

Also Beyerbach and Smith (1990) used a computer-based mapping program successfully to foster and describe changes in pre-service teachers‘ knowledge organization within the field of effective teaching. During the intervention, pre-service teachers constructed and revised concept maps with a partner and reflected on their mapping experiences with regard to implications for teaching in a learning journal. Comparisons between the first and second maps revealed that pre-service teachers incooperated more concepts in their final map and organized it more hierarchical. Students' reflection on their first maps revealed that their focus was more on learning the new mapping program than on the topic of effective teaching. In the end, they still reported on the mapping program, but much more confident and positive. Furthermore, they reflected more about the topic of effective teaching and were more analytic in their reflections. Over both measurement points, it became obvious that pre-service teachers had a main focus on classroom management, when thinking about effective teaching. These results indicate that the technique of concept mapping has to be introduced very slowly and without feeling performance pressure in order to focus pre-service teachers' attention on the relevant aspect, being fostered or assessed. Furthermore, it shows that concept mapping can serve as a resource to uncover pre-service teachers' thinking and knowledge construction, but also promotes reflection.

Overall, the present studies using concept maps as assessment tool to analyze pre-service teachers' knowledge structure in the domain of general pedagogical knowledge as well as empirical findings from experimental studies are relevant to this thesis, because of two reasons. First of all, the experiences and results gathered within these studies are used for the development of an appropriate concept mapping technique within this research. Secondly, the results show that different domain areas of general pedagogical knowledge are suitable for the assessment with concept maps. However, none of these studies have used concept mapping in combination with video as a prompt for activating pre-service teachers' knowledge. Thus, it is one aim to develop and test a concept mapping technique that is able and sensitive enough to elicit pre-service teachers' organization processes, when analyzing a video clip representing the teaching and learning components of goal clarity and learning climate.

Summarization of the third theoretical paragraph

The last theoretical paragraph dealt with teachers' professional vision and pointed out, why this concept is suitable to assess pre-service teachers' deep cognitive learning processes with regard to effective teaching and learning components. Based on theoretical assumptions and empirical findings, it was outlined that the two included processes of noticing and reasoning

are influenced by knowledge allowing to focus on relevant aspects of classroom situations and their interpretation against the background of theoretical principles. Due to the fact that pre-service teachers are at the beginning of their professional career, they differ in their abilities to notice and reason about relevant classroom aspects from expert teachers, as the presented empirical findings reveal. In order to foster pre-service teachers' knowledge acquisition and professional vision towards greater expertise, the investigation of their underlying cognitive processes is thus, an important research topic.

In this context, state-of the-art measurement approaches eliciting pre-service teachers' deep level processes have been identified. It was shown that video is a valuable tool for activating pre-service teachers' knowledge and that the kind of video material matters. Thus, empirical findings with regard to three aspects (own vs. external video; best/worst practice vs. typical practice; and "raw" vs. "edited" video material) have been presented, as they guided the video selection process in Study 1 and 2.

With regard to the assessment of cognitive processes and study limitations, it stood out that current analysis approaches are of qualitative and quantitative nature, whereas qualitative research is so far more common. Qualitative studies have shown that pre-service teachers' knowledge activation is often determined by detailed and subjective information. Furthermore, pre-service teachers often demonstrate a superficial understanding of effective teaching actions. Analysis approaches in this tradition tend to give up the theoretical distinction between noticing and reasoning, do not include the underlying aspect of knowledge, or focus on domain-specific knowledge. Against this backdrop, the question within the first study of this thesis arises, if pre-service teachers show different abilities in activating knowledge for noticing and reasoning and how their abilities are interrelated as an indicator for the quality of their elaboration processes in the domain of general pedagogical knowledge. As it was also worked out that qualitative research has not been combined with quantitative research, however can be seen as a promising way to validate the analysis approach, Study 1 aims to compare the qualitative results with a quantitative measure of standardized rating items connected to the same video clip.

So far, no research has analyzed pre-service teachers' organization processes in the context of professional vision. To bridge this gap, a research approach from the broader area of cognitive psychology assessing knowledge structure and organization – concept mapping – has been introduced to the study context. Against the background of the theoretical origins of concept mapping, relating to knowledge representation models as addressed in the first theoretical paragraph of this thesis, the potential for using concept maps as assessment tool in this work

became obvious. In this regard a classification system could be identified, which is helpful to make decisions about the concept map assessment technique applied in Study 2 with regard to the categories of task, response format and scoring system. Thus, in a next step findings from experimental studies and from studies in the field of teacher education, specifically have been introduced, which reveal that concept maps are in general sensitive tools to measure differences in knowledge organization, and that knowledge organization processes cannot be assumed to be linear. These studies build the empirical basis for narrowing the number of possible techniques and to ensure valid and reliable results in the investigation of pre-service teachers' organization processes. Specifically, to analyze and describe differences in pre-service teachers' structure-related and content-related organization processes with regard to specific teaching and learning components in the context of professional vision.

5 The present research

The focus of this thesis is related to the assessment of pre-service teachers' cognitive learning processes with regard to the teaching and learning components of goal clarity and learning climate using alternative assessment approaches. As it was outlined in the theoretical part, pre-service teachers' engagement in deep level processes of elaboration and organization is crucial for their knowledge acquisition as these activities foster the integration of new information and the construction of knowledge representations. As a consequence, integrated knowledge about effective teaching and learning components helps pre-service teachers to apply their knowledge to real classroom situations and in turn to create teaching-learning situations that foster student learning. Because of the contextualized and situated nature of teacher knowledge, cognitive learning activities can hardly be assessed with distal measures. Therefore, the analysis in the context of professional vision can provide valuable information about pre-service teachers' engagement in elaboration and organization learning activities in an authentic and situated way. Against this backdrop, the investigation of pre-service teachers' capacities in activating knowledge and organizing incoming information according to existing knowledge when observing and interpreting authentic videotaped classroom situations builds the core element of this work. To analyze pre-service teachers' elaboration and organization processes in the context of professional vision two studies were designed, and where different methodology approaches have been combined.

First of all, research findings with regard to specific effects of video material on the activation of knowledge have been used to select video sequences appropriate for the activation of pre-service teachers' cognitive learning processes within both studies.

For the investigation of pre-service teachers' prior knowledge activation as an indicator for their elaboration processes within Study 1, findings from expertise research and studies on teachers' professional vision have been used to identify relevant analysis criteria. In Study 1, the capacities of 109 pre-service teachers in noticing and reasoning of goal clarity and learning climate and in their interplay will be explored, aimed at answering the following research question: 1) *How can the nature of pre-service teachers' elaboration processes in the context of professional vision be described?*
Thereby, video in combination with an open answering format was used to measure pre-service teachers' elaboration processes. In order to validate the qualitative data, a second

quantitative measure was implemented based on following research question: 2) *Is the qualitative analyses a valid approach for measuring pre-service teachers' elaboration processes?*

Study 2 will describe the nature of pre-service teachers' organization processes by looking at patterns of pre-service teachers' knowledge organization about the teaching and learning components under study. In order to get insight into their knowledge organization, a new assessment tool was required. A small-scale exploratory study was carried out, which combined video with concept mapping. Based on models on knowledge representation and acquisition and on empirical findings from expertise research in teacher education, patterns of pre-service teachers' organization processes are analyzed. In this exploratory study with 27 pre-service teachers, coding frameworks on the basis of empirical research were developed to study organizational components within pre-service teachers' concept maps aiming to answer the following research question: 3) *How can the nature of pre-service teachers' organization processes in the context of professional vision be described?*

In order to test the reliability of the scoring system and the validity of the concept mapping technique with regard to the criteria of instructional sensivity, another research aim targets following question: 4) *Is there an indication that an applied concept mapping technique represents a reliable and valid assessment method to assess pre-service teachers' organization processes?*

Therefore, the study was conducted within a German teacher education program. For this purpose, a course on teaching and learning that included elements of decomposition, representation and approximations of practice (video examples, journal writing) aiming to foster integrated knowledge structures, was used as study context and which also builts the basis for exploring individual differences and learning trajectories of pre-service teachers' organization processes. Thus, Study 2 presents also findings aiming to answer following research question: 5) *What are group-specific differences between pre-service teachers with different knowledge entry levels regarding their organization processes and how can group specific changes throughout an one-term course on teaching and learning be described?*

Figure 5 gives an overview of the empirical part of this thesis, including the foci of the two studies. The detailed research questions of Study 1 are addressed in chapter 6. In the following, Chapter 7 answers the specific research questions of Study 2. In chapter 8, a general discussion will synthesize the results from both studies.

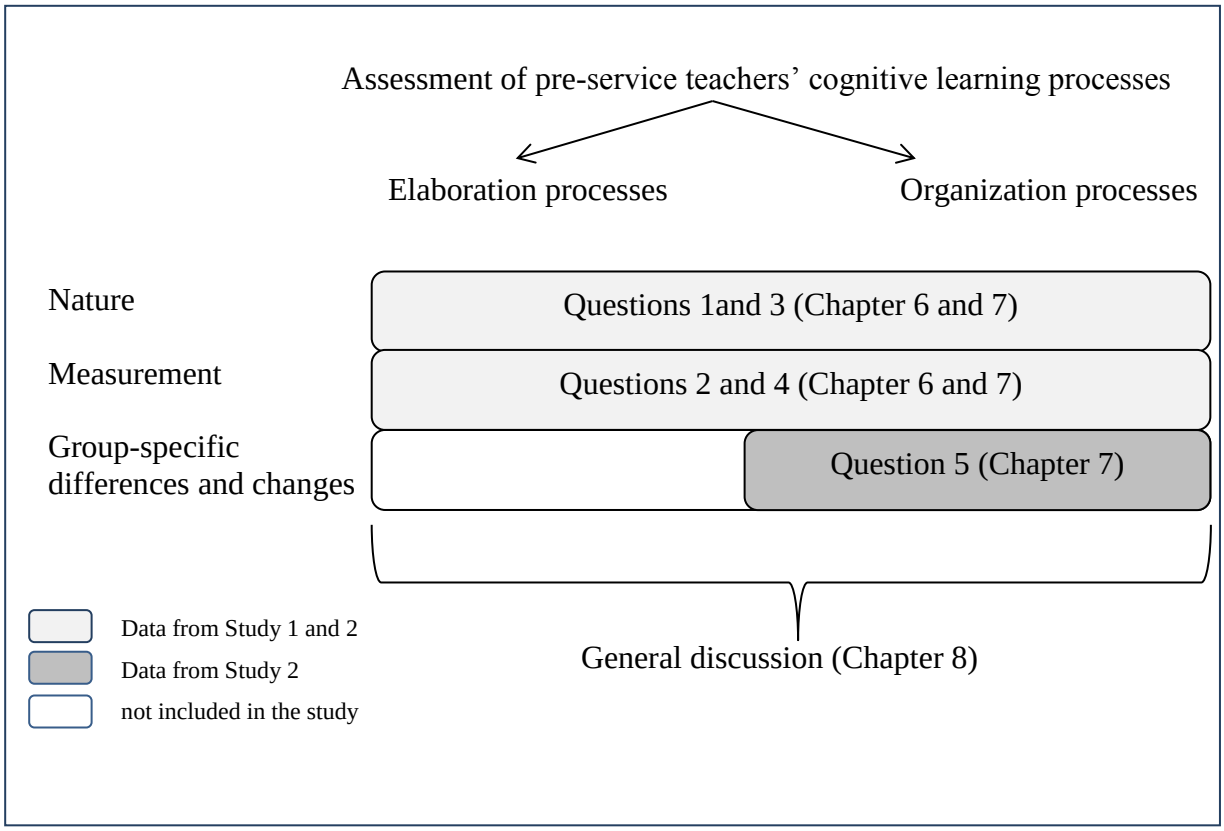


Figure 5. Overview of the empirical part of this thesis.

6 Study 1: Assessment of pre-service teachers' elaboration processes with regard to specific teaching and learning components in the context of professional vision

Knowledge acquisition processes are characterized by encoding, processing, storing, and retrieving of new information, with the aim to apply it later on to new situations (Reinmann & Mandl, 2006). Hereby, the use of elaboration strategies can help to integrate new information meaningful into existing knowledge structures, and with that ensure knowledge application and transfer (Bransford et al., 2000; Friedrich & Mandl, 2006; Krause & Stark, 2006; Schäfer et al., 2012). Therefore, the application of elaboration strategies can be seen as an important issue for pre-service teachers, as classroom situations are characterized by concurrent interactions among multiple persons and events where teachers have to activate their prior knowledge – characterized as an important elaboration strategy – in order to notice and reason about relevant aspects of teaching and learning processes. Thus, the concept of professional vision can serve as an indicator to study pre-service teachers' cognitive learning processes as the contextualized nature of learning and knowledge can be taken into account (Bromme, 1997; Seidel et al., 2011; Seidel & Stürmer, 2014; Sherin et al., 2011; Palmer et al., 2005;). Expertise research in this field indicates that novice and experienced teachers differ in their noticing and reasoning about relevant teaching situations based on differences in their elaboration strategy of knowledge activation, with novices such as pre-service teachers showing minor abilities (Berliner, 2001; Jacobs et al., 2010; Seidel & Prenzel, 2007; Sherin & Van Es, 2009;). However, significant advancements have been made in the study of domain-specific knowledge, pre-service teachers' elaboration processes of generic pedagogical knowledge in the context of authentic classroom situations have not been studied intensively (Blomberg, Stürmer, et al., 2011).

The theoretical model of professional vision proposes that the cognitive processes, involved in noticing and reasoning, are interrelated and the differentiation between noticing and reasoning has proved useful both for studying pre- and in-service teacher learning (Van Es & Sherin, 2002), and for designing learning environments in teacher education (Santagata & Angelici, 2010). So far, studies investigating prior knowledge activation as an indicator for cognitive elaboration processes, involved in the interrelation of noticing and reasoning, put the content of the noticed elements (encoded information) and the reasoning that ensued (processed information) into the same categories, based on the context of the subject under investigation. However, whether the events noticed indeed are relevant to teaching and learning (indicator for the activation of *scientific/professional* knowledge) also has to be

considered when analyzing cognitive elaboration processes, as well as whether the teacher's reasoning about noticed events is adequate when compared to how experts would judge those situations (indicator for a *correct* knowledge activation).

Thereby, research on pre-service teachers' noticing and reasoning has yet not provided comprehensive information about the content of the video material used. This is an important research gap, as it has to be assumed that the material affects, what aspects can be processed with the video (Kleinknecht & Schneider, 2013). Therefore, it has to be defined precisely what future teachers should be able to notice and reason (Gruber & Hascher, 2011).

In addition, knowledge activation processes in the context of noticing and reasoning are studied using video tools (Blomberg, Renkl, et al., 2013; Brophy, 2004a; Krammer et al., 2006). The methodological approach, chosen as state-of-the-art for investigating cognitive processes involved in the interrelation between noticing and reasoning, is qualitative (Borko et al., 2008; Sherin & Van Es, 2009). Advances also have been achieved in developing quantitative measures (Kersting, 2008; Seidel & Stürmer, 2014); findings indicate that the standardized use of videos and rating items is a valid approach to measure teachers' knowledge representations and learning processes. So far, the approaches have not been applied in combination to allow the results gathered, using the different methods, to be compared.

In view of these research gaps, Study 1 was designed to yield new insights into pre-service teachers' capacities to notice and reason about the teaching and learning components of goal clarity and learning climate as indicator for their engagement in elaboration activities during information selection and processing. A video was selected as stimulus on which experts in the field of teaching and learning research agreed that the two pedagogical strategies of goal clarity and learning climate – relevant for student learning – can be noticed and reasoned. The pre-selected video was part of a large-scale video survey in Germany and Switzerland and had been analyzed according to a number of specific observation instruments (Seidel et al., 2007). In addition, the study wanted to validate the state-of-the-art qualitative approach by comparing the results achieved with the results of a second, quantitative measure of pre-service teachers' activation of prior knowledge during reasoning (information processing).

The next section (6.1) specifies the research questions, followed by the outline about the methods used to answer the research questions (section 6.2). Afterwards, the results are presented (section 6.3) and discussed (section 6.4). Main results of this study will also be published in a manuscript in the near future (Schäfer & Seidel, accepted).

6.1 Research questions

The first study addresses the following four research questions, focusing on pre-service teachers' elaboration processes during noticing and reasoning:

1) What do pre-service teachers notice when they observe a pre-selected video of a classroom situation? To what extent do pre-service teachers notice relevant pedagogical strategies in teaching and learning components (goal clarity and learning climate) as an indicator for the activation of professional knowledge?

Answers to this research question indicate pre-service teachers' capacities to activate elaboration processes during information encoding/selection.

Findings from research analyzing novice and experienced teachers' noticing have shown that pre-service teachers often struggle in attending towards instructional significant aspects and instead, turn towards more superficial characteristics and static features of the shown classroom situation (e.g. interior design, teacher speech habits/clothing). The explanation for that is related to the fact that pre-service teachers have not developed schematically organized knowledge categories and case knowledge that help them to distinguish between important and unimportant aspects. However, research in the field of general pedagogical knowledge also revealed that pre-service teachers successfully acquire general pedagogical knowledge within teacher education, which in turn should help them to activate this knowledge to notice relevant teaching and learning components as the effect of professional knowledge is defined as a shift in the categorial perception of classroom situations. Nevertheless, it is also known that pre-service teachers often have developed inert knowledge and thus, have problems to activate their theoretical knowledge learned in university in real classroom situations.

The following hypothesis is assumed:

Pre-service teachers have difficulty in noticing aspects of events that are related to goal clarity and learning climate, as they require a deeper understanding of teaching and learning processes. Because of this, pre-service teachers often focus on other and more literal aspects of the shown classroom situation. At the same time, it can be assumed that pre-service teachers are already able to notice a number of events that are representative of the two teaching and learning components as identified by experts as they already took part in courses on teaching and learning within their teacher education program.

2) Do pre-service teachers base their reasoning about noticed teaching and learning components on professional knowledge?

The answer to this second research question indicates pre-service teachers' capacities to activate elaboration processes during information processing. Two sub-research questions are targeted:

a) Is professional knowledge integrated with regard to linking classroom observations about teaching and learning components (goal clarity, learning climate) to explanations and predictions based on principles of teaching and learning?

Empirical findings show that novice teachers do not have developed complex and connected knowledge structures, what in turn affect not only their ability to attend to relevant aspects but also to process relevant information based on subjective assumptions and beliefs. Similar as for the noticing process, pre-service teachers' reasoning capacity can be developed through the acquisition of professional knowledge. However, when pre-service teachers' knowledge remains inert or when they develop only a superficial understanding, beliefs and preconceptions are often used to deal with complex, ill-defined classroom situations. Based on that, following assumption is made:

Only a small number of pre-service teachers will show elements of activating professional knowledge in an integrated way when reasoning about noticed elements with regard to goal clarity and learning climate. In comparison, most reasoning about the noticed elements is based on naive assumptions and beliefs.

b) Is the content of pre-service teachers' reasoning comparable to expert reasoning about the video?

So far, a few studies have analyzed pre-service teachers' reasoning and their activation of professional knowledge in comparison to how experts would interpret relevant situations. However, these studies do not take the content of pre-service teachers' reasoning into account. For example, pre-service teachers may know what defines effective teaching and may apply their professional knowledge to reason about the noticed situation, however, they still may construct arguments about those events, which lack evidential support and coherence and in turn, wrong conclusions are drawn. The correctness of the reasoned event in comparison to experts' argument is thus, crucial to this study. Consequently, the following exploratory hypothesis is made:

Due to the limited formal and practical knowledge about teaching and learning, pre-service teachers show little agreement with the judgements and conclusions of experts.

3) Are pre-service teachers' capacities in noticing systematically related to their reasoning capacities about teaching and learning components (goal clarity, learning climate)?

In order to gain greater insight into teachers' elaboration processes in the context of professional vision, and to provide specific information for the design of instruction in teacher education, the relationship between pre-service teachers' capacities in their noticing and reasoning about goal clarity and learning climate is targeted. So far, studies conceptualize a connection between the two knowledge-based processes; however it is less clear how they are interrelated. *In turn, a systematic interrelation between noticing and reasoning is assumed. However, with respect to pre-service teachers, various kinds of interrelations are conjectured. Pre-service teachers might be able to notice aspects of teaching and learning components and show a pattern of reasoning that uses some kind of knowledge integration, but still may not come to conclusions similar to those of experts. Therefore, various kinds of interrelated noticing and reasoning abilities are ascribed to pre-service teachers.*

The fourth research question addresses a methodological aspect. Answers to that are important with regard to the validity of the qualitative measure of pre-service teachers' elaboration processes.

4) Are results of the qualitative analyses validated by comparing them to a second, quantitative measure of teacher reasoning?

Studies, mixing different methodology approaches to validate study results barely have been conducted in the field of professional vision so far. *A positive correlation between teacher reasoning as measured by the qualitative analysis and as measured by the second, quantitative measure will indicate, to what extent the qualitative measure is functioning as designed: to elicit pre-service teachers' elaboration processes in the interplay of noticing and reasoning.*

6.2 Methods

Aim of the present study is to draw conclusions about pre-service teachers' elaboration processes assessed by a situated and contextualized measurement approach. Therefore, it is examined if pre-service teachers draw on elaboration learning activities when they notice and reason about authentic teaching and learning situations, how their skills are interrelated, and if the qualitative measurement approach can be validated through a quantitative measure. This chapter aims to illustrate the methodological approach applied to answer the research questions for Study 1. Firstly, I will address the research design (section 6.2.1). Subsequently, the sample of the study will be described (section 6.2.2), and the data analysis approach will be explained (section 6.2.3).

6.2.1 Research design

The present study uses data collected within the second phase of the DFG-project *Observe* (Schwindt et al., 2009; Seidel et al., 2010a). As it was outlined in the introduction, the project focused on the assessment of pre-service teachers' professional vision about specific teaching and learning components as indicator for integrated general pedagogical knowledge. Therefore, a video-based online-tool, the *Observer Tool*, was developed in the first project phase and tested within various study contexts at university-based teacher education in the second project phase (Seidel & Stürmer, 2014).

In the following, I will address the study context related to this work and present how the data collection took place. Furthermore, I will give an insight into the development and structure of the *Observer Tool*, as it builds the basis of the current study. Specifically, I will point out the instrument parts which are crucial for answering the present research questions.

Study context and data collection

The study is based on the structure of German teacher education programs, in which pre-service teachers are required to study two teaching subjects. At the Friedrich Schiller Universität, Jena, in which the present study was conducted, students seek for a secondary teaching credential for upper secondary school (Gymnasium) or for lower secondary school (Regelschule) in their teaching subjects. In addition, students have to acquire general pedagogical knowledge in educational studies courses. One of the four fields of educational studies is related to educational psychology, offering courses on generic aspects of teaching and learning. As this study focuses on general pedagogical knowledge about effective teaching and learning components, the data collection took place in the context of a lecture on

core principles of teaching and learning in the winter term 2009/10. The course enrollment was obligatory for pre-service teachers, who studied in their third year of teacher education independent from their subject-specific or schooling background. As pre-service teachers also spent an amount of time with observing teaching during this term, the course was designed to foster pre-service teachers' knowledge acquisition processes with regard to effective teaching and learning components as addressed in the theoretical part of this thesis, as well as to train their noticing and reasoning skills through the use of video cases. In the first lecture, pre-service teachers were introduced to the obligatory course requirements, where the study participation was one of them. In this context, pre-service teachers were given a link to a website hosting the assessment instrument (*Observer Tool*), and were asked to complete the assessment within the following two weeks.

Data for this study consists of pre-service teachers' responses to one part of the *Observer Tool*. Thus, its structure will be introduced in more detail in the next section.

The video-based online instrument (Observer Tool)

Based on experiences and findings from the DFG-project *LUV* (Seidel et al., 2009), the *Observer Tool* (see figure 6) was developed to assess pre-service teachers' noticing and reasoning with regard to three teaching and learning components (goal clarity, learning climate, teacher support) in an situated yet standardized way (Seidel et al., 2010a; Seidel & Stürmer, 2014).

Figure 6. The *Observer Tool*: Front page.

The assessment tool includes video clips of classroom situations from various subjects, followed by an open answering format connected to the first video clip, and standardized rating items related to all video clips. The internet platform for the online-tool is provided by 'globalpark'. When pre-service teachers start working with the *Observer Tool*, they firstly receive basic information about the practical handling of the instrument as well as a

theoretical introduction into the three effective teaching and learning components, as addressed in the *Observe* project. Afterwards, six video clips (each lasting 2-4 minutes and representing two of the three teaching and learning components under study) are presented, while each of them is followed by 36 rating items targeting the specific teaching and learning components as activated through the video clip and reasoning aspects. In addition, the first video clip is firstly followed by an open answer format to assess pre-service teachers' noticing and reasoning in a more detailed and qualitative way. For all video clips, brief contextual information about the class is provided before they are presented. Furthermore, pre-service teachers have the opportunity to watch the clips a second time, before answering to the open answer format and standardized rating items. The duration of completion in this form takes around 90 minutes. A schematic overview of the structure of the *Observer Tool* is given in figure 7.

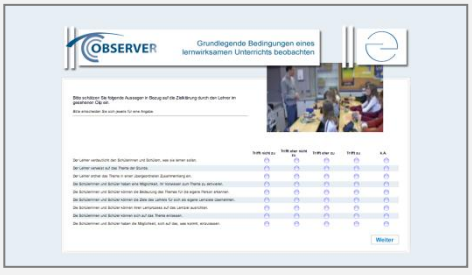
I. Introduction	1) Practical handling	
	2) Theoretical introduction	
II. Video clip 1	1) Presentation of video clip	
	2) Open answer format	
	3) Standardized rating items	
III. Video clip 2 - 6	1) Presentation of video clip	
	2) Standardized rating items	

Figure 7. Schematic overview of the structure of the *Observer Tool*.

Within this study, pre-service teacher' responses to the first video clip are analyzed. Therefore, I will focus in the following outlines on part II of figure 7. More information on

the instrument, specifically on part III is provided in the article from Seidel and Stürmer (2014).

The video clip under study was selected from a Swiss video portal (Reusser, 2005-2009) and shows a three-minute excerpt from a seventh-grade physics lesson, in which the teacher introduces the topic of optics. The video is a typical example of how physics is taught in German and Swiss classrooms (Seidel et al., 2007). The lesson sequence is dominated by teacher activities. The teacher introduces the new topic by giving an overview of the lesson unit that will follow and the students listen to the teacher. Furthermore, the teacher uses a funny anecdote purposely to make his students acquainted with the new topic.

The video selection process was based on three criteria: a) authenticity of the selected classroom situation b) activation of knowledge while at the same time balancing cognitive load, and c) representing teaching situations particularly relevant for student learning with regard to at least two components of goal clarity, learning climate or teacher support. A pilot study with $N = 40$ pre-service teachers showed that the video clip was perceived as authentic and cognitive activating, without too much mental effort (Seidel et al., 2010a). Findings based on video analysis instruments of a German and Swiss video survey provided detailed analyses with regard to the third criterion, and a number of researchers came to the conclusion that the video clip represents situations with regard to the teaching and learning components of goal clarity and learning climate (Seidel, Prenzel, & Kobarg, 2005). Additional, three independent experts in the field of teaching and learning, who were not involved in the video selection previously, provided comprehensive information on the content of the selected video clip. All of them had at least 5-10 years of experience in teacher education and systematic classroom observation. These experts also agreed on the two identified teaching and learning components and gave similar judgments about the pedagogical strategies and the consequences for future learning processes (Seidel et al., 2010a). Their information was used for further qualitative analyses, which will be targeted in detail in the analysis section. Finally, $N = 119$ pre-service teachers, working with the video in another study of the *Observe* project, agreed to a large extent that the selected video clip is a valid example of the two teaching and learning components of goal clarity and learning climate (Seidel & Stürmer, 2014). Thus, it can be assumed that the pre-selected video clip can be used to activate pre-service teachers' elaboration processes with regard to goal clarity and learning climate.

After watching the pre-selected video clip, pre-service teachers were firstly asked in an open question to write down what they had observed. They received following instruction: "Please

note everything down, what you have observed while watching the lesson sequence". While pre-service teachers had the possibility to watch the video clip twice, they could not draw on the video clip during their responses. This condition in combination with the use of a low structured question/prompt is related to the decision that the process of noticing with regard to goal clarity and learning climate should not be prompted too much. The written statements are used for further analysis of pre-service teachers' elaboration processes during noticing and reasoning as captured with an open format.

In a next step, pre-service teachers completed 36 video related standardized rating items on a four-point Likert scale (1 = "disagree" to 4 = "agree") to assess their reasoning within a standardized format. The rating items equally target goal clarity and learning climate and refer to the three scales of reasoning as outlined in the chapter on professional vision (section 4.1): *description*, *explanation*, and *prediction* of classroom events. Rating items assessing the scale of description target pre-service teachers' specific and differentiated observation without making any further judgments. Explanation is concerned with their application of professional knowledge with regard to learning/motivational theories, as pre-service teachers have to explain how the teaching component effects students' individual perception of supportiveness of a classroom situation. Prediction is related to the assessment of pre-service teachers' ability to predict possible consequences of an observed teaching situation on students' cognitive and motivational learning processes.

Example rating items for goal clarity are:

- *"The teacher clarifies what the students are supposed to learn"* (description; clarifying learning goals)
- "*The students have the opportunity to activate their prior knowledge of the topic"* (explanation; clarifying learning goals)
- *"The students will be able to align their learning process to the learning objective"* (prediction, clarifying learning goals)

Example rating items for learning climate are the following:

- *"The teacher is respectful to the students"* (description; teacher takes students' needs seriously)
- "*The students have the opportunity to feel that their teacher takes them seriously"* (explanation; teacher takes students' needs seriously)
- *"The teaching style will motivate the students"* (prediction, teacher takes students' needs seriously)

In sum, written statements as well as responses to the standardized rating items are on hand for every pre-service teacher and can be used for data analysis.

6.2.2 Sample

Participants in this study are N = 109 pre-service teachers, who were in their third year of teacher education at Friedrich Schiller Universität, located in Jena, Germany in the winter term 2009/10. All of them completed the obligatory course on core principles of teaching and learning, but studied different teaching subjects for different school tracks (table 1). The following subjects are included in the mathematics/science category: mathematics, chemistry, physics, biology, kinesiology, geography, and computer science. The social sciences/humanities category consists of following subjects: all languages, history, religion, ethics, philosophy, social studies, law, music, and art.

Table 1

Sample Distribution of Study 1 with regard to Teaching Subjects and School Types

	Upper secondary school		Lower secondary school		Total	
	N	%	*N*	%	N	%
Two mathematics/science subjects	8	9.09	-	-	8	7.34
Two social sciences/humanities subjects	43	48.86	17	80.95	60	55.05
One mathematics/science subject and one social sciences/humanities subject	37	42.05	4	19.05	41	37.61
Total	88	100.00	21	100.00	109	100.00

Overall, most of them studied two social sciences/humanities subjects for the upper secondary school track in Germany (Gymnasium), whereas pre-service teachers studying one subject from each field for the lower secondary school track (Regelschule) were the smallest group. As findings from previous research support the assumption that professional vision is a generic ability applicable across teaching subjects and school tracks (Blomberg, Stürmer, et al., 2011; Jahn et al., accepted; Wiens et al., 2013), pre-service teachers are treated as one sample group in the following.

On average, pre-service teachers were 21 years old (M = 21.42; SD = 1.42) and attended their fifth term of the teacher education program (M = 4.95; SD = 0.21). With regard to the gender ratio, the sample includes more female students (N = 72; 66.1%), which is representative for German teacher education.

Beside the sociodemographic data, two other aspects were relevant for the current study. As the assessment of pre-service teachers' elaboration processes focuses on the activation of prior knowledge in the field of teaching and learning, it was one matter to know how many courses they already attended in the field of teaching and learning during their teacher education program. This question was administered to all pre-service teachers within a questionnaire, which was attached to the *Observer Tool*. With a mean of three passed courses focusing specifically on teaching and learning (M = 2.55; SD = 1.13), pre-service teachers entered the assessment already with academic experience in the field of teaching and learning. Since the assessment used video material as stimulus, an additional question assessed pre-service teachers' experience in observing videos of classroom teaching. Since up to the study, none of the 109 pre-service teachers had previously worked with videotaped classroom situations.

6.2.3 Data analysis

In the previous section, it was outlined that for answering the research questions of this study two different types of data are available: 1) written statements to an open question with regard to the pre-selected video clip and 2) answers to standardized rating items connected to the selected video clip. In this section the data analysis approach will be presented, which has been applied to answer the research questions regarding pre-service teachers' elaboration processes in the context of professional vision. The first part targets the qualitative analysis of the written comments and the second part considers the quantitative measure used to validate the qualitative results. Finally, the data analysis for answering the research questions will be presented.

1. Qualitative analysis of the written comments

The data analysis for pre-service teachers' written comments in order to make statements about pre-service teachers' elaboration processes within an open format took place in several phases. In the following, the development of the coding framework as well as the different analysis steps of pre-service teachers' elaboration processes during noticing and reasoning will be addressed.

a) Development of the coding frameworks and preparation for coding

To capture the focus of pre-service teachers' attention (teaching and learning components vs. superficial and irrelevant classroom events) as an indicator for their elaboration processes during noticing, the depth and content of their elaboration processes during reasoning, and their capacities in the interplay of both perception processes, a qualitative content analysis (Mayring & Gläser-Zikuda, 2008) with an inductive-deductive coding technique (Bortz & Döring, 2006; Seidel & Prenzel, 2010) was applied. The coding frameworks for noticing and reasoning were developed based on literature and prior research on knowledge representations and cognitive learning activities, effective teaching and learning components and teachers' professional vision, as outlined in the theoretical chapters of this thesis (deductive). Based on that, the preliminary frameworks were tested and adapted on a random selected sample of written responses from pre-service teachers who were not part of the current study through writing analytic memos for the written comments (inductive). Using these memos, a manual for coding noticing and reasoning with their single characteristics was worked out and discussed among four researchers (graduate/post-graduate). Issues raised in the discussion were used to clarify and refine operational definitions of the codes. To support an equal understanding about the coding frameworks and thus, to ensure reliable and valid results, a theoretical introduction into the two teaching and learning components under study as well as examples for each coding category was added to the coding manual. Both coding frameworks can thus, be characterized as low inferent (Seidel & Prenzel, 2010), as the single events are directly visible in the written comments and coders do not have to make interpretations in order to assign an event to one specific category. The resulting two frameworks and their disjunctive categories will be described in detail within the following parts on coding pre-service teachers' noticing and reasoning capacities.

However, before coding the written comments of the sample group, analysis units had to be identified according to which the statements are then segmented into (Bortz & Döring, 2006). For the analysis of pre-service teachers' noticing capacities, one sentence or statement was considered as a proper analysis unit. For coding pre-service teachers' reasoning capacities the entire comments built the basis for the coding process. Thereby, a sentence or statement as analysis unit for noticing was rather defined in a logically than in a grammatically correct way. The data revealed that a lot of comments were written in common speech rather than in grammatically correct sentences: lack of words, punctuation marks, or orthographic mistakes. After clarification and review of pre-service teachers' written statements, the research team segmented the statements independently. Based on the definition what constitutes an analysis

unit, they agreed on 97% of the coded segments with a mean Cohen's κ of .87 across all coders. For the ambiguous 3%, consensus was achieved through discussion and consensus validation. Overall, 605 segments/idea units were identified and built the basis for coding pre-service teachers' noticing. As the entire comments were used to code pre-service teachers' reasoning with regard to depth and content, the calculation of the interrater-agreement was not necessary in these cases. Thus, 109 segments/idea units build the analysis basis for coding both aspects of reasoning. Table 2 gives an overview of the characteristics of the two coding frameworks applied.

Table 2

Overview of the Characteristics of the Two Applied Coding Frameworks

Coding framework	Kind of coding framework	Inference	Analysis unit	Number of analysis units
Noticing	disjunctive categories	low	single statement/sentence	605
Reasoning				
Depth	disjunctive categories	low	entire comment	109
Content	disjunctive categories	low	entire comment	109

b) Application of the coding frameworks

The following outlines describe the applied coding frameworks and its categories. Each analysis unit (one statement or entire comment) was coded with regard to noticing and reasoning (depth, content).

Coding of elaboration processes during noticing

This framework is concerned with pre-service teachers' capacities in noticing relevant situations with regard to goal clarity and learning climate as an indicator for their elaboration processes during information selection. As outlined in chapter 3.2.1 and referring to the definition of the *Observe* project which is based on empirical findings from the IPN video study, noticing situations with regard to goal clarity was operationalized through different indicators of this effective teaching and learning component. One indicator refers to a clear and transparent communication of learning goals (stating the topic of the lesson; providing

specific learning goals) at the beginning of the lesson, where organizational cues and contextualized anchors are supportive instructional elements.

The second indicator is related to a clear and transparent communication of tasks and requirements. The operationalization of noticing events with regard to the second component of learning climate is also based on the definition of the *Observe* project, as outlined in chapter 3.2.2. According to that, indicators of a positive and supportive learning climate are fulfilled when students are taught and encouraged to ask and contribute to lessons without embarrassment and anxiety and when respect, care and enthusiasm indicated by taking students' needs seriously and using humor are integral parts of the teaching practice.

Based on that definitions and indicators, and informed by research from Kobarg (2009), each segment was coded as to whether goal clarity or learning climate was addressed. The category "goal clarity" could include statements about the clarification of goals, objectives and requirements. The category "learning climate" was coded, if a segment addressed aspects, such as teachers taking the needs of their students seriously, balancing between closeness and distance with students, or using humor as an element to establish a positive atmosphere in the classroom. To assign a segment to one of these categories, it was not imperative to adhere to scientific terminologies or underlying concepts. Statements referring to superficialities or irrelevancies (e.g., clothing/speech/habits of the teacher; interior design) were assigned to a third category called "irrelevant aspects". The detailed coding framework for noticing is displayed in table 3.

Table 3

Noticing of Teaching and Learning Components: Coding Categories and Examples

Category	Indicators	Definition/Coding rule	Examples	Excluding aspects
Goal clarity	The analysis unit addresses aspects with regard to teachers' clarification of learning goals.	Comments about whether the teacher gives an overview of the topic of the (next) lesson(s) and/or describes the learning goals. Comments from students' perspective as well as the impact on their learning processes can be included as long as	"The topic of the next lessons as well as the procedure was mentioned to the students." "The teacher has presented the learning goals of his lesson to the students."	Comments where it is not obvious, if the observed teacher clarifies learning goals; e.g. "The topic of the lesson is optics."

		it obvious, if the noticed event is related to the clarification of the learning goals.		
	The analysis unit addresses aspects with regard to teachers' clarification of tasks and requirements.	Comments about whether the teacher points out the tasks and describes the requirements explicitly. Comments from students' perspective as well as the impact on their learning processes can be included as well as long as it obvious, if the noticed event is related to the clarification of tasks and requirements.	"The students received detailed information about the upcoming tasks in the lesson (and with regard to the topic)."	Comments where it is not obvious, if the observed teacher clarifies tasks and requirements. "The implementation of experiments will surely have a positive impact on students' learning success and motivation."
Learning climate	The analysis unit addresses aspects with regard to the use of humor to create a positive learning climate	Comments about whether the teacher creates a positive learning climate by using humor. Comments from students' perspective as well as the impact on their learning processes can be included as long as it obvious, if the teacher creates a positive learning climate by using humor.	"As introduction into the topic, the teacher told a joke, which is – referring to the teacher –not a real joke and with that no one has to laugh. Through this, the teacher takes away its effect, that students are focused and feeling comfortable."	Comments where it is not obvious, if the observed teacher takes students uses humor to create a supportive learning climate. "The joke about the Austrians does not affect students' laughter."
	The analysis unit addresses aspects with regard to taking students' needs seriously in order to create a positive learning	Comments about whether the teacher creates a positive learning climate by taking students' needs seriously. Comments from students' as well as	"The teacher tells the students, that the learning content is at the beginning easy to comprehend, what takes away students' fear about	Comments where it is not obvious, if the observed teacher takes students need seriously to create a supportive

	climate	the impact on their learning processes can be included as long as it obvious, if the teacher creates a positive learning climate by taking students' needs seriously.	the new topic."	learning climate. "The teacher has a very calm nature."
Irrelevant aspects	The analysis unit addresses aspects, which are not relevant for teaching and learning processes.	Comments about superficial aspects of the classroom situation, like comments about the interior design, teachers' clothing or speech, video material.	"Too much 'eh' in the teacher's language (particularly because of the conspicuous subtitle)." "The desks were arranged like in university settings""	Comments where goal clarity or learning climate or other relevant teaching strategies are targeted, e.g. classroom management. "The students behaved exemplary, which is for me an indicator for the good classroom management of the teacher."

After the development of this coding scheme and training on its application, the research team coded the segmented units using MAXQDA software (Kuckartz, Grunenberg, & Dresing, 2007). To ensure inter-rater reliability, the members of the research team coded a randomly selected subset of 30%. A mean inter-rater agreement of 86.9% and a Cohen's Kappa (κ) of .81 was achieved across the three categories of noticing.

Coding of elaboration processes during reasoning about the noticed events

The assessment of pre-service teachers' elaboration processes during information processing was operationalized through a coding framework, which takes the depth and the content of pre-service teachers' reasoning about noticed events with regard to goal clarity and learning climate into account. Both aspects have been outlined in the theoretical chapters 2 and 4 as integral parts of successful knowledge acquisition processes and teachers' professional vision. The coding with regard to the depth refers to whether the noticed event is based on professional knowledge or on implicit theories, and the coding for content is concerned with whether pre-service teachers' reasoning about noticed events is adequate when compared to expert judgements. The coding encompassed pre-service teachers' entire comments and

distinguished based on the two sub-codes of reasoning different levels and abilities with regard to goal clarity and learning climate (table 4).

Table 4

Levels of Elaboration Processes during Reasoning about Noticed Events

Level	Noticing	Reasoning Depth	Content	Characteristics
0	No	-	-	No noticing and reasoning
1	Yes	Activation of implicit theories	No agreement with expert judgment	Noticing and low reasoning ability
2a	Yes	Activation of knowledge	No agreement with expert judgment	Noticing and mixed reasoning ability
2b	Yes	Activation of implicit theories	Agreement with expert judgment	Noticing and mixed reasoning ability
3	Yes	Activation of knowledge	Expert agreement	Noticing and high reasoning ability

Regarding the five levels the categories 0 and 1 characterize the two lower levels of elaboration processes during reasoning about noticed events, whereas category 3 represents the optimal case. The two subcategories 2a and 2b represent mixed forms of reasoning abilities, either characterized by the activation of professional knowledge without expert agreement or vice versa. As so far little is known about the consequences of this mixed pattern in pre-service teacher education, the two categories are summarized as a mixed reasoning pattern in further analyses. In the following, the coding procedure for both reasoning patterns is targeted.

Sub-code 1 – Depth of Reasoning

Informed by a prior coding scheme on (pre-service) teachers' lesson analysis skills from Schwindt (2008) and research on teacher expertise, each comment with regard to "goal clarity" or "learning climate" was either assigned to the category of "activation of knowledge" or the category "activation of implicit theories".

The category "activation of knowledge" was coded when the statement showed that the noticed event with regard to goal clarity/learning climate was linked to professional terms and

central concepts of pedagogical strategies of the two teaching and learning components (e.g. "advance organizer" as a pedagogical strategy for goal clarity and coherence) and/or to theories related to the effects of the teaching and learning components on student learning (e.g. application of educational-psychological theories related to teaching and learning processes, such as Deci and Ryan's (1985) self-determination theory). For example, when stating that the teacher misses clarifying learning goals with the consequence that the students are less likely to direct their learning towards the goals with negative consequences for motivation and knowledge acquisition.

The second coding-category "activation of implicit theories" included statements, in which the noticed classroom event with regard to goal clarity/learning climate was not connected to professional terms or learning theories, however, was described in a superficial, judgmental way and naive interpretations were provided. An example for goal clarity would be, stating that the teacher starts the lesson by using language of everyday life with an evaluating character and without any further explanations ("Unfortunately, the teacher often used "eh" in his language and failed therefore"). The two-level coding framework with further examples for each category with regard to goal clarity and learning climate is displayed in table 5.

Table 5

Elaboration Processes during Reasoning – Depth of Reasoning: Coding Categories and Examples

Category	Description of the category	Examples for goal clarity	Examples for learning climate
Activation of implicit theories	Noticed events are described in a judgmental manner including naive assumptions and beliefs.	"I like that the teacher explained the syllabus of the next lessons to the students."	"In his way of using humor to support a positive learning climate, he [the teacher] seems a bit clumsy to me. Nevertheless, the class was quiet and focused."
Activation of knowledge	Noticed events are described and explained through appropriate conceptual terms in a neutral way and by indicating the effect of teaching on students' learning processes.	"To introduce the students to the field of optics the teacher tells a story, which can activate their thought processes. It also increases their motivation and provides a good plug."	"He [the teacher] mentions that the students should feel comfortable firstly with the topic, which takes away the pressure to perform and influences their learning motivation."

Sub-code 2 – Content of Reasoning

Within this sub-code 2, it was explored whether the content of pre-service teachers' reasoning about noticed events regarding goal clarity and learning climate is in line with how experts in the field of teaching and learning would interpret and judge those situations. As it was addressed in chapter 2 and 3, it is not sufficient at all to activate professional knowledge but also that it is adequate related to the specific teaching situation. Therefore, the content of pre-service teachers' comments was compared to the judgments provided by three independent experts about the content of the pre-selected video clip. In the case of the video used in this study, the experts agreed with regard to goal clarity that the observed teacher introduces the students to the topic of optics by stating the topic of the lesson and by providing a detailed description of the organization of the course. Furthermore, they agreed on that the teacher explains the tasks of the lesson to the students and outlines his requirements to them. The teacher, however, fails to provide the students with specific learning goals. Thus, the video sequence cannot be seen as a best practice example for the implementation of the teaching and learning component of goal clarity. With regard to learning climate, the experts agreed that the teacher created a supportive learning atmosphere for the students. This is indicated through situations, where the teacher makes a funny joke during his introduction. Furthermore, the teacher shows that he takes his students seriously by communicating that he fully understands potential learning problems. Thus, the video shows a good example for the implementation of a positive learning climate in classrooms.

With regard to the analysis of pre-service teachers' reasoning, this information was used to capture the extent to which pre-service teachers agreed with these expert judgments. Therefore, the units on goal clarity and learning climate were coded into the category "no agreement with expert judgement" or in the category "agreement with expert judgment" (Table 6).

Table 6

Elaboration Processes during Reasoning – Content of Reasoning: Coding Categories and Examples

Category	Description of the category	Examples	Rule of thumb
No agreement with expert judgment	The content of the noticed event is not correct interpreted. The experts agreed for goal clarity that the topic of the lesson as well as an overview of the (next) lesson was stated; however the learning goal as a second indicator for goal clarity was not described.	"I think the teacher's goal was clear." "The teacher starts the lesson with an introduction into the upcoming learning content and ensured with that that the students know short-term as well long-term learning goals."	If the comments addresses that goal clarity is well implemented in the observed situation, the comment can be regarded as no expert agreement.
	The content of the noticed event is not correct interpreted. The experts agreed for learning climate that the teacher uses humor and takes the needs of his students' seriously.	"There is a tense learning atmosphere." "To start the lesson with a funny anecdote is a good teaching strategy for supporting students' learning, although it does not seem to have the desirable success (considering his humoristic delivery).	If the comment addresses that the teacher does not create a supportive learning climate in the observe situation, the comment can be regarded as no expert agreement.
Agreement with expert agreement	The content of the noticed event is correct interpreted. The experts agreed for goal clarity that the topic of the lesson as well as an overview of the (next) lesson was stated; however the learning goal as a second indicator for goal clarity was not described.	"The class was introduced into the topic and tasks of the lesson, however the teacher did not mentioned the learning goals."	If the comments addresses that goal clarity is not implemented on its best in the observed situation, the comment can be regarded as expert agreement.

	The content of the noticed event is correct interpreted. The experts agreed for learning climate that the teacher uses humor and takes the needs of his students' seriously.	"He mentions that they [students] first should feel comfortable with the topic. This takes away the pressure on the students to perform." "To introduce the students into the topic of optics, the teacher tells a story, which should encourage the students to think about it, and helps to ensure motivation and is an interesting plug in the same time. Thus, the students were noticeable focused, attentive and very quiet. They have listened to him [the teacher]."	If the comments addresses that the teacher creates a supportive learning climate in the observed situation, the comment can be regarded as expert agreement.

To ensure inter-rater reliability also on the coding of the levels of elaboration processes during reasoning about the noticed events, again training on that coding framework took place. Furthermore, 30% of the data was coded twice. A mean inter-rater agreement of 94.83% for goal clarity and 79.31% for learning climate was achieved. Furthermore, Cohen's Kappa (κ) was calculated and revealing with $\kappa = .89$ for goal clarity and $\kappa = .64$ for learning climate a satisfactory level of consistency. All discordant codings (especially for learning climate) were discussed and validated.

2. Quantitative analysis of the standardized rating items

To validate the qualitative data with regard to pre-service teachers' capacities in their elaboration processes during noticing and reasoning, pre-service teachers' written answers are compared to their responses to the standardized rating items connected to the same video clip. Due to the fact that teaching effectiveness research does not provide right or wrong answers with regard to pre-service teachers' ratings of the video clip, a reference norm based on the judgments of three experts was established within the development of the *Observer Tool* to study pre-service teachers' responses. These experts are part of the research team of the *Observe* project and thus, are not identical to the ones who provided comprehensive information on the pre-selected video clip; nevertheless each of them also had 100 to 400 hours of experience in observing classroom situations according to the teaching and learning

components under investigation. The calculation of Cohen's Kappa (κ) with a mean Cohen's κ of .79 across all three experts' ratings indicated a satisfactory level of consistency. In cases where they disagreed, agreement was reached by consensus validation (Seidel et al., 2010b). This resulting reference norm is used to draw conclusions on pre-service teachers' reasoning as captured by standardized rating items by comparing pre-service teachers' answers with the expert rating. In this context, a strict measure for the agreement with experts ('1' = hit expert rating and '0' = miss expert rating) was established, as it turned out to be superior to a less strict version taking the tendency into account (Seidel & Stürmer, 2014). As indicators for their capacities in the standardized format, scale scores for reasoning in total were used along with the three subscales of description, explanation, and prediction. All scores are calculated for each of goal clarity and learning climate and as percentages of agreement with the criterion-referenced norm of the expert ratings (hit = 1/miss = 0). Results of a scaling study have shown that the standardized rating items provide a valid and reliable assessment of pre-service teachers' capacities in reasoning (Seidel et al., 2010b; Seidel & Stürmer, 2014). For the present study, the scaling procedure was replicated, resulting in good reliabilities for the four scales of reasoning in total (α = .92), description (α = .83), explanation (α = .85) and prediction (α = .88).

3. Data analysis for answering the research questions

To describe pre-service teachers' capacities in noticing, reasoning, and in their interplay about goal clarity and learning climate as indicator for the nature of their elaboration processes within the open answer format (research question 1-3), the coded qualitative data will be presented descriptively. Therefore, all codes were transferred and aggregated on the level of pre-service teachers as analysis unit.

To validate the qualitative analysis, bivariate correlations for each of the four reasoning scale scores assessed with the standardized rating items with the qualitative levels of reasoning about noticed events both for goal clarity and learning are calculated to determine, if and how strong both assessment results are related to each other (research question 4). A significance level of .05 was chosen.

6.3 Results

The presentation of the study results is guided by the research questions addressed in section 6.1. First, in section 6.3.1 results with regard to pre-service teachers' capacities in activating relevant knowledge about teaching and learning components to notice aspects of goal clarity and learning climate in the pre-selected video clip are reported (research question 1). Second, the analysis, of whether and to what extent pre-service teachers' reasoning about the noticed teaching and learning components is based on the activation of implicit theories versus on professional knowledge about teaching and learning, is displayed in section 6.3.2 (research question 2a) as well as in section 6.3.3, the extent to which the content of the pre-service teachers' reasoning matched that of experts in the field of teaching and learning (research question 2b). Afterwards, in section 6.3.4, pre-service teachers' knowledge activation process within in the interplay of noticing and their reasoning (encoding and processing) by classifying each pre-service teacher to one of four levels regarding the combination of their noticing and reasoning abilities will be displayed (research question 3). Finally, results with regard to the relationship between the results of the qualitative analyses and the results of the quantitative approach for validation reasons are addressed in section 6.3.5 (research question 4).

6.3.1 Pre-service teachers' elaboration processes during noticing

In the following, pre-service teachers' capacities in noticing events with regard to goal clarity and learning climate are presented. The theoretical basis builds the assumption that the activation of prior knowledge as indicator for elaboration processes is important to encode and notice relevant aspects in the context of learning as information-processing. The coding scheme for goal clarity was operationalized through the indicators of a clear and transparent communication of learning goals and a clear and transparent communication of tasks and requirements. The operationalization of noticing events with regard to learning climate was indicated by addressing aspects with regard to taking students' needs seriously and using humor are integral parts of the teaching practice. Statements, which target irrelevancies, are assigned to the third category "irrelevant aspects". Overall, 605 analysis units were identified. The following table 7 displays the results of the descriptive analyses and the distribution across the categories under investigation.

Table 7

Pre-Service Teachers' Noticing of Teaching and Learning Components – Descriptive Analysis and Distribution (Percentages) (Schäfer & Seidel, accepted)

	M	*SD*	*Min*	*Max*	*%*
Goal clarity	1.28	1.02	0	6	23.10
Learning climate	1.67	1.53	0	8	30.10
Irrelevant aspects	2.60	1.99	0	13	46.80
Total	5.55	2.94	1	22	100.00

Note. Aggregation of N = 605 analysis units to the level of N =109 pre-service teachers.

As the table reveals, pre-service teachers commented in about 5 to 6 analysis units on the video clip that they had observed. The standard deviation with 2.9 analysis units is substantial, with a range between a minimum of one and a maximum of 22 analysis units. In total, the pre-service teachers noticed thereby a number of aspects in both of the two teaching and learning components (overall 53% of analysis units per pre-service teacher). Pre-service teachers referred in half of their statement to goal clarity (23% of analysis units per pre-service teachers; 1.3 units) and learning climate (30% of analysis units per pre-service teacher; 1.7 units) as relevant teaching and learning components. Nevertheless, almost half of their statements (47%, 2.6 units) referred to other, more superficial aspects of classroom teaching like teacher's clothing and speech habits, or the interior design of the classroom. As assumed, pre-service teachers are already able to activate prior knowledge as indicated by their noticing of relevant aspects of classroom teaching and learning. But as they also tend to focus on superficial and irrelevant facets quite a lot, they are not able yet to show elaboration processes during noticing. The following figure 8 illustrates the distribution of percentages with regard to each category.

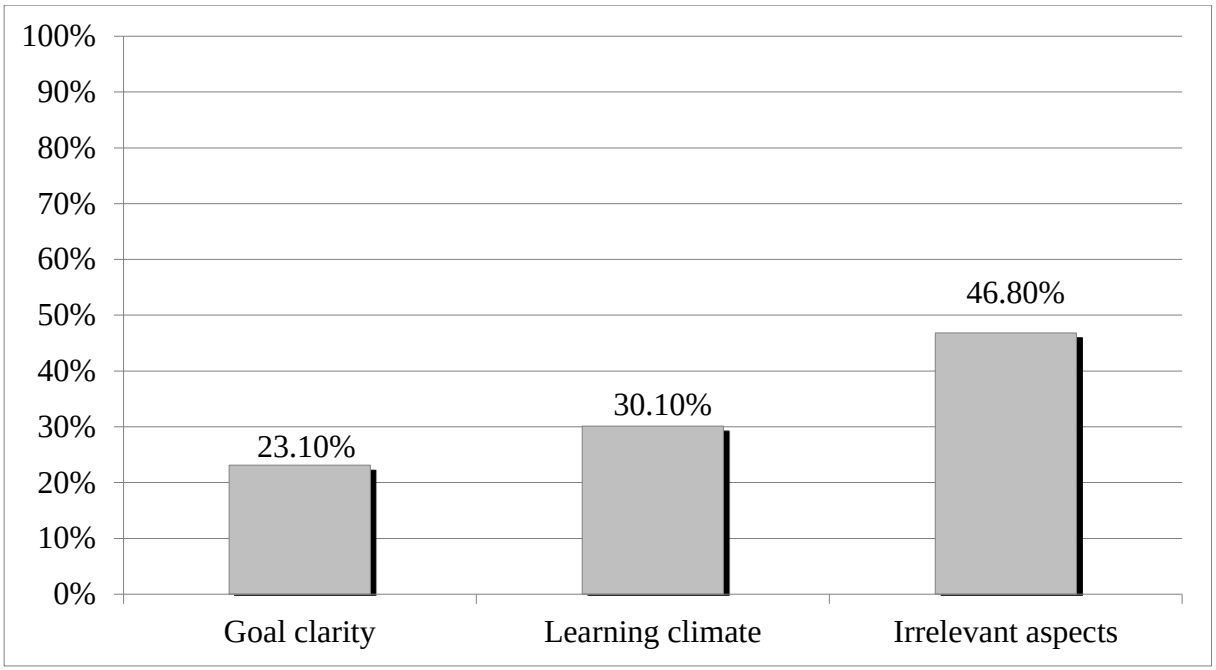


Figure 8. Distribution of analysis units (percentages) with regard to pre-service teachers' noticing of teaching and learning components (Schäfer & Seidel, accepted).

6.3.2 Pre-service teachers' elaboration processes with regard to depth of reasoning

Learning as knowledge acquisition is characterized by a deeper understanding of information. In this context, reasoning about relevant features of classroom situations based on professional knowledge is an important indicator for elaboration processes and integrated knowledge structures. Pre-service teachers' elaboration processes during reasoning with regard to depth was operationalized whether and to what extent pre-service teachers' reasoning is based on implicit theories or on knowledge about teaching and learning. Pre-service teachers' entire comments targeting events with regard to goal clarity (N = 81) and learning climate (N = 80) were used as analysis unit. Table 8 presents the frequency distribution for the two categories and the two teaching and learning components under investigation.

Table 8

Pre-Service Teachers' Reasoning with regard to Depth. Distribution of Frequencies (Schäfer & Seidel, accepted)

Noticing		Activation of implicit theories	Activation of knowledge
Goal clarity	*n*	59	22
	%	72.80	27.20
Learning climate	*n*	71	9
	%	88.80	11.20

Note. 109 Pre-service teachers; Min = 0 %, Max = 100%.

The results show that for both goal clarity and learning climate, reasoning about noticed events was based mainly on implicit theories with judgmental character (e.g. "I like"; "I believe") about teaching and learning (73% for goal clarity and 89% for learning climate respectively). Of the participating pre-service teachers, who noticed such events 27% demonstrated the activation of knowledge about aspects of goal clarity (such as writing about the importance of making learning goals explicit for students in order to activate knowledge and orient their learning) and 11% of them used it in connection with aspects of learning climate (such as the importance of teachers taking the needs of their students seriously). Overall, the findings reveal that pre-service teachers struggled in their attempts to activate relevant professional knowledge to reason about the noticed events; especially knowledge activation related to learning climate seemed to be more difficult compared to goal clarity. The distribution of pre-service teachers with regard to the depth of their reasoning is displayed in the following figure 9.

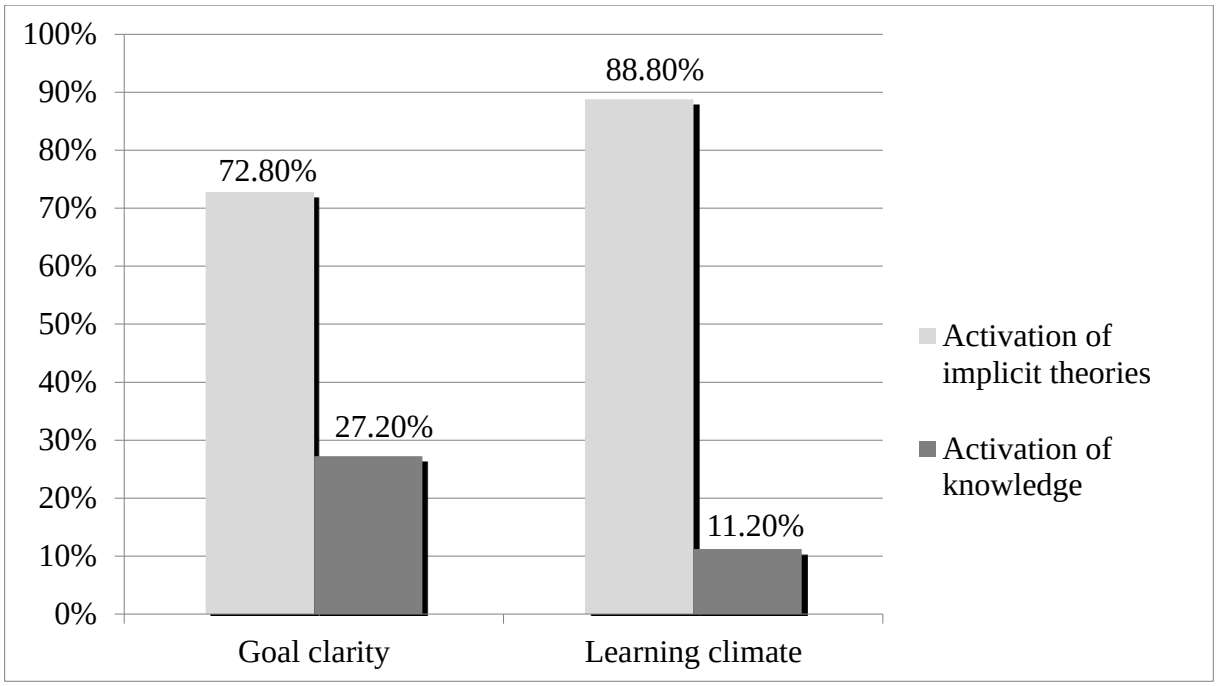


Figure 9. Distribution of pre-service teachers with regard to the depth of their professional knowledge.

6.3.3 Pre-service teachers' elaboration processes with regard to content of reasoning

An adequate information processing takes also the specificities of teaching and learning situations into account. Thus, the content of their reasoning is a further important indicator for the quality of pre-service teachers' elaboration processes. Therefore, pre-service teachers' comments about noticed events with regard to goal clarity (N = 81) and learning climate (N = 80) were analyzed regarding the extent to which the content of their reasoning about goal clarity and learning climate in the video, they were shown, matched that of experts in the field of teaching and learning. The frequency distribution for no agreement with experts' judgment and agreement with expert judgment and the two teaching and learning components is provided in Table 9.

Table 9

Pre-Service Teachers' Reasoning with regard to Content: Agreement with Expert Judgement. Distribution of Frequencies (Schäfer & Seidel, accepted)

Noticing		No agreement with experts	Expert agreement
Goal clarity	*n*	51	30
	%	63.00	37.00
Learning climate	*n*	59	21
	%	73.75	26.25

Note. 109 Pre-service teachers; Min = 0%, Max = 100 %.

As indicated in the table, the content of pre-service teachers' reasoning matched with that of the experts in more than a third of their statements for goal clarity (37%) and in about one quarter for learning climate (26%). The higher proportion of matches for goal clarity indicates that it was easier for pre-service teachers to reason in the same direction as experts do about this component than about learning climate. The majority of the content of pre-service teachers' reasoning for both components, however, did not match the experts' judgments (goal clarity, 63%; learning climate, 74%). Thus, in reasoning about noticed events, for example, the pre-service teachers did not recognize that learning goals scarcely were mentioned by the teacher in the observed video, or that the teacher created a supportive learning climate by telling a funny anecdote and taking the needs of his students seriously. The distribution of pre-service teachers with regard to their agreement with experts' reasoning is shown in figure 10.

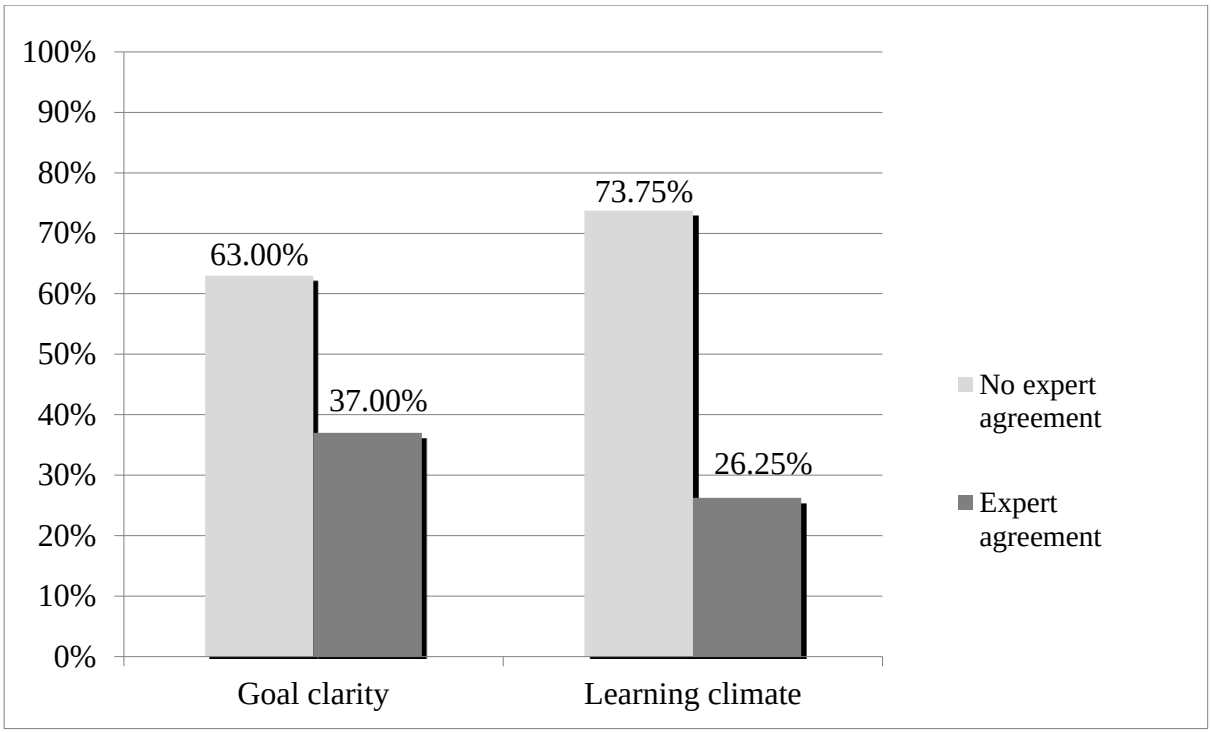


Figure 10. Distribution of pre-service teachers with regard to the content of their reasoning.

6.3.4 Pre-service teachers' elaboration processes in the interplay of noticing and reasoning

So far, the nature of pre-service teachers' elaboration processes within noticing and reasoning was outlined and the data suggests that pre-service teachers are able to notice some aspects of teaching and learning components, but that their reasoning relies mainly on naive and implicit theories about teaching and learning, and that their interpretation of the situations do not match those of the experts. Now, pre-service teachers' capacities within the interplay of both knowledge based processes are targeted. To clarify combinations of elaboration processes within noticing and reasoning, each participating pre-service teacher was classified as belonging to one of four levels (see methods section). Pre-service teachers' distribution across these four categories is provided in Table 10.

Table 10

Pre-service Teachers' Elaboration Processes in the Interplay of Noticing and Reasoning: Distribution of Frequencies (Schäfer & Seidel, accepted)

		No noticing	Noticing and low reasoning ability	Noticing and mixed reasoning ability	Noticing and high reasoning ability
Goal Clarity	*n*	28	10	65	6
	%	25.70	9.20	59.60	5.50
Learning Climate	*n*	29	17	59	4
	%	26.60	15.60	54.20	3.60

Note. 109 Pre-service teachers; Min = 0%, Max = 100 %.

Applying this approach, about a quarter of the 109 pre-service teachers was assigned to the lowest level of elaboration processes. These participants did not notice elements of goal clarity or learning climate and therefore, did not do any reasoning in connection with them. The majority of pre-service teachers did notice aspects of goal clarity and learning climate. In looking at their reasoning more closely, it can be seen that about 10% (9% for goal clarity, 16% for learning climate) of the participants did not activate knowledge and the content of their reasoning did not match that of the experts (level 1). The largest group of pre-service teachers (60% for goal clarity and 54% for learning climate) showed noticing and mixed reasoning abilities. This means either these pre-service teachers activated knowledge to reason about the situation; however, they did not match the content of the experts (level 2a). Another pattern was, in which the content of their reasoning matched the expert judgment; their reasoning, however, was based on implicit theories and naive assumptions (level 2b). The biggest challenge was to activate knowledge about general pedagogical concepts and simultaneously to match with experts' judgments during reasoning about the noticed situation. Only around 5% of participating pre-service teachers were assigned to this level 4, both for goal clarity (5.5%) and learning climate (3.6%). The below presented figure 11 illustrates these distribution graphically.

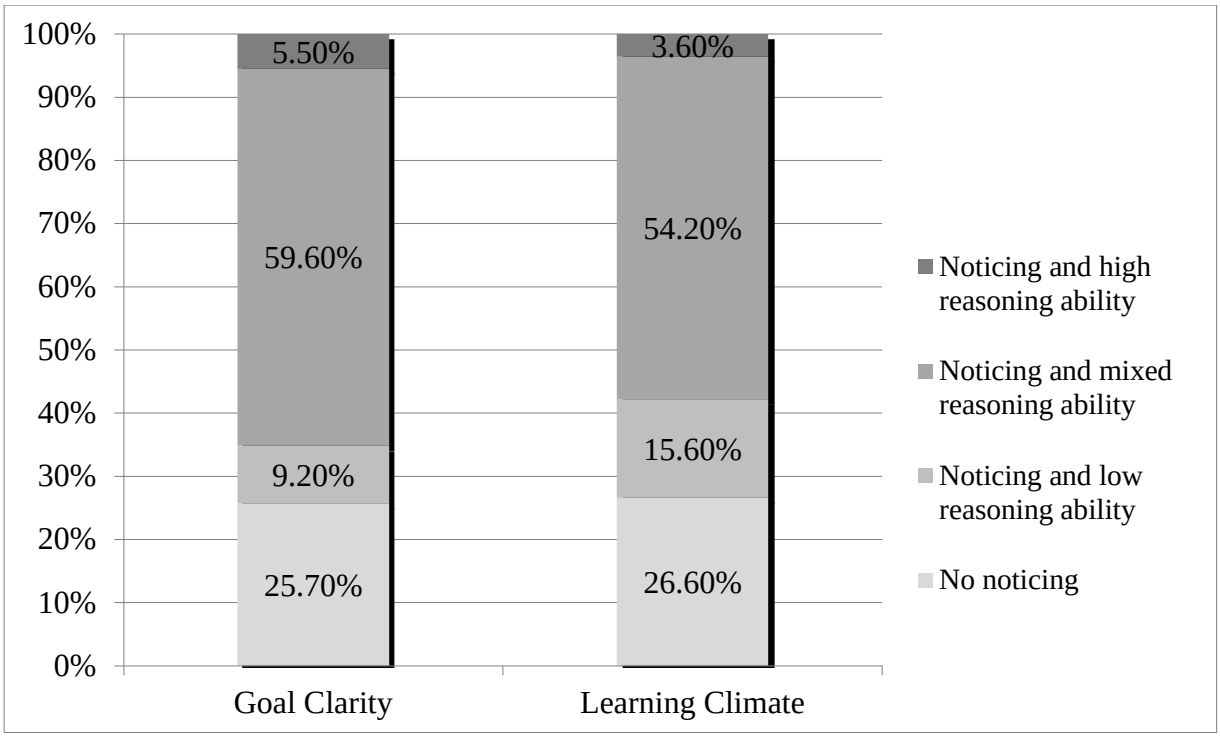


Figure 11. Distribution of pre-service teachers with regard to the interplay of noticing and reasoning.

All in all, these results indicate that pre-service teachers may have problems to activate relevant and scientific correct knowledge during the interplay of encoding and processing of relevant information regarding the two teaching and learning components in a complex classroom situation.

6.3.5. Validation of the qualitative analysis

In a final step, it was one research aim to validate the qualitative analyses of written responses by a quantitative measure of teacher reasoning. Therefore, pre-service teachers' reasoning scores assessed by the standardized format of the *Observer Tool* (total, description, explanation, prediction) were calculated based on the percentages of expert agreement and correlated with the qualitative assignment. Table 11 displays on the left side the descriptive values of reasoning as measured with the standardized format and shows on the right side the bivariate correlations with the qualitative analysis of pre-service teachers' elaboration processes in the interplay of noticing and reasoning.

Table 11

Descriptive Values of Reasoning as Measured with Standardized Rating Items of the Observer Tool based on Percentages of Expert Agreements and Bivariate Correlations with the Qualitative Analyses (Level of Noticing and Reasoning) (Schäfer & Seidel, accepted)

Observer Tool			Qualitative analyses	
			Goal clarity	Learning climate
	Percentages of Expert Agreement			
	M	*SD*		
Total	30.00	21.00	.21*	.12
Description	40.00	21.00	.10	.07
Explanation	20.00	23.00	.22*	.11
Prediction	29.00	29.00	.20*	.11

Note. $^{*}p < .05$.

As Table 11 indicates, pre-service teachers generally scored in the low third of reasoning abilities (total) as assessed by the *Observer Tool* (*M* = 30% expert agreement). Pre-service teachers scored highest on describing relevant classroom situations (*M* = 40%), followed by the dimension of predicting consequences (*M* = 29%), and explaining situations (*M* = 20%).

The correlation pattern between the two measurement approaches shows the desirable and assumed direction of positive relationships (Table 11). The higher the level of elaboration processes in the interplay of noticing and reasoning as measured by qualitative analysis, the higher the scores in the *Observer Tool*. A significant positive, though small, relationship was found with goal clarity on the total scale (r = .21; $p < .05$) and, with regard to explaining (r = .22; $p < .05$) and predicting (r = .20; $p < .05$) such classroom events, the two scales most strongly connected to the activation of professional knowledge.

6.4 Discussion

The goal of Study 1 was to enhance the understanding of elaboration processes, pre-service teachers report on during selecting (noticing) and processing (reasoning) relevant information regarding specific teaching and learning components when observing a video of a specific classroom situation. This was studied to provide insight into pre-service teachers' capacities to activate knowledge about specific relevant teaching and learning components as important elaboration strategy for meaningful knowledge acquisition processes in university-based

teacher education (Schäfer & Seidel, accepted). The concept of professional vision with its interrelated processes of noticing and reasoning was chosen as research context to account for the situated and contextualized nature of teacher cognition (van Es & Sherin, 2002; Kersting, 2008), especially as professional knowledge acquisition is visible in teachers' categorial perception of classroom situations (Bromme, 1992). Regarding the methodology approach used for activating pre-service teachers' elaboration processes, a video clip was chosen that contained specific information on goal clarity and learning climate, and which was validated by experts in the field of teaching and learning research. To date, studies have focused on describing knowledge activation during noticing and reasoning in broader terms such as whether teachers notice elements regarding the teachers, students, or contents of the video or whether their reasoning is generally related to pedagogy, general content or pedagogical content (Borko et al., 2008; Sherin & Van Es, 2009). However, no information is given whether the events noticed indeed are relevant to teaching and learning as indicator for the activation of scientific/professional knowledge as well as whether pre-service teacher's reasoning about noticed events is in line with how experts would interpret those situations as indicator for the dimension of correct/adequate knowledge activation. This is attributed to the fact that previous studies barely have provided information on the type of aspects that actually are represented in the video from a general pedagogical point of view, how experts explain the situation, and what kind of consequences experts would predict (Seidel & Stürmer, 2014). This study made a first attempt at addressing this issue by exploring not only pre-service teachers' professional knowledge activation during noticing and reasoning but also comparing the content of their knowledge activation to experts' information processing of relevant aspects visible in the video clip. Another specificity of this study was the combination of a qualitative methodology approach of using video in combination with an open answer format with a quantitative methodology approach, in which the video was rated by means of standardized items. This combination could be used to validate the qualitative analyses.

The findings of research question 1, targeting pre-service teachers' noticing as indicator for their elaboration processes during information selection, showed that the participating pre-service teachers intuitively noticed quite a number of aspects of the two teaching and learning components under investigation. This finding confirms earlier work showing that activating knowledge to select relevant classroom events is already being put into effect when pre-service teachers are involved in teacher education courses (Lefstein & Snell, 2010; Wiens et al., 2013). In this study, pre-service teachers were half-way through their initial university-based teacher education with a mean of about three passed courses on teaching and learning.

This empirical finding is also in line with other studies assessing the development of pre-service teachers' general pedagogical knowledge acquisition in German teacher education (König & Blömeke, 2009; Stürmer, Könings et al., 2013; Voss et al., 2011). Nevertheless, pre-service teachers also were quite attentive to other, more irrelevant and superficial aspects of classroom teaching and learning. This fact shows on the one hand that important events with regard to pedagogical strategies (such as clarification of goals or the learning climate) are inherently subtle, nuanced and difficult for pre-service teachers to notice. Furthermore, it indicates that activating prior knowledge to determine what is and what is not important in a lesson is not a trivial task for teachers at the beginning of their professional careers and impacts the activation of their learning activities (König & Blömeke, 2009; Lind & Sandmann, 2003; Oser et al., 2010; Seidel & Prenzel, 2007; Star & Strickland, 2008).

The findings regarding research question 2a reveal that although they activated elaboration processes to identify teaching and learning components, pre-service teachers struggled in their attempts to activate professional knowledge during information processing indicated by their rather low reasoning capacities. This may imply either that pre-service teachers' so far acquired knowledge structures still are too fragmented or that they lack the ability to activate elaboration strategies during information processing in authentic classroom situations (Berliner, 2001; Kardash & Amlund, 1991; Lind & Sandmann, 2003; Mandl et al., 1986; Putnam & Borko, 2000). As no more data is available to test for both assumptions, future research is needed to give specific answers on that.

Data analysis of research question 2b, targeting pre-service teachers' correct knowledge activation during reasoning, contributes to the above outlined assumptions as two third of the participating pre-service teachers did not match with the content of experts' reasoning. A typical example, where a match was missed, was a situation in which the teacher only very briefly indicated a learning goal but elaborated in detail about the course of the lesson and the tasks for the students. Many of the pre-service teachers misinterpreted this advance organizer as clarification of learning goals. This finding shows again that it is important to acquire and activate professional knowledge in order to process on relevant pedagogical events (König & Blömeke, 2009; Stürmer, Könings et al., 2013). Furthermore, it can also be seen as indicator for pre-service teachers' rather low capacity to activate correct/adequate professional knowledge during information processing on relevant teaching and learning components. This aspect provides relevant new information for the design of video-based teaching and learning courses aiming to support pre-service teachers to engage in meaningful knowledge acquisition processes (Seidel et al., 2013). However, as also one third of pre-service teachers activated

correct professional knowledge, it highlights also that course designers have to think about how to stimulate pre-service teachers' different capacities best (Blomberg, Sherin et al., 2013; Stürmer, Seidel et al., 2013).

To answer research question 3, pre-service teachers' elaboration processes during information selection (noticing) and processing (reasoning) were explored in their interplay. Overall, the majority of participating pre-service teachers attempted to activate professional knowledge during noticing and reasoning, as pre-service teachers showed mostly mixed noticing and reasoning abilities. The biggest challenge was as assumed to activate knowledge about general pedagogical concepts to notice and reason about relevant teaching and learning events while simultaneously being in line with the interpretation of the experts as indicator for correct/adequate knowledge activation. These findings are again of particular interest for further research on pre-service teachers' learning and the design of learning environments in teacher education revealing that the engagement in elaboration processes in authentic classroom situations includes not only the activation of professional knowledge, but also the *correct* activation to show expert-like information processing.

Finally, in research question 4 targeting the validity of the qualitative measurement approach, the results of the qualitative analyses were compared to the results achieved by means of a second, quantitative approach. First of all, it was found that pre-service teachers' information processing capacities assessed with the quantitative measure of the *Observer Tool* were comparable to previous findings using the instrument with different samples of pre-service teachers (Seidel & Stürmer, 2014). Secondly, a systematic positive, though small, relationship between the qualitative and quantitative measure of pre-service teachers' elaboration capacities during information processing was found. Given the fact that the qualitative analysis included different dimensions of elaboration processes during noticing and reasoning, this finding is nevertheless promising for studying pre-service teachers' elaboration processes with a video-based qualitative approach and validating it through a quantitative measure: First of all, the use of pre-selected videotaped classroom situations providing expert-based content information can overcome the barrier of measuring pre-service teachers' knowledge activation without a close temporal and contextual connection to the learning situation as well as a well-defined description of the structure of the learning material and the learning condition can be provided (Artelt, 2000a; Marton & Saljö, 1976a). Two more strengths of this video-based approach are that the assessment of cognitive learning processes in "action" and the use of dynamic, but not too complex problem situations can be taken into account (Wirth, 2005). In sum, through the use of a combined qualitative and

quantitative analysis approach, disadvantages of both methodologies can be minimized by focusing on their advantages (Gläser-Zikuda, Seidel, Rohlfs, Gröschner, & Ziegelbauer, 2011). Through the qualitative approach, it was possible to analyze different dimensions of pre-service teachers' elaboration strategies, what would have not be possible through standardized rating items only (Leopold & Leutner, 2002). In contrast, the quantitative approach has its potential in a more efficient data analysis and thus, the results about pre-service teachers' capacities can be used much faster as feedback tool in teacher education courses (Seidel & Stürmer, 2014). Though, this study was a first attempt at mixing different methodological assessment approaches and further research is needed to substantiate the current results, the combination of qualitative and quantitative measures with a pre-selected video seems to be promising for measuring different dimensions of pre-service teachers' elaboration processes in a contextualized and standarized way (Schäfer & Seidel, accepted).

Another interesting finding of the study contributes to the assumption that cognitive learning activities involved in knowledge acquisition processes are domain- and topic-specific respectively (Alexander et al., 1997; Berliner et al., 1988; 2004; Wiens et al., 2013). Pre-service teachers participating in this study showed better elaboration processes in connection with goal clarity than with learning climate. Three potential mechanisms could explain this finding: First, it may indicate that pre-service teachers still lack the underlying knowledge structures about learning climate that would allow them to activate knowledge relevant for elaboration during information selection and processing (Putnam & Borko, 2000). Second, pre-service teachers' knowledge about learning climate may remained inert (Calderhead, 1991) and thus, subjective beliefs and their own experiences as students in school may have an great influence on their cognitive processing (Nespor, 1987). Thirdly, Kagan (1992) highlights the central role of pre-existing beliefs and prior experiences in filtering the content of lessons. Learning climate in particular might represent a component that especially activates personal prior experiences and beliefs. These activated intuitive assumptions, experiences and beliefs might in turn guide pre-service teachers more strongly when activating elaboration processes about learning climate than about goal clarity. However, it is difficult to identify the exact reasons for pre-service teachers' different elaboration capacities, as this was not the aim of the study. Therefore, further research on domain- and topic-specific elaboration processes is needed.

Overall, this study provides promising evidence that it is necessary to define the learning content more precisely by using the expertise of professionals in the field in order to understand what pre-service teachers should learn and in turn, to assess their actual cognitive

capacities more systematically. Furthermore, it adds new value to previous research on analyzing elaboration processes of pre-service teachers in the way that not only the activation of knowledge during information selection and processing was examined, but also whether the activated knowledge is correct in relation to the specific teaching situation. Despite that, the findings indicate the domain-specific character of cognitive learning processes as well as individual differences and capacities in activating elaboration processes about specific teaching and learning components. Finally, it can be argued for the combination of mixed-methods approaches in research on cognitive learning processes. Despite these advantages, the study also has some limitations, which I want to address in the following.

First, as the assessment of pre-service teachers' elaboration processes regarding goal clarity and learning climate took place with one specific video, the study remains so far exploratory and the argument remains a hypothesis. Therefore, future investigations should use this approach by including a set of videos for which similar information is provided and test it with other sample groups in order validate the study findings.

Second, further research taking design variations into account is needed. Longitudinal designs, for example, would allow the investigation of changes in pre-service teachers' elaboration processes during noticing and reasoning over time (Santagata & Angelici, 2010; Stürmer, Könings, et al., 2013). This is particular important given recent research by Grossman, Valencia, Evans, Martin, Place and Thompson (2000), who stress not to make claims about pre-service teachers' learning based only on data from their first year of teaching. But with regard to the nature of expertise development (Ericsson, Krampe, & Tesch-Römer, 1993), the implementation of such studies in teacher education is quite challenging and time consuming. In this context, it would be also necessary to test, whether and how specific instructional elements shown to be effective for elaboration processes of students at schools (e.g. goal clarity) (Herweg, 2008; Seidel, 2003), also support pre-service teachers' elaboration capacities. First results regarding pre-service teachers' knowledge application assessed in the context of authentic classroom situations already indicate differential effects depending on the instructional approach used (Seidel et al., 2013). Considering that pre-service teachers with different elaboration capacities during information processing were found in this study, differential effects of supportive instructional elements on pre-service teachers' activation of elaboration processes depending on their prior capacities should be investigated as well (Lehtinen, 1992). In this line, and although they might be as well difficult to implement in the setting of teacher education, experimental study designs including a control group and taking also other parts of general pedagogical knowledge (e.g. classroom

management) or different knowledge domains (e.g. pedagogical content knowledge) into account, would be useful to gain a deeper insight into supportive domain-specific conditions for pre-service teachers' activation of elaboration processes. In turn, adaptions of the assessment and analysis approach have to be considered.

Another methodological issue is of particular interest for future research: Pre-service teachers' elaboration processes during noticing and reasoning were assessed within the qualitative and quantitative measurements in comparison to the viewpoint of experts in teaching and learning. This approach is based on the assumption that experts are characterized by having an integrated knowledge base while also being able to activate those knowledge when noticing and reasoning about a pre-selected video clip and thus, their information can provide a systematic baseline about learning capacities pre-service teachers could achieve in best case (Ericsson et al., 1993). The experts from the current study came from the field of educational research and teacher education and had years of experience in the field of observing teaching and learning processes from a general pedagogical view – the knowledge aspect under study. Nevertheless, further evidence is required for validating this expert-based criterion norm, for example, by comparing different groups ranging in their expertise (teacher educators, experienced teachers, or school inspectors) or relating the results to other criterion-related measures of elaboration processes (Kobarg, 2009; Lefstein & Snell, 2011). A first attempt in this direction was successfully accomplished in this study by comparing the results of the qualitative measure of elaboration processes with pre-service teachers' elaboration capacities as shown in the quantitative analysis. In the context of the *Observe* project, further studies already validated the content of the pre-selected video clip by comparing experts' information about the identified teaching and learning components with pre-service teachers' opinion about the extent to which the selected video clip is a valid and authentic example of the two teaching and learning components. The results showed high agreement between both groups (Seidel & Stürmer, 2014).

In addition, the study was designed to make statements about the nature of pre-service teachers' elaboration processes during information selection and processing. It was not possible to explore specific challenges pre-service teachers encounter when activating knowledge about teaching and learning in the context of classroom teaching. Previous studies, however, suggest that these challenges are indeed related to teacher noticing and reasoning about video-taped classroom situations (Berliner, 1991; Kersting et al., 2010; Roth, 2009). Future research would benefit thus, from examining potentially moderating factors of pre-service teachers' elaboration processes in the context of authentic teaching situations. For

example, it can be assumed that motivational aspects (e.g. interest in the learning content and video-based learning) influence pre-service teachers' elaboration during knowledge acquisition processes (Alexander et al., 1997; Klauer & Leutner, 2007; Krapp & Prenzel, 1992).

Furthermore, decisions about the selection of further methodological approaches have to be made, as it is obvious that the complexity of cognitive learning processes involved when observing classroom situations goes beyond what can be measured with an open answer format (Kane, 1994). Given the fact that a small but significant relationship between the two measurement approaches was found, the chosen methodology approach seems to be promising for studying the cognitive process of elaboration. Therefore, future research can make use of this approach and on the findings to continue research on pre-service teachers' elaboration processes. In the context of this thesis, the exploratory study findings were already taken into account within the development of the analysis framework for investigating pre-service teachers' organization processes in Study 2 (see section 7.2.5). Besides, the claim of using alternative tools for assessing cognitive learning processes is considered as well in Study 2, as a new assessment method that combines video with concept mapping is applied.

In the long run, an exploration of the relation between pre-service teachers' elaboration processes and their teaching performance (planning, action, reflection) would further advance the understanding of how meaningful learning activities impact knowledge transfer to real classroom practice. Information on that could help to implement knowledge application opportunities proximal to teaching practice, as university-based teacher education is often been criticized for not adequately preparing pre-service teachers for the reality of classroom teaching (Grossmann & McDonald, 2008).

In sum, the findings of Study 1 illustrate that professional vision serves as a successful proximal indicator for investigating cognitive learning processes during phases of knowledge acquisition as the activation of prior knowledge is sufficient for pre-service teachers to notice and reason like experts. Besides, the results suggest assessing different dimensions of knowledge activation when studying the nature of pre-service teachers' elaboration processes. These findings also underpin, that university-based teacher education has to think about strategies how to support the different dimensions of prior knowledge activation best to foster the application of elaboration strategies as an important prerequisite to ensure complex knowledge structures within pre-service teachers.

7 Study 2: Investigation of pre-service teachers' organization processes with regard to specific teaching and learning components in the context of professional vision

As outlined in the theoretical background, processes of learning are also strongly constituted by organization activities. The activation of organization strategies can help to reduce complexity by structuring and organizing the new information consistent with the existing knowledge base through macrostructure processes (Friedrich & Mandl, 2006). Therefore, Study 2 wants to contribute to this research by investigating pre-service teachers' organization processes when reducing complexity and integrating information about specific teaching and learning components from a pre-selected video clip on specific teaching and learning components into a concept map using a "construct-a-map-by-yourself" task (Ruiz-Primo & Shavelson, 1996).

Within teacher education research, it is argued that teachers, who organize their knowledge into coherent and integrated structures, are more effective in terms of being better problem solvers, as it is easier for them to access the knowledge and to cope with the dynamic demands of teaching (Roehler et al., 1988; Wahl, 1991). Other researcher have found that differences between experienced and novice teachers' abilities in perceiving, understanding and interpreting classroom events are also attributed to experts' better organized, more interconnected and more accessible cognitive chunks and schemata (Peterson & Comeaux, 1987; Sabers, Cushing, & Berliner, 1991; Livingston & Borko, 1989; Leinhardt & Greeno, 1986). Research in the broader area of cognitive psychology suggests that a coherent organization of knowledge according to high-level principles is critical for initial learning processes, subsequent retention, and later transfer (Anderson, 1996). Consequently, assessing and supporting the development of a coherent knowledge organization seems to be crucial in teacher education, either for pre-service teachers' learning as well as for future job demands. In this context, strategies, such as the reflection and summarization of new learning contents and the transfer of new knowledge to different situations through the use of different representations have been discussed as useful elements for fostering the application of organization strategies in order to develop integrated knowledge structures (Hugener, 2008; Steiner, 2001). But as specific inferences about knowledge organization also have to be anchored in the context of the specific domain, little is known about pre-service teachers' initial processes of knowledge organization in the context of general pedagogical knowledge, specifically about relevant teaching and learning components (Brouwer, 2010; Koster et al., 2005, Stürmer et al., 2013). First results have shown that the acquisition of theoretical

concepts about teaching and learning in university-based teacher education help pre-service teachers to engage in processes of abstraction by predicting possible consequences from teaching strategies on students' learning processes (Stürmer, Könings et al., 2013). Detailed studies, which explore specific patterns of the cognitive structure on the structural level and in terms of semantical relations or the organization through chunks and higher-order concepts as indicators for content-related organization processes, as well as changes through formal university-based teacher education courses, are still missing. Expertise research in other domains, for instance medicine, suggests that in domains, where knowledge is mostly organized hierarchically, novices miss some intermediate knowledge levels (Patel & Arocha, 2001; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Others showed that novices' representations are more like lattices than hierarchies (Chi & Ohlsson, 2005). Against the backdrop that knowledge organization processes mainly have the function to reduce complexity, macrostructure processes such as abstraction and generalization are necessary operators over all domains, but especially in dynamic and complex systems, such as the teaching domain is (Van Dijk, 1980).

In sum, however, we do not yet have a clear understanding on how pre-service teachers' organization strategies in the context of authentic classroom situations regarding teaching and learning components can be described. Their knowledge organization might be characterized one the hand as a hierarchical knowledge system, where super- and macrostructures are visible necessary to reduce complexity, but also as a dynamic system with many reciprocal and causal relationships within each macrostructure unit as classroom situations are ill-structured and constantly changing (Dörner, 1976; van Dijk, 1980; Chi, 2006).

These research gaps induced the exploration of initial knowledge organization processes of pre-service teachers, and how they reduce complexity. This is studied in the context of professional vision by investigating different patterns of their structure- and content-related organization strategies (see section 2.3.2). To advance the understanding of pre-service teachers' use of organization strategies during phases of knowledge acquisition in university-based teacher education, individual differences between pre service teachers with regard to their use of higher order concepts/principles and the interaction with other organization patterns at the beginning of a course on teaching and learning, as well as specific learning trajectories over time are part of the research activities. This issue addresses the often stated research gap to investigate, how university-based courses aiming to support knowledge transfer through the integration of different representations of practice and reflection tools, affect pre-service teachers' cognitive learning processes necessary to acquire knowledge and

apply it to complex teaching situations (Bauer et al., 2012; Brouwer & Korthagen, 2005; Stürmer, Könings et al., 2013).

In the context of the assessment of processes regarding knowledge organization, concept maps have proven to be useful and valid assessment tools for many domains as they are interpreted as representative of knowledge structures and understandings of concepts (e.g. Yin et al., 2005; Beyerbach & Smith 1990; Novak, 1990a). Most of the studies using concept maps are embedded in the context of students' science learning and exploring students' conceptual changes over time. A few studies, which used concept maps as an approach to explore knowledge structures in teacher education, showed that pre-service teachers' concept maps became more integrated and cohesive over time (Beyerbach & Smith, 1990; Morine-Dershimer, 1993); some others showed an apparent decline in cognitive organization (Winitzky & Kauchak, 1995) or a non-linear growth (Winitzky et al., 1994; Roehler et al., 1988). Taking Ruiz-Primo & Shavelson' s (1996) definition of concept mapping assessment as a combination of a task, a response format, and a scoring system into account, multiple concept mapping techniques exist. However, to my knowledge, no empirical investigation used concept mapping in combination with video examples to take the contextualized nature of teacher knowledge into account, when assessing organization strategies (Ruiz-Primo & Shavelson, 1996). With regard to the importance of the technical qualities of assessment tools, decisions about the applied concept mapping assessment have to be based on theoretical models and empirical findings. In this line, scoring indicators have been derived from theoretical models on knowledge representations and empirical findings from expertise research in the domain of teaching.

Against these outlines, Study 2 aims to adapt the methodology of concept mapping from cognitive psychology research to the study context. Therefore, authentic video sequences of classroom situations are used as prompts for activating pre-service teachers' knowledge about the effective teaching and learning components of goal clarity and learning climate in order to explore their structure- and content-related organization processes through the technique/task of "construct-a-map-by-yourself". Identical to Study 1, video material as stimulus was selected, on which experts in the field of teaching and learning research agreed that the two teaching strategies of goal clarity and learning climate – relevant for student learning – are represented.

In combining this new assessment approach, Study 2 wants to contribute to the advancement of research methods in the field of professional vision and pre-service teachers' organization processes. Furthermore, it aims to add new information to existing findings, gathered by the

qualitative and quantitative state-of-the-art approach. In order to address these research aims, the next sections outline the specific research questions (section 7.1) and the methods applied for answering them (section 7.2). Afterwards, the study results will be presented (section 7.3), and discussed within the last section (7.4).

7.1. Research questions

Within this study, following three research questions with regard to the assessment of pre-service teachers' organization processes are addressed:

1) How can pre-service teachers' organization processes at the beginning of a course on teaching and learning be described when observing and integrating information from a pre-selected video of a classroom situation into a concept map?

In sum, studies in the field of general pedagogical knowledge barely have investigated pre-service teachers' organization strategies in the context of an authentic and ill-structured classroom situation yet. However, a central assumption of this work is that pre-service teachers need to organize and structure incoming information regarding relevant teaching and learning components based on professional knowledge in order to reduce the complexity of classroom situations in their future jobs. Thus, it is investigated how and to what extent pre-service teachers are already able to use their knowledge to organize selected information in an authentic classroom situation by combining a videotaped classroom situation with a concept mapping task. In order to describe pre-service teachers' organization processes, theoretical indicators have been derived from knowledge representations models. Findings from the expert-novice paradigm provide a further basis for this exploratory study. Thereby, studies in the field of teacher education reveal that concept mapping can serve as a resource to uncover pre-service teachers' knowledge organization.

In this line, constructing a concept map requires pre-service teachers to apply supportive macro-operators referring to the processes of omission and selection of information, and to abstraction and construction processes. Pre-service teachers have to select relevant information from the classroom video and integrate the single information pieces into main concepts of teaching and learning. Hereby, their structure-related organization processes might become obvious. Furthermore, constructing a concept map requires pre-service teachers to bring the concepts into a clearly arranged scheme by linking the selected information pieces and concepts by labeled arrows and to precise their relationships. Thus, the kind of semantical links might indicate their content-related organization processes. Thereby,

intrarelated links as well as interrelated links may be used (see section 2.2.2). An intrarelated link between two concepts may indicate that pre-service teachers' knowledge has been activated as comparisons of similarities and differences between the two concepts are necessary. For interrelated relations, instead, case knowledge plays a relevant role assumed to be highly context-related and organized around personal experiences, as concrete events or activities have to be defined. Pre-service teachers' content-related organization processes also might become obvious through the integration of higher order principles and concepts related to the teaching and learning components of goal clarity and learning climate (e.g. learning goals, advanced organizer), outlined by work related to schema theories (see section 2.2.2). Overall, the nature of pre-service teachers' structure- as well as content-related organization processes at the beginning of a course on teaching and learning is targeted in this research question.

a) How do pre-service teachers organize the selected information in relation to the structure of the observed pre-selected video in their concept maps? Does pre-service teachers' superstructure (type of concept map) also trigger their macrostructures (number, type of structure)?

In line with the above stated idea, answers to this research question reveal how pre-service teachers' try to structure the selected information in relation to the presented information in the video clip as an indicator for their structure-related organization processes.

Based on the outlines in the theoretical part (see sections 2.2.2; 2.3.2) different structure-related organization processes are expected. Firstly, they might be characterized by a special focus or superstructure, through which pre-service teachers analyze and integrate aspects of the shown classroom situation (superstructure) into the concept map (process of omission and selection). A concept map structure revealing detailed information about persons and procedures, shown in the video clip, would indicate a more surface structure-related process, whereas a concept map including specific information related to teaching and learning events would reveal a more intentional organization. *Considering the fact that pre-service teachers have not gained much experience in analyzing video-based classroom situations and novice teachers tend to focus on the teacher when observing classroom situations, it is assumed that large number of concept maps reveal a person-centric superstructure. At the same time, it can be assumed that pre-service teachers are already able to structure their map with regard to specific teaching and learning events as they already took part in courses on teaching and learning within their teacher education program.*

Furthermore, as pre-service teachers may have problems to decide what sub-ordinate concepts/information could be omitted and thus, construct many linked nodes, it can be hypothesized that the concept map' macrostructures often appear as lattices. In the same time, many single macrostructure units, indicated through only one or two connected concepts, are expected due to their so far limited knowledge representation regarding teaching and learning components at the beginning of the course. Finally, considering the theoretical assumption that the superstructure is a determining structural factor for the macrostructures, it is assumed that differences in the type of superstructure (type of concept map) illustrate also differences on the level of macrostructures (number and structure).

b) What content-related organization processes do pre-service teachers show when integrating information from the observed pre-selected video of a classroom situation into their concept maps? What kind of semantical links are included and to what extent do pre-service teachers integrate higher order principles with regard to specific teaching and learning components?

As not only structure-related organization processes, but also content-related organization processes are necessary to reduce complexity and to develop a well-organized knowledge base, this organization activity will be investigated within this research question.

According to work based on the semantical network approach, content-related knowledge organization can be analyzed through investigating the semantical relationsships between concepts. Thereby, inter- and intrarelated links are distinguished, which include different types and indicate the semantical complexity of a knowledge structure. Furthermore, the integration of higher-order principles (e.g. learning goals, advanced organizer) is used as a content-related indicator for their knowledge organization process. These theoretical and empirical considerations build the basis for this exploratory study.

In line with that and based on findings from expertise research, pre-service teachers are expected to create several kinds of links and might be able to connect a lot of aspects of teaching and learning, but still may not have developed propositions similar to those of experts, like bringing a complex series of related aspects into a sequence or hierarchy indicating intrarelated links, respectively. Empirical findings, so far, showed that novice teachers do not only have a less well-connected knowledge structure, but also that their information processing is driven by misconceptions and beliefs. In turn, it can be assumed that pre-service teachers' concept maps at the beginning of a course on teaching and learning reveal also erroneous relations. As well as it can be assumed that pre-service teachers' fail to

specify the kind of relation between two concepts as they still may miss the relevant prior knowledge necessary for indicating the semantical relationship.

With regard to the integration of higher-order principles related to goal clarity and learning climate in their concept maps, only a low amount of knowledge-based macrostructures is expected, as pre-service teachers are at the beginning of a course on teaching and learning and thus, still may miss the relevant prior knowledge necessary for content-related abstraction processes.

2) Is the applied concept mapping technique a valid assessment method to identify pre-service teachers with different entry levels regarding knowledge about the teaching and learning components of goal clarity and learning climate indicated through the integration of higher order principles at the beginning of the course on teaching and learning?

Using concept mapping as assessment tool, it is one important issue to investigate the validity of the concept mapping technique with regard to the criteria of known group differences. This issue is targeted by investigating, if it is possible to identify with the concept mapping technique groups of pre-service teachers differing in their knowledge about the teaching and learning components of goal clarity and learning climate indicated through the integration of higher order principles at the beginning of the course. *Thereby, it is assumed that the concept maps reveal different qualities and thus, pre-service teachers with a low and high entry level can be found already at the beginning of the course. However, it can be assumed, that only a small number of pre-service teachers integrate higher-order principles in their concept maps as they are at the beginning of their professional career and thus, cannot have developed an integrated knowledge structure yet.*

3) How can organization processes of pre-service teachers starting with different entry levels regarding the integration of higher order principles be characterized? What kind of changes can be reconstructed for the two groups of pre-service teachers over time of the course on teaching and learning?

In order to gain insight into individual differences, pre-service teachers with different entry levels regarding the integration of higher order principles are compared whether and how they differ in their organization patterns. As structural-related and content-related organization strategies complete each other during knowledge organization processes (see section 2.3.2), it can be hypothesized - even if the difference in pre-service teachers' knowledge level is thin –

that differences in pre-service teachers' content-related knowledge organization illustrate also differences in their structure-related organization processes. Furthermore, differences regarding the kinds of semantical relations between concepts as a second indicator for the quality of content-related organization processes are expected. This is also based on assumptions from schema theory (see section 2.2.2), where knowledge in terms of schemata determines what information is perceived and selected (bottom-up process) and how the information is processed further (top-down process). Various knowledge forms are involved, including formal knowledge acquired during formal learning settings, practical or case knowledge acquired in real teaching situations or intuitive theories and beliefs based on personal experiences. In line with these conjectures, it is assumed that pre-service teachers in general – as they have not developed a highly differentiated knowledge structure and have not gained a lot of practical knowledge yet – select information from the videotaped classroom situation based on existing schema (assimilation). In this context, however, it is expected that pre-service teachers with a rather high knowledge entry level differ on a fine grained level regarding their organization processes from pre-service teachers showing a rather low entry level of formal knowledge. Furthermore, it is examined, if pre-service teachers with different knowledge entry levels also show different learning trajectories and changes over the university-based course on teaching and learning, aiming to test another validity aspect of the concept mapping technique (instructional sensivity). Differences are targeted separately for structure- and content-related organization processes.

a) What kind of structure-related organization processes can be identified for pre-service teachers starting with different entry levels regarding the integration of higher order principles? What kind of changes can be reported for the two groups of pre-service teachers over time of the course?

It is assumed that concept maps from pre-service teachers with a low entry level regarding the integration of higher order principles about teaching and learning components reveal on the structural level in general a more detailed and surface information organization combined with more single and unrelated information pieces than pre-service teachers from the high entry level group. Changes in pre-service teachers' organization processes are expected, especially with regard to pre-service teachers with a low entry level regarding the integration of higher-order principles. These pre-service teachers might profit most from theoretical knowledge combined with video-based examples and reflection tasks in the university course, which in turn affect their formal knowledge necessary to engage in

information selection and abstraction processes. However, only little changes of organization activities on the structural level are expected, as restructuring processes need more time than one course in university-based teacher education usually can provide. Nevertheless, small positive changes towards a larger and hierarchical network of interrelated concepts are expected for both groups.

b) What kind of content-related organization processes can be identified for pre-service teachers starting with different entry levels regarding the integration of higher order principles? What kind of changes can be reported for the two groups of pre-service teachers over time of the course?

Regarding content-related organization processes, it is specifically expected that concept maps from the low entry level group reveal more misconceptions and unspecified relationships between concepts than concept maps from the high entry level group. Furthermore, a lot of procedural relations, which describe actions observed in the video clip, are expected, as they are considered to be easier to activate than hierarchical relations for example. With regard to differential changes, it is hypothesized that specifically concept maps from pre-service teachers with a rather low entry level reveal fewer misconceptions and unspecified relationships at the end of the course, as it is assumed that the acquired knowledge helped them to reverse their misconceptions and subjective beliefs. Furthermore, a greater amount of macrostructure units, which are organized around higher order principles are expected for this group of pre-service teachers. For the high entry level group, an increase of functional and hierarchical relations, indicating a knowledge restructuring process on a micro-level is expected, as they already possess first knowledge at the beginning of the course and thus start to reorganize their existing knowledge structure.

7.2. Methods

Aim of the present study is to investigate pre-service teachers' organization processes with regard to specific teaching and learning components in a situated and contextualized way. In this context, the study also wants to add new information on the use of research methods in the context of professional vision by applying concept mapping, originally a methodology approach from cognitive science.

In this section the methodology approach of the current study is described in detail. Therefore, I first present the research design in which the research questions were tested (section 7.2.1). Secondly, I describe the sample of the study (section 7.2.2). In the following, a summary

about the data collection (section 7.2.3) and the instruments used in the study (section 7.2.4) is provided. Finally, the data analysis approach will be presented (section 7.2.5).

7.2.1 Research design

The study was conducted within the teacher education program offered by the TUM School of Education at the Technische Universität München, Germany. The teacher education program for upper secondary school (Gymnasium) offers in the obligatory study field of educational science based on the German teacher education system an innovative learning concept (TUM*paedgogicum*), which is characterized by different features to foster knowledge application and transfer to real classroom settings at an early stage of teacher education (Gröschner & Seidel, 2012; Prenzel, Reiss, & Seidel, 2011). A central component builds an educational course (TUM*paed* 2a) which provides knowledge on the design of effective learning environments in school and is taught through instructional elements (use of video examples, journal writing) related to "representations, decompositions and approximations of practice" (Grossman et al., 2009) (see section 3.3.1). This obligatory educational course during the second year of teacher education builds the study context for answering the current research questions.

This university course is preparatory for a following practical internship at school and designed to support pre-service teachers in acquiring conceptual knowledge and in developing their skills to transfer this knowledge to praxis. In particular, the course focus with regard to its content about principles of teaching and learning on what is known from teaching effectiveness research about effective teaching and learning components (see section 3). Analogous to that, pre-service teachers are introduced to important concepts and learning theories, where the effective teaching and learning components of goal clarity and learning climate build two of them (see section 3.2). With regard to scaffold and apprentice pre-service teachers into meaningful learning and foster pre-service teachers' knowledge application in authentic contexts, the course is designed based on research on the use of video excerpts and learning journals in teacher education (see section 3.3.1).

The sessions, targeting teaching and learning components, started with presenting knowledge about one specific component by explaining the concept, providing definitions and referring to empirical findings of practice descriptions and effects of student learning. Regarding goal clarity, for example, the course instructor presented a definition/explanation of the concept (e.g. goal clarity means that learning goals are explicitly outlined and clarified and that learning activities are aligned to the goal) and provided information with regard to the effect

on student learning (e.g. clarifying learning goals drives students' attention towards relevant information for reaching the learning goals and helps students to focus on the main concepts). Following this instruction, pre-service teachers were provided with principles in observing and analyzing teaching and learning components in video clips along with directions concerning what they should focus on when observing this component. Afterwards, videotaped examples of authentic classroom situations were presented and analyzed with the course instructor with regard to the specific teaching and learning component. For each video example, pre-service teachers wrote also their own observation protocol and shared their observations with the other course participants. All video clips illustrated typical classroom practice (good and bad teaching) and were chosen from the pool of video material screened and selected within the *Observe* project (Seidel & Stürmer, 2014). For example, video clips, selected to illustrate clarifying learning goals and requirements, often focused on the beginning of a lesson allowing pre-service teachers to observe how the teacher introduced the lesson goals and oriented students accordingly. Video clips representing aspects of learning climate generally tackled situations, in which teachers had to find a balance between taking the needs of students seriously and still challenging them cognitively, for example, not giving them direct and easy solutions. Finally, to ensure knowledge acquisition in an integrated way and to foster reflective learning, journal writing was an essential part of the course. After the sessions pre-service teachers received an assignment with guided questions to reflect about the specific topic of the lesson and their own experiences. Prompted questions among other things were for example ''Write what you understood very well in today's session'', ''Provide examples from classroom situations, own experiences etc. that confirm and/or contradict what you learned today''. Pre-service teachers had to submit their reflections as part of the course requirements through a computer-based learning platform called *moodle*.

7.2.2 Sample

The present study consists of data from N = 27 pre-service teachers (14 females; 13 male), who participated in the above described "TUM*paed* 2a" course at the TUM School of Education during the winter term 2011/12. They were in their second year of teacher education and studied in their third term (M = 3.07; SD = 0.39) for the upper secondary school track (Gymnasium) in the fields of mathematics and science (including chemistry, biology, physics, computer science, and sports). Their mean age was 21 years (M = 21.37; SD = 1.45) and their final high school examination score ("Abitur") was good (M = 2.23; SD = 0.44). So far, pre-service teachers already attended on average two courses in the field of teaching and

learning (*M* = 1.68; *SD* = 0.90) and showed a high interest in teaching and learning (*M* = 4.07; *SD* = 0.74 with a Likert-Scale ranging from 0 = low to 5 = high), assessed with a questionnaire developed by Drechsel (2001).

It has to be noted that the participating pre-service teachers are not the full cohort (*N* = 69) of the mandatory course, as the primary goal of this study was to explore a new assessment method with the potential to capture pre-service teachers' organization processes. Once such a measure is established, it can be tested with a bigger sample size measuring program effects more rigorously than this exploratory study can provide. Nevertheless, as all pre-service teachers filled out a questionnaire tapping (study) background information at the beginning of the course, participants could be compared with the full cohort. Table 12 gives an overview about the mean characteristics of the participating group of pre-service teachers as well as about the non-participating group, indicated through the values in the parentheses. Comparisons showed no significant differences between participants (*N* = 27) and the non-participating pre-service teachers (*N* = 42) in gender, age, study term, high school examination score, attended courses, and interest in teaching and learning (all t-tests: $p > .05$).

Table 12

Characteristics of the Study Sample of Study 2 (N = 27)

	Gender	Age	Study term	High school examination score	Number of attended courses in teaching and learning	Interest in teaching and learning
Mean average	60% female *(55% female)*	21. 37 *(21.74)*	3.07 *(3.07)*	2.23 *(2.34)*	1.68 *(1.60)*	4.08 *(3.88)*

Note. Mean average of the 42 non-participating pre-service teachers in parentheses.

Furthermore, it has to be mentioned that the pre-service teachers, who took part in the study, did not receive any kind of official study credits, instead, just a small expense allowance. Therefore, participation was on a voluntary basis. In this context, it can be assumed that the sample was quite motivated with regard to video-based assessment and learning. Concerning their prior experiences with the concept-mapping technique, two pre-service teachers reported that they worked ones or twice before with concept maps, whereas the other 25 pre-service teachers had no experience since up to the study. This was important to know as the

assessment included a concept mapping technique. Beside, none of them had previously worked with videotaped classroom situations before participating in the course.

7.2.3 Data collection

After pre-service teachers agreed on their study participation in the first lecture, each student was invited to an individual session at the beginning (during October 2011) and the end of the winter term (during February 2012). Each assessment session lasted around 60-90 minutes and took place in a study room of the TUM School of Education. In order to ensure objective assessment conditions, each session had the same procedure and was guided by the author of this work. Figure 12 gives a schematic overview of the study procedure.

I. Introduction	1) Welcome and theoretical introduction 2) Practical handling of the mapping software
II. Training	1) Analysis of a concept map example 2) Construction of a computer-based concept map
III. Assessment	1) Presentation of video clip 2) Concept mapping task 3) Questionnaire on concept mapping (pre-test)

Figure 12. Overview of the study procedure of Study 2.

At the beginning of the session, each pre-service teacher received an theoretical introduction to concept mapping, the terms 'node/concept' and 'link' were explained, the differences to mind maps were outlined and an example of a concept map (see figure 2) was provided. Furthermore, the three phases of the circular process of successful concept mapping based on Hilbert and Renkl (2008) were introduced: planning, constructing, and controlling. Planning the concept map is the first step. Then, while constructing the concept map special attention to the relationships between the concept nodes has to be given. In the end, the concept map has to be controlled for its correctness and completeness and thus, in some cases new planning activities have to be started in order to revise the concept map. With introducing this technique, a successful concept map construction within the assessment task should be supported. In the following, each pre-service teacher received a description about the practical handling of the mapping software "Easy Mapping Tool" (for more information see http://www.cognitive-tools.com) as a computer-based concept map technique was used. This

software is especially developed for concept mapping and provides different forms and colors for nodes. Besides, as links connecting the nodes can be labeled. In sum, around 30 minutes were spent for this introduction phase.

In the following training phase, pre-service teachers were firstly given a concept map example about the topic 'apple' including mistakes as well as misses of concepts and links. In order to ensure that they understood the theoretical part, pre-service teachers were given 10 minutes to fill in the concepts and lines as well as to correct mistakes. In a second exercise – aiming to overcome assessment problems due to the use of the mapping software – pre-service teachers were ask to construct a computer-based concept map about the topic "Munich" using the 'Easy Mapping Tool' (around 10 minutes).

After pre-service teachers felt comfortable with the concept mapping tool, the assessment of pre-service teachers' organization processes started. In this context, a video clip – selected from the pool of videos from the *Observe* project (Seidel, Stürmer, Prenzel, Jahn, & Schäfer, submitted) and thus, representing the two teaching and learning components of goal clarity and learning climate – was presented to activate pre-service teachers' cognitive processes. Beforehand, brief contextual information about the class as well as about the teaching and learning components under study was provided.

After watching the video clip with the opportunity to take notes and to watch it a second time, pre-service teachers were given an instruction to construct a concept map related to the clip in 20 minutes. In the end, pre-service teachers were given a questionnaire adapted from Stracke (2004) tapping their attitude towards concept maps and the acceptance of the concept map assessment with regard to interestingness, usefulness and ease of use.

The assessment procedure was the same within the pre and post-test. However, in the post-test, the introduction and excise phases were shortened and adapted to each pre-service teacher as they already worked with video and concept maps before. Besides, pre-service teachers had not to fill in the questionnaire on concept mapping again.

Overall, data for this study consists of two concept maps from each pre-service teacher; one constructed at the first measurement time and one concept map constructed at the second measurement time. Figure 13 gives an example of a concept map created at the first measurement time.

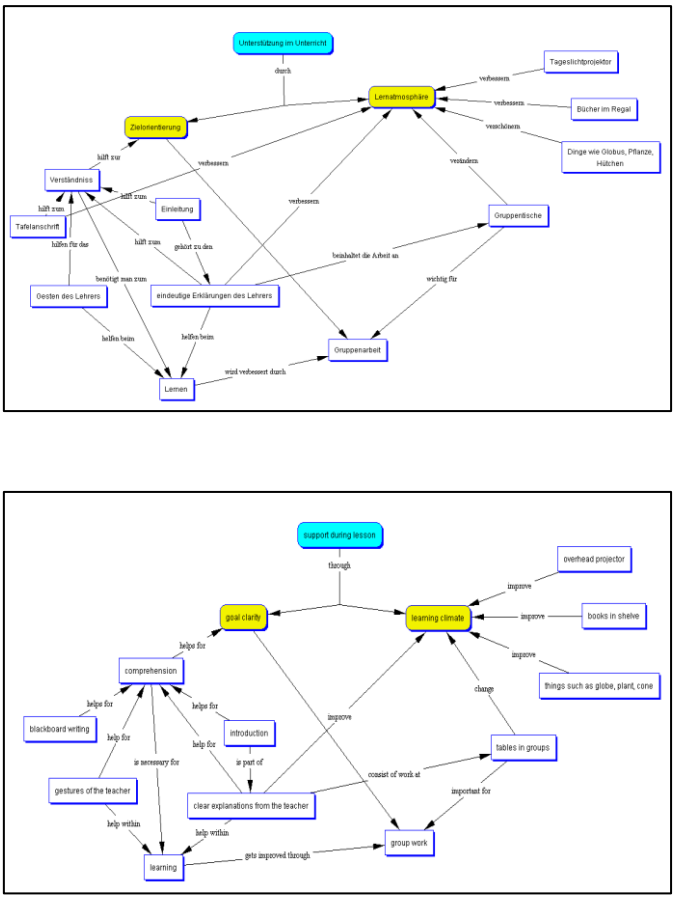


Figure 13. Example of a concept map created from a pre-service teacher at time 1 (original version and translated English version).

Furthermore, the data collected with the questionnaire on concept mapping was especially relevant for research question 2 to learn more about the sample group and their attitude towards the concepts mapping assessment.

7.2.4 Instruments

In order to understand the concept map assessment applied in this study in a more detailed way, I will provide in this section information on the video clip, integrate the specific elements of the concept map technique with regard to 'task' and 'response format' into Ruiz-Primo's and Shavelson's (1996) framework (introduced in section 4.3.1) and finally, address the concept mapping questionnaire. The characterization of the 'scoring system' will be introduced in the data analysis section.

Video clip to activate pre-service teachers' organization processes

Another video clip from the video-based assessment *Observer Tool* – introduced in Study 1 (see section 6.2.1) – was adapted to this study as the video clip selection was based on the

identification of the relevant teaching and learning components. Furthermore, the authenticity of the selected classroom situation as well as a balance between cognitive stimulating and overloading were further video selection criteria in the development of the *Observer Tool* (Seidel & Stürmer, 2014). Another selection criteria in this study was that the video clip should present teaching examples with a rather good implementation of goal clarity and learning climate, as they are more noticeable than in examples, where these components are not implemented very well. This decision was made due to the fact that the assessment task was considered as already quite challenging and pre-service teachers should not be overburdened too much.

The video clip used to activate organization cognitive processes at pre- and post-assessment, was selected from the Swiss video portal (Reusser, 2005-2009) as already the video clip from Study 1. In contrast, it shows a three-minute excerpt from a ninth-grade history lesson on the topic of "rights to freedom". The teacher starts the lesson by repeating and highlighting important aspects from the previous lesson, which are additionally listed at the blackboard as they are relevant for the current history lesson. After activating students' prior knowledge, the teacher gives an overview of the topic and tasks that will follow while the students are listening to his speech. Furthermore, the teacher refers to how students should work on the following tasks by outlining his requirements.

Also for this video clip, the three independent experts in the field of teaching and learning – introduced in Study 1 – provided information on the content of the video clip with regard to the teaching and learning components. First of all, they agreed on that the video clip is a discernable example for goal clarity and learning climate. Furthermore, the experts came to the conclusion that the teacher shows a good example of making the learning goals and requirements clear and transparent to the students. The teacher activates students' prior knowledge, gives a structured overview of the lesson and learning goals and scaffolds students learning through a clear presentation of how the task should be solved. Despite the fact that the teacher does not directly use humor (e.g. telling a funny story) as an indicator of a supportive learning climate, it was outstanding to the experts that he speaks in a respectful and careful manner and takes the needs of his students seriously. Therefore, it can be assumed that this pre-selected video clip can serve as a cognitive stimulus for goal clarity and learning climate.

Concept map technique to assess pre-service teachers' organization processes

An important first step in using concept mapping as assessment tool was to create a *task* that invites pre-service teachers to provide evidence on their knowledge structure and organization processes. Closely related, a *format* for pre-service teachers' *responses* had to be chosen. With regard to Ruiz-Primo and Shavelson's framework for conceptualizing concept maps as assessment tool (1996), figure 14 gives an overview about the task and response format used in this study.

Task
Task demands: "Construct-a-concept-map-by-yourself"
Task constraints: Two concepts are provided (goal clarity, learning climate)
Task content structures: The topic of "effective teaching and learning components" combined with video as knowledge activation prompt do not impose necessarily a hierarchical structure, rather represents a more ill-structured knowledge domain thus a combination of different structure types might be observed.
Response format
Response mode: Computer-generated with the use of a special concept-mapping-software
Characteristics of the response format: Format include the two concepts of "goal clarity" and "learning climate"
Mapper: Pre-service teachers, who individually constructed their maps on the computer

Figure 14. Integration of the concept mapping technique into Ruiz-Primo and Shavelson's framework (1996) with regard to task and response format.

Within the current applied concept mapping task, pre-service teachers were encouraged after watching the video clip tapping specifically goal clarity and learning climate to construct a concept map by their own. Therefore the two nodes of "goal clarity" and "learning climate" were given and pre-service teachers were asked to create further concepts and their own linking phrases. Furthermore, they were not bound to a specific concept map structure. This low-directed mapping technique was chosen due to the fact that this method might be better able to reflect differences in learners' knowledge structure including their information selection and construction processes than through making too many restrictions beforehand (Ruiz-Primo et al., 2001). Two presented concepts were given in order to ensure that they construct their maps with regard to the topic of effective teaching and learning components.

Besides, as this is an exploratory study and no theoretical or empirical rationale was available, the number of concepts and links was not limited.

With regard to the response format the construction of a computer-generated concept map was chosen, mostly because of practical reasons. First, it is easier for pre-service teachers to reconstruct a map on the computer than re-drawing a concept map on the paper. Secondly, for scoring it might be easier to "read" a computer-generated map than a concept map drawn by pre-service teachers themselves. In order to keep the construction process simple and to avoid cognitive overload caused by the software, the user-friendly concept-mapping software 'Easy Mapping Tool' was used. Furthermore, previous studies have shown that a computer-based concept mapping tool receives high acceptance among learners (e.g. Stracke, 2004; Beyerbach & Smith, 1990). Due to the fact that pre-service teachers were asked to construct a map with two provided concepts individually, the surface of the computer program included the two concepts, however no more information was provided. Based on that, pre-service teachers started constructing their individual concept maps.

Questionnaire on concept mapping

Within the final questionnaire, pre-service teachers' acceptance of the concept mapping task was assessed. Therefore, the questionnaire developed by Stracke (2004) was adapted, which focuses on three aspects:

- Interestingness: What kind of motivation do pre-service teachers show for their concept map construction?
- Usefulness: What advantages do pre-service teachers see in the concept-mapping technique?
- Ease of use: How well do pre-service teachers get along with the concept mapping technique and software?

All scales were assessed on a four on a four-point Likert-Scale ranging from 1 = I totally do not agree to 4 = I totally agree. In table 13 the number of items for each scale, the reliabilities and an example item are listed.

Table 13

Questionnaire Tapping Pre-Service Teachers' Acceptance of the Concept Mapping Task

Scale	Number of items	Cronbachs Alpha	Example item
Interestingness	6	.74	"I enjoyed the concept mapping task".
Usefulness	7	.77	"Through the concept map construction, I became aware about my knowledge gaps".
Ease of use	8	.74	"The concept mapping technique is easy to learn".

7.2.5 Data analysis

In order to answer the research questions with regard to pre-service teachers' organization processes in the context of professional vision, it is fundamental to address the data analysis approach. In this line, firstly the developed coding system of the concept mapping assessment, based on the framework proposed by Ruiz-Primo and Shavelson (1996), will be presented. Secondly, the applied statistical procedures for answering the research questions will be outlined.

Coding system

The analysis of pre-service teachers' concept maps was derived from theoretical assumptions and empirical findings outlined in the theoretical chapters. In the following, the development of the coding system as well as the different analysis steps will be presented.

a) Development of the coding system

For analyzing pre-service teachers' concept maps with regard to their structure- and content-related organization processes when integrating information from a video clip on effective teaching and learning components, an inductive-deductive coding approach (Bortz & Döring, 2006; Seidel & Prenzel, 2010) was employed. This strategy allows to integrate the current research into existing findings on the use of concept maps as assessment tool as well as to articulate a new frame for understanding pre-service teachers' knowledge organization processes.

Overall, decisions about the coding system were based on literature and empirical research on information processing and knowledge representation models, specifically on semantical network approaches, schema theory and the theory on macrostructures. Furthermore, assumptions and findings with regard to organization learning activities in the context of expertise research and findings about knowledge of effective teaching and learning components were part of the development process.

Based on empirical findings from research on the use of concept map assessment (see section 4.3.), the evaluation of components of pre-service teachers' concept maps has been chosen as scoring strategy. In this context, informed by prior research on lesson analysis and teacher expertise research (see sections 2.2.2; 4.2.2), the structure-related organization processes have been analyzed through identifying types of concept maps indicating the type of superstructure. Furthermore, the analysis of the subsequent macrostructures was part of the exploration. To capture pre-service teachers' content-related organization processes, the semantical relations/links (propositions) and the integration of higher order principles (main concepts) related to goal clarity and learning climate within their concept maps have been investigated based on assumptions from cognitive psychology and content knowledge (see section 2.2.2., 3.2).

In this context, decisions against the use of a common criterion map have been made. As selecting an expert for the creation of a criterion map would impose a "right" way, how to organize the knowledge in congruence with the video, and as this is a novel approach, this cannot be reasoned theoretically neither empirically. Despite, using a criterion map can also be problematic as even experts vary in their concept map construction (Acton et al., 1994). However, a new form of criterion reference was established by using experts' information on the presented video clip to score the accuracy of content-related organization processes (see application of coding system below).

Before the coding of the concept maps started, the usefulness of this framework was tested on a set of concept maps, which have been constructed by pre-service teachers in a small pilot study. In this context, notes have been made and the preliminary categories have been discussed between the author of the study and a graduate student involved in the coding process. After this review and testing process, the coding manual was reworked and operational definitions were finalized. Since the maps varied in format, guidelines were added to help the coding team in scoring. The resulting four main scoring components and their distinctive categories including coding guidelines will be described in the following part targeting the application of the coding system. The scoring strategies of the final coding

system are summarized in figure 15, which consider Ruiz-Primo and Shavelson's (1996) classification of a concept mapping scoring system (see section 4.3.1).

Coding system: Scoring strategies

Components: total concept map (type of concept map/superstructure), units of the map (number and macrostructure), main concepts (higher order principles regarding goal clarity and learning climate), propositions (kind of relations)

Criterion map: No criterion map was used, rather experts ratings on the video clip were used as criterion norm for scoring the accuracy of the main concepts and propositions

Figure 15. Integration of the concept mapping technique into Ruiz-Primo and Shavelson's framework (1996) with regard to scoring system.

b) Application of the coding system

In the following, the coding of the structure-related organization processes is targeted, followed by presenting the coding of the content-related patterns.

Coding of structure-related organization processes

The analysis of pre-service teachers' activities to select and structure information from the video clip with regard to goal clarity and learning climate in order to reduce complexity was operationalized through a coding system taking the superstructure and macrostructure units of pre-service teachers' concept maps into account. Both have been shown as crucial components of successful knowledge organization processes based on cognitive load theory and are especially important for teachers, who have to structure and organize incoming information all the time (see section 2.3.2). The coding with regard to superstructure refers to the focus under which pre-service teachers construct their concept map in relation to the content of the video clip. The coding of the macrostructure is related to the subsequent organization of the concept map, depending on the superstructure and is concerned with exploring the structure of each macrostructure unit.

S*uperstructure*

This coding category is concerned with the type of pre-service teachers' concept map as indicator for the kind of superstructure they chose to organize and arrange information from the video clip (Van Dijk, 1980). Informed by expertise and lesson analysis research in teaching (e.g. Carter et al., 1988; Leinhardt & Greeno, 1986; Star & Strickland, 2008), each

concept map was coded with regard to whether, it reveals a person-centric, a procedure-centric or an event-centric superstructure.

The category "person-centric" included concept maps, where a strong focus on the teacher and/or on students stood out. This was indicated through highlighting them with colors or through the fact, that most of the concepts included in the map were linked with labeled lines with the concept teacher and/or students. Thereby, it was also distinguished, whether pre-service teachers focused on teacher's action, students' behavior, or on both indicating the interaction of teaching and learning. Figure 16 shows an example of a person-centric concept map revealing a focus on the teacher.

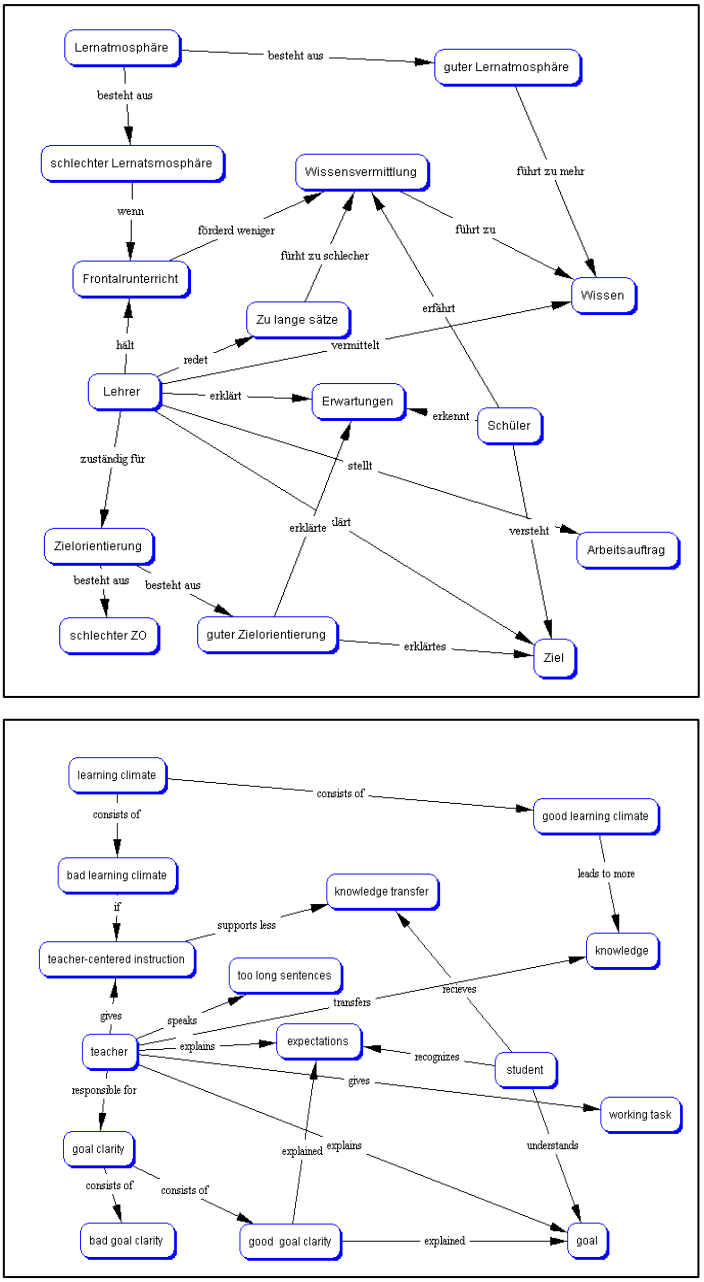


Figure 16. Example of a person-centric superstructure (original version and translated English version).

Concept maps with a "procedure-centric" superstructure (see figure 17) were characterized through a detailed and/ or chronological description of occurring activities and procedures in the video clip. Thereby, actions are in the center of pre-service teachers' concept maps.

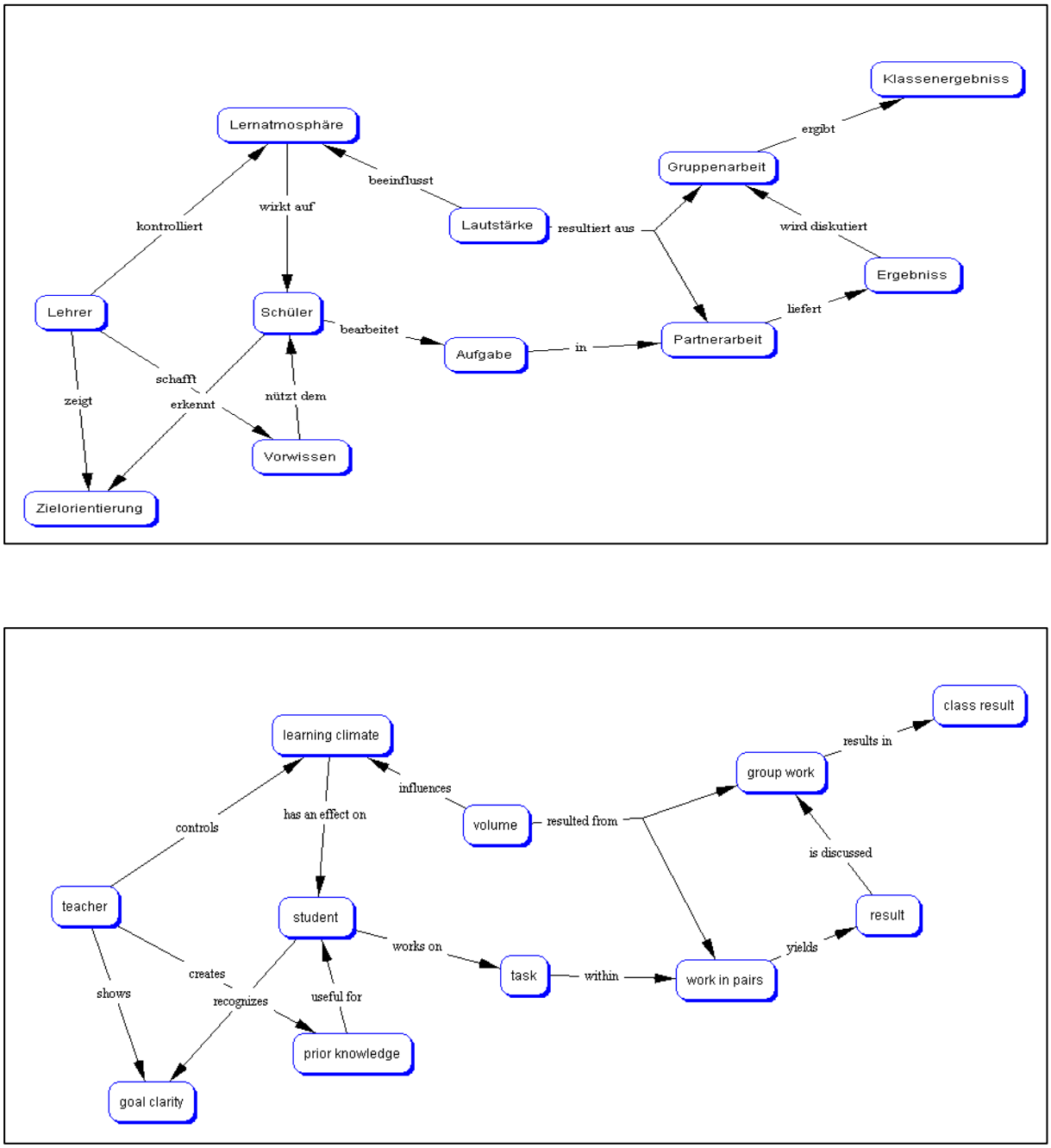
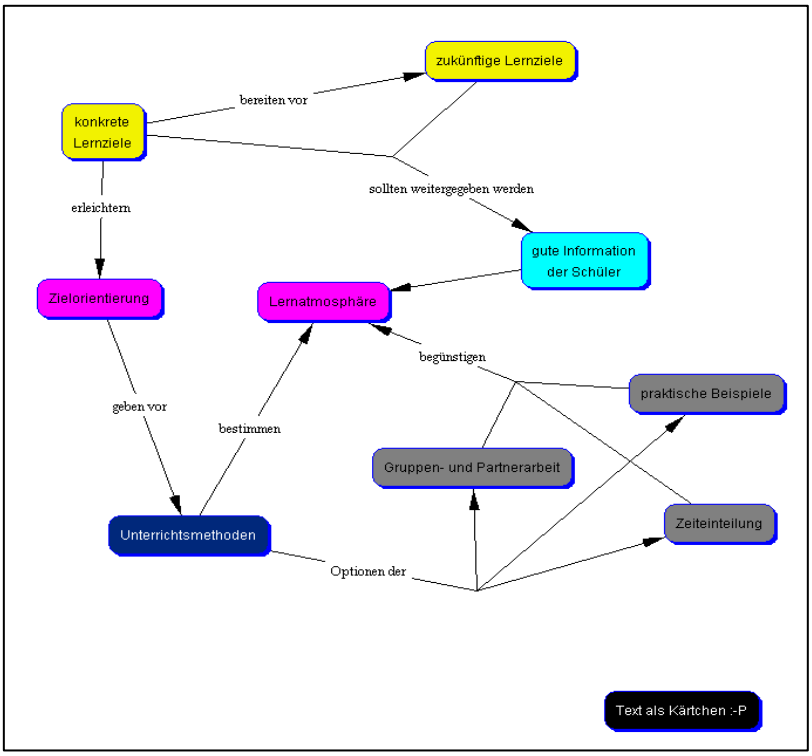


Figure 17. Example of a procedure-centric superstructure (original version and translated English version).

Lastly, a concept map was assigned to "event centric", when pre-service teachers structured specific events from the observed video clip related to the concepts "goal clarity and learning climate" imposing a more abstract way of information reduction. This included also that the persons or actions were no longer in the center of the information structuring process. To

assign a concept map to this type, it was not imperative that scientific terminologies were used or that they included no naive/wrong understandings. In figure 18, an example of such a concept map is illustrated.



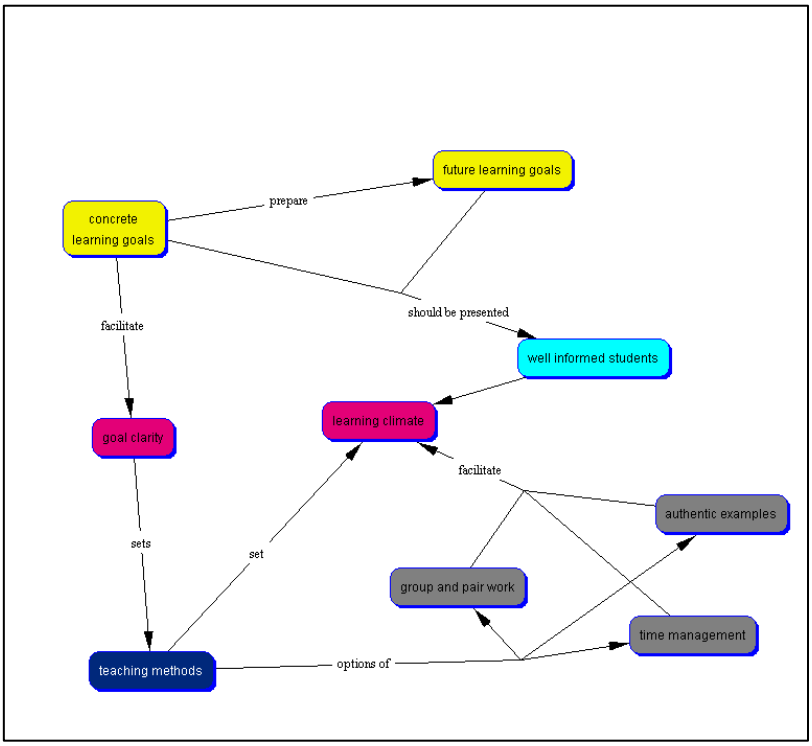


Figure 18. Example of an event-centric superstructure (original version and translated English version).

The coding framework for all categories related to the type of superstructure is summarized in table 14.

Table 14

Structure-Related Organization Processes – Type of Superstructure: Coding Categories and Indicators

Category	Indicators	Description of the category/Coding rules
Person-centric superstructure	Role of the teacher and/or students is highlighted and builds the core structuring component of the concept map.	All links and nodes are somehow related to teacher and/or students Persons are highlighted through colored nodes (and links)
Procedure-centric superstructure	Activities and procedures are highlighted and build the core structuring components of the concept map.	Links and nodes reveal a chronological description of the observed video clip. Links and nodes include detailed information on activities and procedures shown in the video clip. Chronological sequences are highlighted through color.
Event-centric superstructure	Events with regard to goal clarity and learning climate are highlighted and build the core components of the concept map.	All nodes and links are somehow related to goal clarity and learning climate Goal clarity and learning climate are highlighted through color and related links.

Macrostructure

After assigning the type of superstructure, each concept map was coded along its "macrostructure" informed by the theory on macrostructures and by semantical network approaches. As it was outlined in the theoretical chapter (see section 2.2.2), macrostructures organize and chunk information represented in single nodes on a higher level and are related to the superstructure. Furthermore, macrostructures differ from schemata in the way that they not only consist of knowledge, but also of beliefs and naive assumptions. These facts imply that pre-service teachers may differ in their macrostructures and thus, macrostructure units had to be identified for every concept map separately before coding their structure. Moreover,

this procedure is also caused by the fact that the content domain to be mapped (teaching and learning components) is more ill-structured than implying a specific content structure (e.g hierarchical) and thus, no specific restrictions regarding mapping the macrostructures were made beforehand.

In this line, macrostructure units were determined by the type of superstructure. Thereby, one macrostructure unit from a person-centric concept map was defined through the person (node "teacher ad or/ student") linked with related concept nodes through labeled lines structuring one specific event or behavior. The direction of the arrows was not important and the macrostructure unit included all concepts and links, which were related to the specific information. One macrostructure unit in figure 16 includes for example the concept nodes *„teacher, goal clarity, bad goal clarity, good goal clarity, goal, student, expectations" ("Lehrer, Zielorientierung, schlechter Zielorientierung, guter Zielorientierung, Ziel, Schüler, Erwartungen")* and the labeled links *"responsible for, 2x consists of, 4x explains(ed), understands, recognizes" ("zuständig für, 2x besteht aus, 4x erklärt(e), versteht, erkennt").*

Referring to the definition of a macrostructure unit from a procedure-centric map, all concept nodes and labeled links – no matter of their direction – specifying a certain activity or event build the including elements of one unit. Illustrating it on the procedure-centric-map in figure 17, one macrostructure unit is defined through the concepts *"student, task, work in pairs, result, group work, class results" ("Schüler, Aufgabe, Partnerarbeit, Ergebnis, Gruppenarbeit, Klassenergebnis")* and the labeled links *"works on, within, yields, is discussed, results in" ("bearbeitet, in, liefert, wird diskutiert, ergibt").*

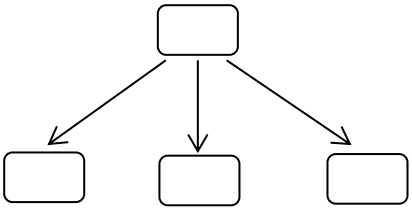
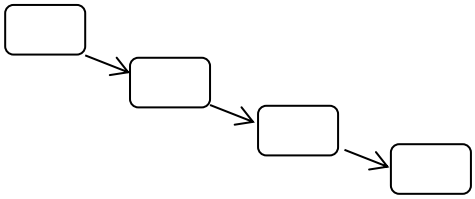
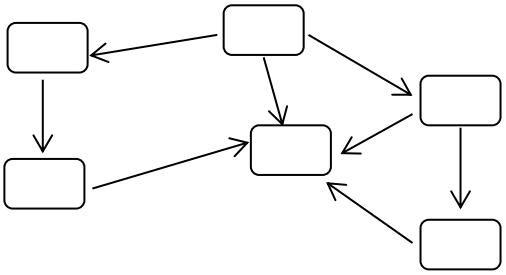
In concept maps with an event-centric superstructure, a macrostructure unit was defined through linked concepts related to one specific event with regard to goal clarity or learning climate. The concept map displayed in figure 18 is an example, where the total map defines the macrostructure unit as all included concepts are somehow related to each other. Based on that, the number of macrostructure units for each concept map could be counted.

After identifying the macrostructure units within every concept map, the coding of the "structure" of each macrostructure unit begun. As it was addressed in chapter 2.2.2, knowledge representations from novices differs from experts in terms of hierarchy levels and being more like lattices than hierarchies. This information gives also insight into the assumed knowledge structure of the domain of teaching and learning. Therefore, the macrostructure units were analyzed in terms of complexity and hierarchy level. It was investigated, whether a macrostructure unit has a low complexity denoted as "single", is structured as a "spoke"

showing already some hierarchical organization, has a "chain" structure indicating a logical or sequenced organization, or reveals a structure denoted as "lattice" as it includes several interconnected relations (see table 15).

Table 15

Structure-Related Organization Processes - Structure of the Macrostructure Units: Coding Categories and Examples

Category	Example
Single	
Spoke	
Chain	
Lattice	

The category "single" was coded, when the macrostructure unit consisted of one concept or one linked pair of concepts demonstrating a low level of structure-related knowledge organization.

Macrostructure units assigned to "spoke" revealed a radial structure, in which all the related aspects of the topic are linked directly to one core concept, but are not directly linked to each other. This type of macrostructure unit reveals a first hierarchical knowledge organization on a single level.

The coding category "chain" included macrostructure units, in which concepts are linked to those immediately above and below. Thus, a sequence exists from the beginning to the end and implies a hierarchical nature of many links.

The last category "lattice" was coded for macrostructure units in which concepts are highly interconnected. Though an interrelated network may exists, a highly integrated network with justifiable hierarchy levels demonstrating a deep understanding was not imperative to assign a macrostructure unit to this coding category.

Coding of content-related organization processes

To advance the understanding about pre-service teachers' content-related knowledge organization processes, a coding framework was applied, which takes the quality of semantical links and the use of higher order principles with regard goal clarity and learning climate into account. The coding distinguished different categories, which are outlined in the following.

Semantical links

According to work based on the semantical network approach (Klix; 1984a,b; Van der Meer, 1984), the semantical relationships between concepts have been investigated indicating the semantical complexity of pre-service teachers' content-related organization processes. According to that, all links included in pre-service teachers' concept map over all macrostructure units have been analyzed. The coders had to decide, if one link is either part of "interrelated links" or can be considered as "intrarelated link". The first group of interrelated links included also different link types (structural, procedural, and functional links). Besides, unlabeled links and links indicating wrong relationships have been coded. Thereby, the coders had to decide for every link, which kind of semantical relation it characterizes. Before outlining each coding category, it is important to mention that links indicating the same relationships between several concepts (like concepts linked in a spoke structure) have been coded only as one semantical relation, instead of counting the number of all links indicating the same relationship. Besides, some labeled links had to be interpreted in the context of its macrostructure unit in order to assign it to one category, especially prepositions like "through; by; within".

First of all, when a link between two concepts was not labeled, it was assigned to the category "no relation" as naming the kind of relationship is a main characteristics of concept maps.

This category was also coded when the link was labeled; however the word did not display any relationship rather described only the concepts in the box. Such words were often adjectives or nouns.

When a link was labeled, however indicated a wrong kind relationship between to concepts, it was assigned to the category of "erroneous relation". This fact could either related to links indicating a wrong arrow direction or an assumed relationship based on naive assumptions and misconceptions. For example, stating that *the interior design improves the learning climate*. In this context, the information from the experts on the pre-selected video clip built a helpful basis to code, if the constructed relationship between two concepts is adequate.

The links characterizing relations between concepts with regard to objects, concrete actions or events were assigned to the category of "interrelated links", distinguishing between different types: "structural", "procedural", and "functional" relations. Thereby, the last one is considered to be more difficult to activate as more cognitive processing is necessary to describe the relationship (Klix et al., 1984).

A "structural relation" describes a relation between two objects or outlines a possessive relation. Semantical links like *"is, are, has, have"* are examples for this category.

A labeled link was coded as "procedural" when an action or procedure was described. For example, verbs like *"explains, know, work out, listen to, and asks"*. Also labeled links such as "then, afterwards" were coded as structural relation when they indicated a procedure.

If a "functional relation" was coded, the link indicated an instrument-relation meaning that that one concept supported the other. This was indicated by words like *"helps, support; used for, benefit from"*.

Beside this group of links, also intrarelated links were coded in pre-service teachers' concept maps. Such links indicated a somehow "hierarchical relation" between two concepts and outlined similar/different properties of the linked concepts. An example of such a superordinate-subordinate concept relation was indicated through phrases like *"consists of, comprises, contains, includes, achieved by"*.

Integration of higher-order principles

Informed by the coding scheme from Study 1 and research on teacher expertise and knowledge representation, each macrostructure unit was either assigned to the category of

"integration of higher order principles" or the category "no integration of higher order principles".

The category "integration of higher order principles" was coded, when the macrostructure unit was structured based on professional concepts and central indicators referring to the two effective teaching and learning components of goal clarity and learning climate related to the content of the video clip. Based on the conceptualization of goal clarity and learning climate in the theoretical chapters, the integration of higher principles was operationalized through different indicators, such as *"clarification of learning goals; structured orientation/presentation towards those goals; use of organization cues; use of contextualized anchors; clarification of learning tasks and requirements"* for the component of goal clarity. With regard to learning climate concepts like "*taking students' needs seriously; valuing student contributions/support of competence; or encouraging students in their learning processes/support of autonomy*" were scored as higher-order principles.

However, as it was found out in Study 1 that it is not sufficient to activate only professional knowledge but also that it is adequate related to the content of the specific teaching event in order to reveal a deep understanding, the category "use of higher order principles" was only coded when also the content of the macrostructure unit was interpreted correct in comparison to the judgements provided by the three experts about the content of the pre-selected video clip and thus, included no misconception. For example, the sequential linked concepts *'learning climate', 'bad learning climate', 'instruction', 'teacher'* linked with the labeled lines *consists of, if* and *gives* would indicate a misinterpretation as well as a misconception. Therefore, the macrostructure unit would not be assigned to this category, rather to the following one.

The coding-category "no integration of higher principles" comprised macrostructure units, in which the selected information was not connected to professional terms or indicators referring to goal clarity or learning climate. Instead, included irrelevant information or naive assumptions and misconceptions with regard to goal clarity or learning climate like *'learning climate' leads to 'attention' leads to 'silence' leads to a good 'learning climate'*. Although in this example concepts are connected to 'learning climate', only a naive understanding is visible. The two-level coding framework is displayed in table 16.

Table 16

Content-Related Organization Processes – Integration of Higher OrderPrinciples: Coding Categories and Examples

Category	Description of the category	Examples
Integration of higher order principles	Macrostructure units are organized through conceptual terms and indicators related to goal clarity and learning climate and do not include wrong interpretations or misconceptions based on experts judgements that the video clips provide good examples for the implementation of goal clarity and learning climate.	Examples related to goal clarity: Embedding into (short-term, mid-term; long-term) objectives; learning goals, overview about topic of the lesson, advanced organizer; structured lesson; clarification of tasks and requirements; assurance of understanding; activation of prior knowledge; review; transparency of the lesson; structuring the working steps Examples related to learning climate: Appropriate use of respect; compassion, kindness, positive attitude towards students; loss of fear; valuing students' contribution; support of students' autonomy, Support of students' competencies; cognitive engagement of students; motivated students; taking students' needs seriously; interested students; common negotiation and discussion
No integration of higher order principles	Macrostructure units consist of rather irrelevant information with regard to goal clarity and learning climate and consist of naive assumptions and misconceptions. Macrostructure units are not organized based on conceptual terms and indicators related to goal clarity and learning climate.	Superficial aspects of the classroom situation are summarized and build the main leading concepts; e.g. the interior design, teachers' speech, the content of the lesson "English language; upcoming test; right of freedom; seating arrangement" Concepts are related to goal clarity and learning climate, however reveal misconceptions and naïve understanding, e.g. "learning climate is good, productive; teacher implements goal clarity; goal clarity is freedom of rights reached through group work"

c) *Interrater-agreement on the coding system*

After the development and training on the coding frameworks, two raters coded all concept maps independently from each other. In order to ensure reliable concept mapping responses, interrater agreements in percentages as well as Cohen's Kappa between the two coders were calculated. As for two coding categories (type of macrostructure unit; semantical relations) no satisfying interrater-agreements were achieved, the rater team discussed their discordant codings and validated them together. Table 17 gives an overview about all coding categories over the two measurement times and concept map tasks. For the categories "type of superstructure" and "macrostructure unit", the analysis unit referred to the total concept map. The analysis unit for the other three categories was related to the macrostructure unit. The values from all macrostructure units within one map were then aggregated to one mean value. In the end, the values from each concept map were aggregated on the level of all concept maps (N = 27).

Table 17

Interrater-Agreement over all Categories with regard to Time and Concept Mapping Task

	Analysis unit	Time 1		Time 2	
		Agreement in percentage	Cohen' s ' Kappa	Agreement in percentage	Cohen' s ' Kappa
Type of superstructure	Total concept map	96.30	.94	81.48	.72
Macrostructure units	Total concept map	87.04	.81	85.19	.80
Type of macrostructure unit	Macrostructure unit	70.06	.53	61.32	.47
Semantical relations[a]	Macrostructure unit	68.37	-	73.85	-
Integration of higher order principles	Macrostructure unit	90.87	.83	81.07	.70

Note. [a] Numbers of semantical relations were counted; thus, only agreement in percentage was calculated.

Analysis of the coded data

To describe the nature of pre-service teachers' organization processes with regard to structure and content at the beginning of the course (research question 1), the data will be presented descriptively. To investigate within pre-service teachers' structure-related organization processes (research question 1a), if concept maps with a different superstructure also reveal a different amount of macrostructure units, a Kruskal-Wallis test was applied. This non-parametric test allows comparisons between more than two sample groups that are independent and are of unequal size without assuming a normal distribution. This test is appropriate since a) the variable was not normal distributed, and b) every concept map was assigned to one of three superstructure types and thus, is independent from each other, however comprises unequal sample sizes. As the test, however, does not identify where the differences occur or how many differences actually occur, Mann-Whitney-U tests were conducted afterwards to analyze the specific sample pairs for significant differences.

To analyze one validity aspect of the applied concept mapping technique regarding the criteria of known group differences (research question 2), two groups of pre-service teachers based on the integration of higher order principles at time 1 were differentiated. Therefore, all macrostructure units coded with "integration of higher order principles" were aggregated and divided by the total number of macrostructure units to the level of the sample size (27 pre-service teachers).

To test, if pre-service teachers, who already integrate higher-order principles at time 1, differ from the other group of pre-service teachers in other organization patterns (research question 3), different non-parametric tests depending on the scale levels were conducted. With regard to differences in each type of superstructure at the beginning of the course, Fisher's exact tests (chi-square with Yates correction for small sample size) were used. For testing differences regarding the number of macrostructure units and the number of semantical links, Mann-Whitney-U tests were conducted. Differences in the type of macrostructure units and the integration of higher principles within their macrostructure units were analyzed descriptively, as each pre-service teacher varied in the amount of macrostructure units and thus, no baseline could be established neither a mean could be calculated.

To investigate changes and trajectories over the course on teaching and learning within each of the two groups (research question 3), a Wilcoxon test for the number of macrostructure units and for the semantical links was applied. This non-parametric test allows comparing repeated measurements on a single sample to assess, whether their mean ranks differ and can be applied when the sample size is small. With regard to category "superstructure" the

Bowker test was used, which is an extension of the McNemar test for testing two categorical variables with more than two categories. The changes and differences with regard to the type of macrostructure units and the integration of higher order principles were again analyzed descriptively.

Overall, a significance level of .05 was used for all statistical tests.

7.3 Results

Within this chapter the results about the nature of pre-service teachers' organization processes with regard to specific teaching and learning components at the beginning of the course are described firstly (research question 1). For the analysis of pre-service teachers' knowledge organization, structure- and content-related organization processes have been worked out in the theoretical chapters of this work. Based on different research traditions, it can be assumed that they are important processes with regard to a meaningful knowledge organization and that the use of concept mapping is a promising approach to elicit them. Within structure-related organization processes, the analysis of superstructure and macrostructure units are targeted, whereas the analysis of content-related organization processes differentiate between semantical relations and the integration of higher order principles. Against this backdrop, section 7.3.1 describes pre-service teachers' structure-related organization processes (research question 1a), and section 7.3.2 displays pre-service teachers' content-related organization processes in the context of the specific teaching and learning components (research question 1b).

In section 7.3.3, pre-service teachers with different levels regarding the integration of higher order principles are identified and characterized (research question 2).

Afterwards, in section 7.3.4 pre-service teachers with low and high entry levels are compared regarding their structure-related organization processes (research question 3a), and in section 7.3.5 regarding their content-related organization processes (research question 3b), as well as group-specific changes are addressed for both organization patterns.

7.3.1 Pre-service teachers' structure-related organization processes

In this section, it is addressed how pre-service teachers structure and integrate information from the presented video clip on teaching and learning components within their concept maps before taking part in a course on teaching and learning. Therefore, results with regard to superstructure, macrostructure and the interaction of both are targeted.

Analysis of superstructure

Pre-service teachers' organization processes with regard superstructure were operationalized, whether pre-service teachers' concept map structure reveals a person-centric, a procedure-centric or an event-centric focus. This is based on the assumption that meaningful construction and organization processes include the awareness towards relevant information and main ideas what in turn, drives the way how the selected information is organized. For example, if it is more on the surface indicated by details and person centric aspects, or on the intentional content of the presented material indicated by facts and main events. Overall, 27 concept maps were analyzed. Table 18 displays the results of the descriptive analyses and the distribution across the categories under investigation.

Table 18

Type of the Superstructure as Identified in the Present Sample

		Concept maps
Person-centric	*n*	11
	%	40.74
Procedure-centric	*n*	4
	%	14.81
Event-centric	*n*	12
	%	44.44

Note. Concept maps from $N = 27$ pre-service teachers.

In total, the superstructure of pre-service teachers' concept maps reveals a more detailed structuring process indicated by the number of identified person-centric and procedure-centric superstructures (overall 56%; 16 concept maps). Around 41% pre-service teachers structured their concept maps with a focus on the teacher and/or students. The analysis of the main focus showed that the interaction of teaching and learning was obvious to almost all pre-service teachers with a person-centric concept map, as the main focus was mostly on both, teacher and students (82%; 9 concept maps). Only two of the eleven pre-service teachers (18%) focused on the teacher, and none of them on students only. The second type of superstructure indicating a more detailed and descriptive organization is related to procedure-centric maps, which represent with a number of four concept maps (15%) the fewest in the present sample at the beginning of the course. However, almost half of the pre-service teachers (44%; 12

concept maps) organized and structured their concept maps in a more abstract way indicated by an event-centric superstructure. In this line, pre-service teachers at the beginning of a course on teaching and learning show some kind of abstract information organization, however, they also tend to focus on details in the video clip, when structuring the selected information from the video clip. The following figure 19 illustrates the distribution of percentages with regard to each category.

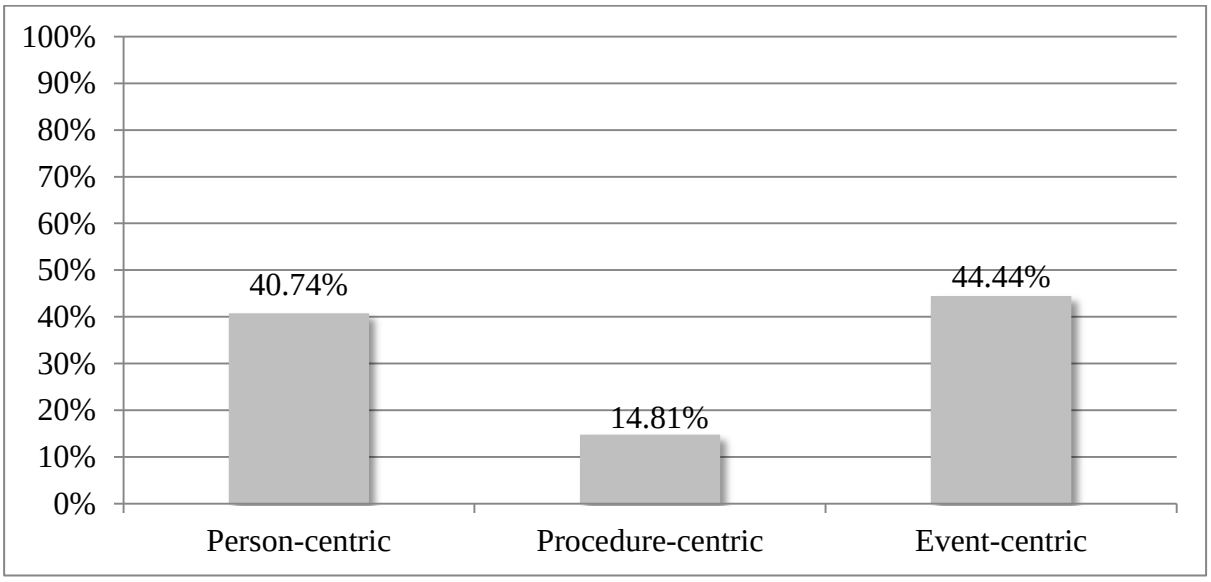


Figure 19. Distribution of percentages with regard to each type of superstructure as identified in all concept maps at time 1.

Analysis of macrostructure

Within the investigation of pre-service teachers' process of structuring relevant information about goal clarity and learning climate in relation to the pre-selected video-clip, the analysis of the macrostructure was also considered. This analysis aspect was operationalized whether the macrostructure can be characterized as single, spoke, chain or lattice. This information plays an essential role, when analyzing knowledge representations in terms of structural complexity and hierarchy levels, and indicates how knowledge in the field of teaching and learning might be organized.

Therefore, pre-service teachers' concepts maps were firstly segmented into macrostructure units depending on their type of superstructure. Table 19 displays that the concepts maps revealed in average about two to three macrostructure units with a standard deviation of about one unit. The number of macrostructure units within one concept map ranged between a minimum of one and a maximum of six macrostructure units. Overall, 71 macrostructure units have been identified.

Table 19

Number of Macrostructure Units as Identified in all Concept Maps

	M	*SD*	*Min*	*Max*	*Sum*
Macrostructure units	2.63	1.25	1	6	71

Note. Concept maps from *N* = 27 pre-service teachers.

After segmenting the concept maps into their units, each macrostructure unit was analyzed regarding its structural characteristics. The frequency distribution for each identified structure under investigation is provided in Table 20.

Table 20

Structure of the Macrostructure Units as Identified in all Concept Maps

		Concept maps
Single	*n*	10
	%	14.08
Spoke	*n*	4
	%	5.63
Chain	*n*	24
	%	33.80
Lattice	*n*	33
	%	46.48

Note. Percentages related to the total number of 71 macrostructure units.

The results show that the macrostructure units as identified over all concept maps mainly have a lattice-like organizing structure (46%; 33 from 71 units). This means that pre-service teachers have drawn many connections between the concepts integrated within one macrostructure unit. Another main proportion of the macrostructure units are characterized through a chain structure. Around 34% of all macrostructure units refer to this category, which indicate that the concepts within a macrostructure unit are brought into a sequence.

Within around 14% macrostructure units, only one concept or two concepts were linked, which suggests a low knowledge organization level. Finally, four macrostructure units (6% of all units) were identified in which pre-service teachers organized the selected information in

terms of a radial structure revealing a first hierarchical knowledge organization on a single level. Overall, as assumed, pre-service teachers' organization processes on the macrostructure level at the beginning of a course on teaching and learning is more characterized through lattices than through a structure revealing a hierarchy. However, not so many single macrostructure units have been found as expected, what indicates that pre-service teachers already tried to build relations between the single information pieces. Furthermore, the different identified macrostructures might indicate that the knowledge domain of teaching and learning represents different types of content structures. The distribution of macrostructure units with regard to their type of structure is illustrated in figure 20.

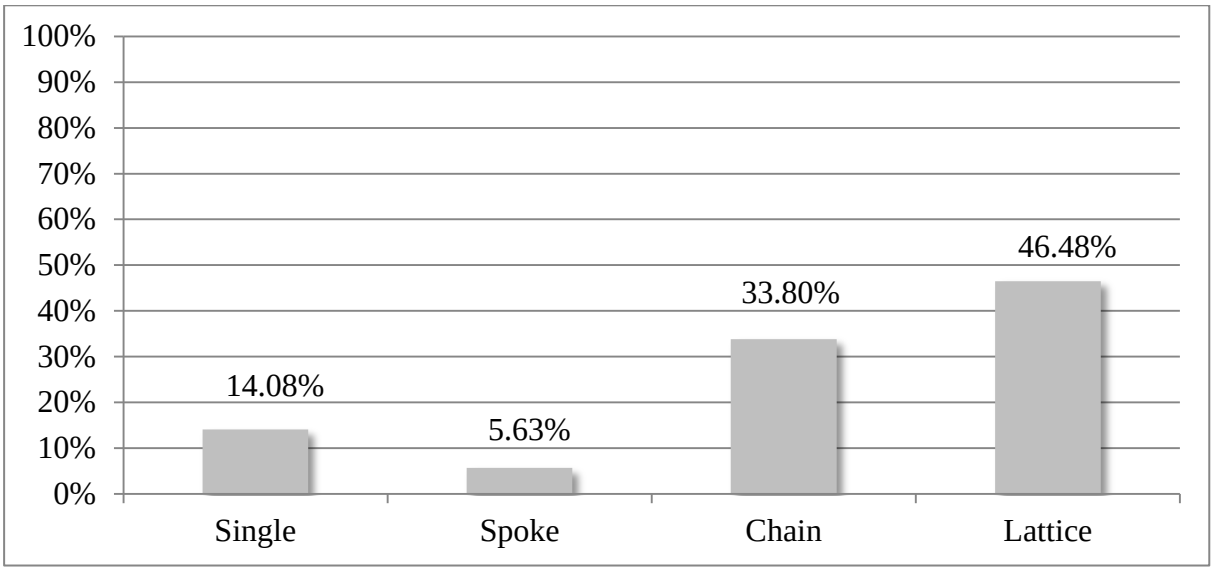


Figure 20. Distribution of percentages with regard to type of macrostructure as identified in all concept maps at time 1.

Analysis of the interaction of superstructure and macrostructure

So far, the superstructures and macrostructures of pre-service teachers' concept maps were described and the findings suggest that pre-service teachers' concept maps reveal different patterns of superstructures and macrostructures. Now, it will be addressed whether the type of superstructure within pre-service teachers' concept maps trigger the number and structure of the identified macrostructure units within their concept maps. This is based on the assumption that superstructures order the selected information on the global level and thus organize the macrostructure units on a lower organization level.

With regard to the number of macrostructure units, the Kruskal-Wallis test revealed a significant difference between the three superstructure types, λ^2 (2) = 6.25; p = .04. In order to identify which types differ in the number of macrostructure units, post-hoc comparisons were

calculated. The Mann-Whitney-U test showed a significant difference between concept maps with a procedure-centric and an event centric superstructure, $Z = -2.41$; $p = .02$. As table 21 indicate, procedure-centric concept maps include, with a mean of around four macrostructure units ($M = 4.25$, $SD = 1.71$), significantly more macrostructure units than event-centric concept maps ($M = 2.08$, SD = 0.52). Furthermore, the standard deviation with 1.71 and a range between a minimum of 2 and a maximum of 6 macrostructure units is higher for procedure-centric concept maps. No significant difference with concept maps revealing a person-centric superstructure was found. These concept maps included in average three macrostructure units ($M = 2.64$, $SD = 1.21$).

Table 21

Macrostructure Units as Identified in the Concept Maps with Different Types of Superstructure

	M	*SD*	*Min*	*Max*	*Sum*
Maps with person-centric superstructure ($N = 11$)	2.64	1.21	1	5	29
Maps with procedure-centric superstructure[a] ($N = 4$)	4.25	1.71	2	6	17
Maps with event-centric superstructure[a] ($N = 12$)	2.08	0.52	1	3	25

Note. Concept maps from $N = 27$ pre-service teachers. [a] significant difference.

These results show that pre-service teachers, no matter of what superstructure type, tried to integrate single information pieces into higher macrostructure levels. However, it seems that pre-service teachers with an event-centric map showed better organization processes as their maps revealed the lowest number of macrostructure units, especially in comparison to pre-service teachers with a procedure-centric concept map.

In a next step, it was analyzed whether differences in the superstructure type also can be illustrated in the type of macrostructure. Table 22 gives an overview about the three superstructure types.

Table 22

Structure of the Macrostructure Units as Identified in the Concept Maps within Different Types of Superstructure

		Person-centric Map (*N* = 11)	Procedure-centric Map (*N* = 4)	Event-centric Map (*N* = 12)
Single	*n*	6	3	1
	%	20.69	17.65	4.00
Spoke	*n*	0	3	1
	%	0.00	17.65	4.00
Chain	*n*	5	8	11
	%	17.24	47.06	44.00
Lattice	*n*	18	3	12
	%	62.07	17.65	48.00

Note. Percentages related to the total number of 71 idea units.

Within the group of concept maps with a person-centric superstructure, most of the macrostructure units (62%) show a lattice-like structure with highly interconnected concepts. Furthermore, 21% macrostructure units of person-centric concept maps are characterized through a single structure. The remaining 17% macrostructure units indicate a sequence as none of them reveal a radial spoke structure. Overall, pre-service teachers' concept maps with a person-centric superstructure reveal mostly a structure with highly interconnected concepts and information pieces. However, it is also visible that a lot of unconnected concepts are included.

In contrast, in pre-service teachers' concept maps with a procedure-centric superstructure, most of the macrostructure units revealed a chain structure (47%). However, this is not surprising since these pre-service teachers mostly focused on actions and procedures within their concept map construction and which are ordered mostly in form of a chain or sequence. The other macrostructure units are equally divided over the single, spoke and lattice structure (18% each).

The concept maps with an event-centric superstructure again showed the highest proposition of units with a lattice-like structure (48%). Further 44% are characterized through a chain structure. Followed by only one included single and spoke macrostructure unit (4% each). In sum, event-centric concept maps are mostly characterized through a network of interrelated concepts, and where a first hierarchical structure is visible in many macrostructure units.

Overall, the results from research question 1a indicate that pre-service teachers show as expected different structure-related organization processes characterized by a different focus under which they organize and integrate information (superstructure) and through which they structure them (macrostructure) at the beginning of the course on teaching and learning. Furthermore, it seems that a different superstructure is related to different macrostructures units in terms of number and structure. Finally, it indicates that the representation of knowledge structure in the domain of teaching and learning includes different types of map structures.

7.3.2 Pre-service teachers' content-related organization processes

After analyzing organization processes on the structural level, this section targets pre-service teachers' organization processes with regard to content. First, results with regard to semantical links are presented, followed by the integration of higher order principles.

Analysis of semantical links

For the analysis of semantical complexity during knowledge organization, the kinds of semantical links included in a concept map function as important indicators (Klix, 1984a,b; Mandl et al., 1986). Within the coding procedure of the present study, six different semantical relationsships have been considered. As not all links were labeled, one category comprised "no specified relation". A semantical link, which was labeled, however indicated a wrong relationship, was coded as "erroneous relation". When a relation between two objects was described (e.g. possessive relation), it was coded as "structural relation". A "procedural relation" referred to linked concepts indicating an action or procedure, whereas a "functional relation" characterized an instrumental relation. These three kinds of relations are considered as interrelated links with functional relations being assigned to be more complex than the other two relations. Furthermore, these interrelated links are regarded as not so difficult to activate as the last group of intrarelated links represented through "hierarchical relations" as more cognitive processes have to be activated to compare the concepts on similarities and differences. The semantical links were coded within each macrostructure unit and thus all semantical relations from every concept map (N =27) were available for the analysis. In table 23 an overview about the distribution of links identified within all macrostructure units is given.

Table 23

Kinds of Semantical Links as Identified in all Macrostructure Units – Descriptive Analysis and Distribution of Links (Percentages)

	M	*SD*	*Min*	*Max*	*%*
erroneous relation	1.19	1.52	0	13	7.86
no specified relation	1.04	1.19	0	8	6.88
Interrelated links					
structual relation	1.70	2.15	0	13	11.30
procedural relation	5.41	3.50	0	23	35.87
functional relation	1.85	1.85	0	10	12.29
Intrarelated links					
Hierarchical relation	3.89	3.03	0	23	25.80

Note. Percentages related to the total number of links over all 27 concept maps.

As the analysis reveals, semantical links indicating a procedural relation between two concepts were identified with a mean of 5.41 links per concept map the most in pre-service teachers' concept maps (36% of all links). This suggests that pre-service teachers tried to bring the activities noticed in the shown classroom sequence into an organizing and summarizing frame indicated through many action-related relations like "listen to, speaks, asks, structures". The standard deviation with 3.50 links and a range of a minimum of one and a maximum of 23 procedural relations within one concept map is substantial and indicates that some maps might include more detailed and irrelevant information on the content than others.

Furthermore, their concept maps include with an amount of 26% of all links many hierarchical relations (M = 3.89 per concept map). Semantical links like "consists of, contains, includes, e.g." point out that pre-service teachers already tried to hierarchical structure related concepts. However, a huge range was found over all concept maps.

With around 12% and 11% of all semantical relations, links indicating a functional (M = 1.85 per concept map) or structural relation (M = 1.70 per concept map) built the third largest group of semantical relations found in pre-service teachers' concept maps. This shows that

pre-service teachers also described relations among subjects and objects as well as point out instrument-relations between concepts.

On average, only one erroneous relation and one link which does not specify the relation were found within every concept map (8% erroneous relations, 7% not specified relations).

As expected, pre-service teachers' content-related organization processes vary with regard to semantical complexity as indicated by the several kinds of links involved and the partial enormous standard deviations. Thereby, pre-service teachers are already able to create relationships between concepts similar to those of experts indicated by the amount of hierarchical relations. But as they also created erroneous relations and were not able in some cases to indicate the kind of relation, they still struggle in showing semantical complex organization processes with regard to the topic of teaching and learning components at the beginning of a course on teaching and learning. A graphical overview about the distribution of semantical links over all concept maps is given in figure 21.

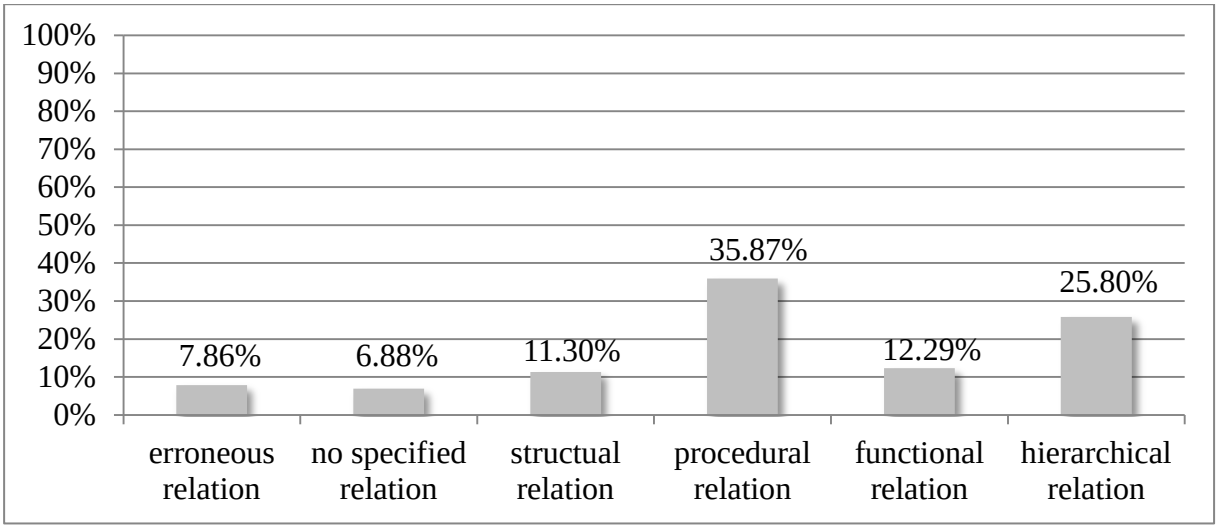


Figure 21. Distribution of percentages with regard to type of semantical links as identified in all concept maps at time 1.

Analysis on the integration of higher order principles

Pre-service teachers' integration of higher order principles with regard to goal clarity and learning climate is targeted as a second aspect of the analysis of their content-related organization processes. This is important since knowledge organization around specific schemata or concepts is an important indicator of the size or extent of knowledge and in turn, indicates expert-like information processing. In this line, the coding framework comprises the category "integration of higher principles", when a macrostructure unit is structured around professional terms in the context of the specific teaching and learning components. If a

macrostructure unit does not include them or reveals a wrong understanding, the category "no use of higher principles" has to be coded. Based on that, the 71 macrostructure units over all concept maps at measurement time 1 were analyzed. Table 24 displays the distribution of all macrostructure units over both categories.

Table 24

Integration of Higher Order Principles as Identified in the Macrostructure Units over all Concept Maps

		Macrostructure units
No integration of higher order principles	*n*	60
	%	84.51
Integration of higher order principles	*n*	11
	%	15.49

Note. Percentages related to the total number of 71 idea units.

The descriptive analysis show that the macrostructure units are mainly not organized around higher order principles related to goal clarity or learning climate (86% of all macrostructure units; 60 from 72 macrostructure units) at the beginning of the course on teaching and learning. Instead, information pieces (concepts) included aspects of the shown classroom situation, which were not linked to professional terms or revealed misconceptions and naive assumptions about the concepts of goal clarity and learning climate. An example of a macrostructure unit, which includes no professional terms, is shown in figure 22.

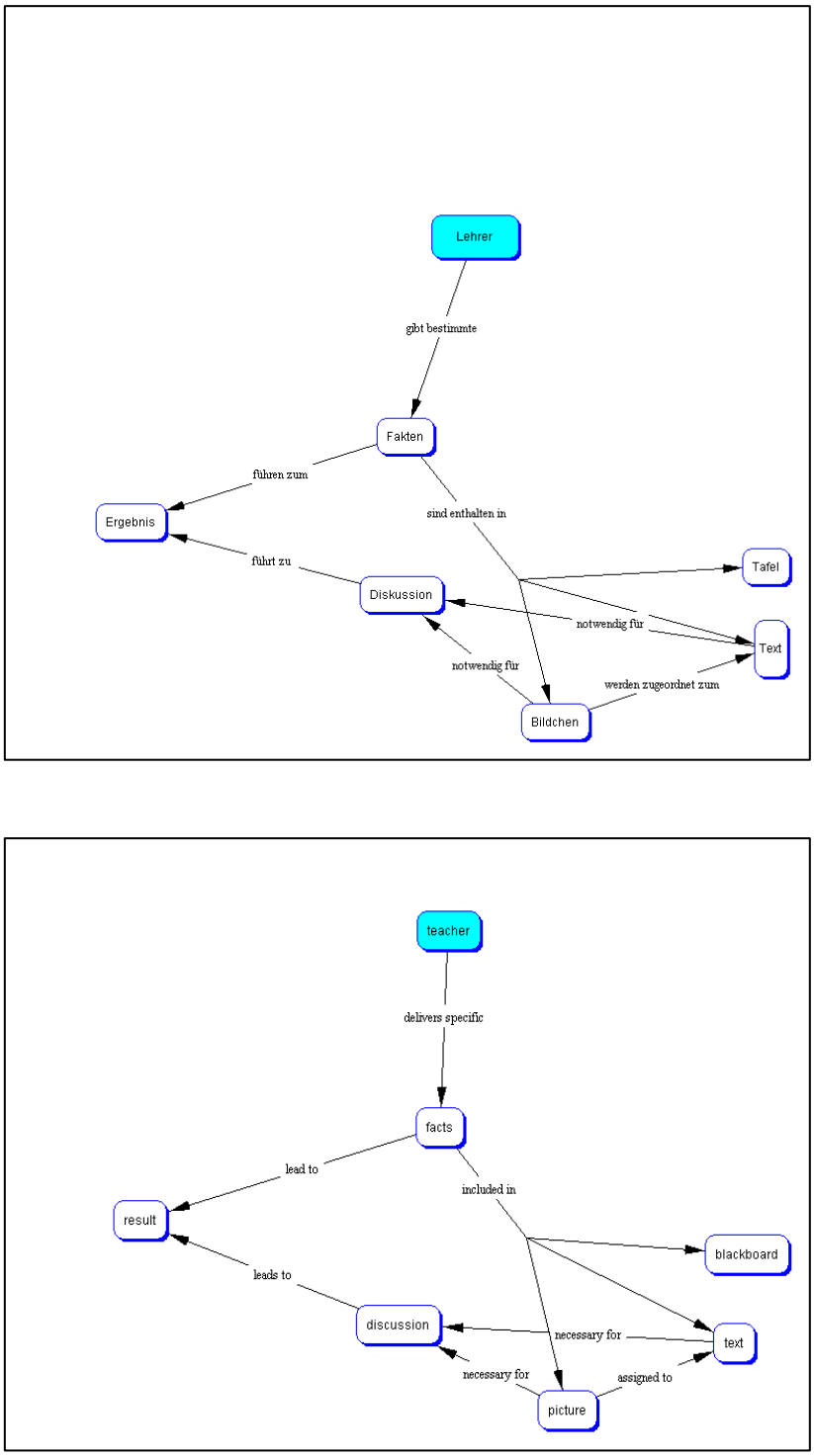


Figure 22. Example of a macrostructure unit coded as "no integration of higher principles" (original version and translated English version).

An example, where the concept of goal clarity is included, however a naive interpretation is outstanding is given in the following figure 23.

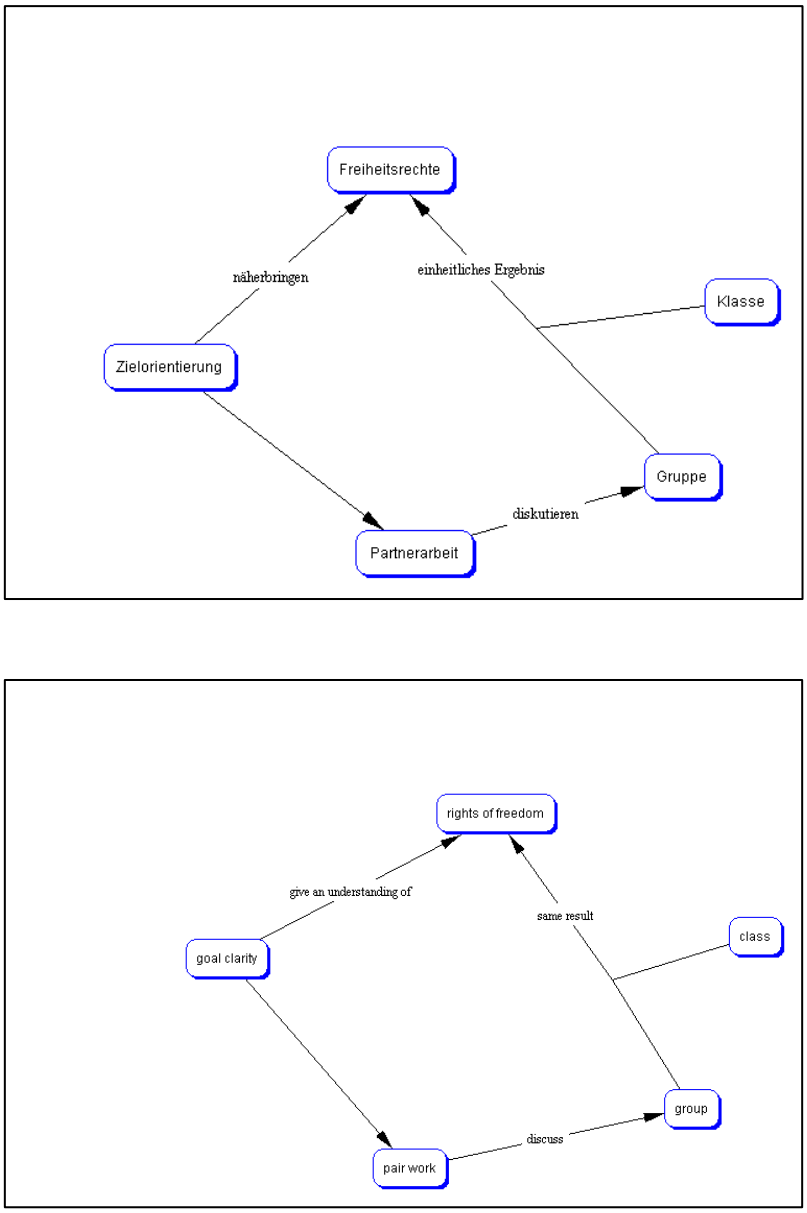


Figure 23. Second example of macrostructure unit coded as "no integration of higher principles" (original version and translated English version).

Only in 11 macrostructure units (15%) a knowledge-based information organization was visible indicated by a correct integration of higher order principles based on the expert judgements on the pre-selected video clip. Figure 24 illustrates one example macrostructure unit for this coding category.

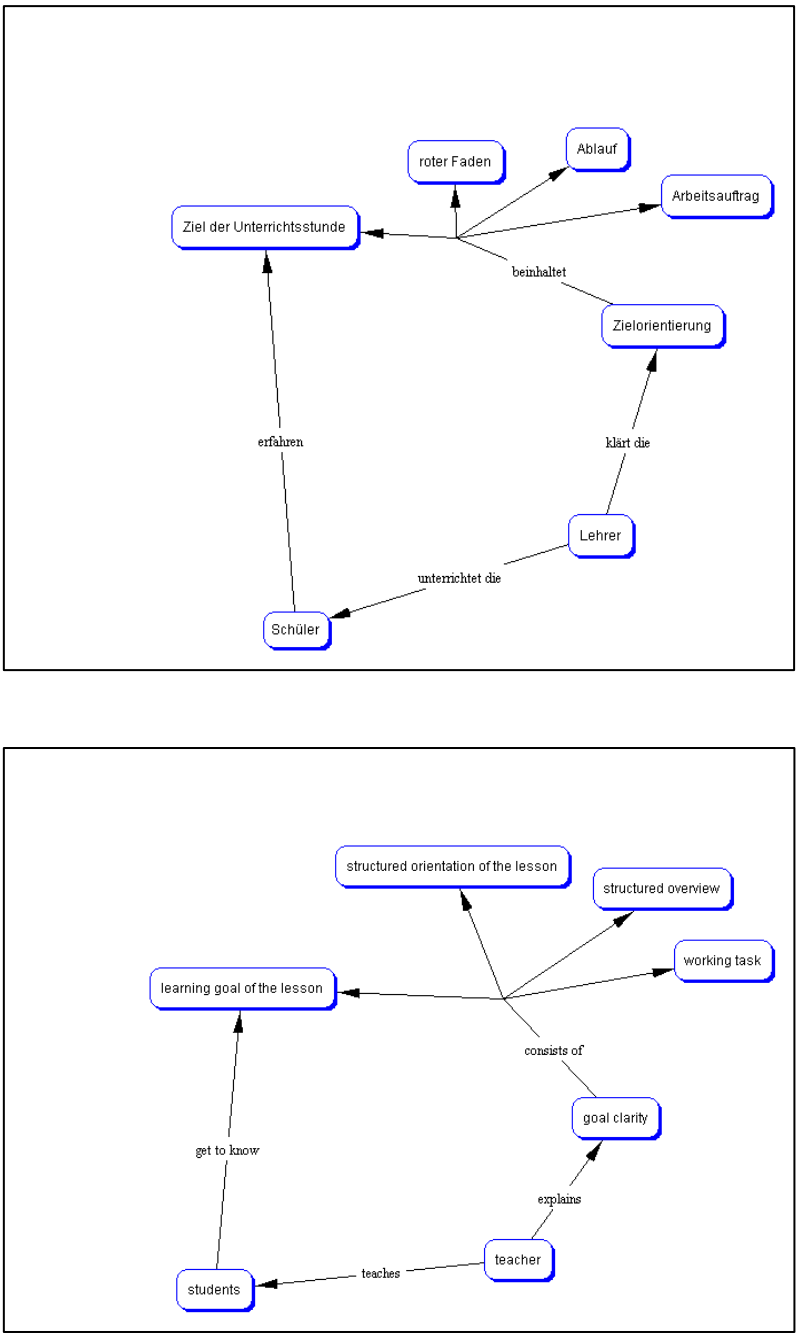


Figure 24. Example of a macrostructure unit coded as "integration of higher principles" (original version and translated English version).

In sum, this finding suggest that pre-service teachers at the beginning of a course on teaching and learning are not able yet to organize the selected information from the observed classroom situation in a manner that reveals meaningful content-related organization processes.

7.3.3 Identification of pre-service teachers with different entry levels regarding the integration of higher order principles

So far, the results indicate that the structure-related organization processes of pre-service teachers can be characterized at the beginning of the course on teaching and learning through are more surface information organization approach, where many information pieces are connected and a lattice-like concept map structure is visible. With regard to the content-related organization processes, pre-service teachers' concept maps suggest that pre-service teachers' knowledge structure in the field of the two teaching and learning components is not very complex yet. However, within both organization components, partly enormous ranges are outstanding. In order to gain a deeper insight into pre-service teachers' organization activities, this section takes a more differential perspective. As (prior) knowledge plays an essential role for the organization of information according to existing knowledge (see section 2.3.2), concept maps were analyzed with regard to identifying individual differences regarding pre-service teachers' integration of higher order principles at the beginning of the course on teaching and learning. This is also investigated against the backdrop of providing information on one validity aspect of the concept mapping technique (known group differences).

In this context, all macrostructure units coded as "integration of higher order principles" divided by the total number of macrostructure units on the individual level, were aggregated in order to assign pre-service teachers either to the group with a low level or a high level regarding the integration of higher order principles. Pre-service teachers' distribution across the two groups is provided in Table 25.

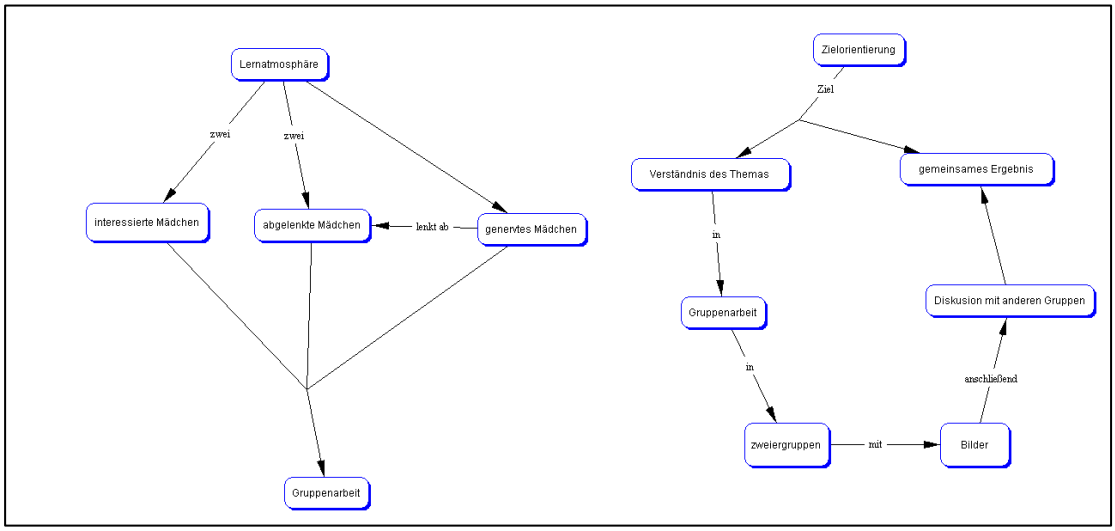
Table 25

Pre-Service Teachers' Integration of Higher-Order Principles at Time 1: Distribution of Frequencies

		Pre-service teachers
Group with a low entry level regarding the integration of higher-order principles	*N*	21
	%	77.77
Group with a high entry level regarding the integration of higher-order principles	*N*	6
	%	22.22

Note. Aggregation to the level of 27 Pre-service teachers; Min = 0 %, Max = 100%

As assumed, it was possible to identify concept maps with different qualities regarding the integration of higher order principles. Furthermore, as assumed, most of pre-service teachers' concept maps do not reveal an information organization around higher-order principles (78%; 21 pre-service teachers) at the pre-test. These pre-service teachers are assigned to the group with a low entry level regarding the integration of higher order principles. However, six pre-service teachers (22%) organized the information selected from the video clip within their concept map based on higher-order principles. These pre-service teachers are considered as the group with a high entry level regarding the integration of higher- order principles. The figures 25 and 26 illustrate two example concept maps, the first from a pre-service teacher assigned to the low entry level group, and the second one from a pre-service teacher belonging to the high entry level group.



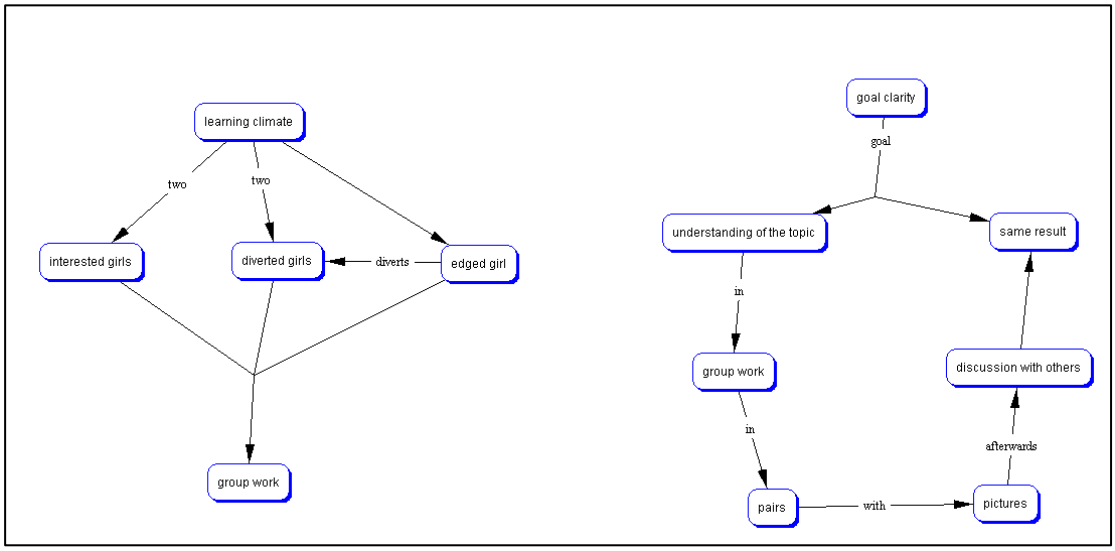
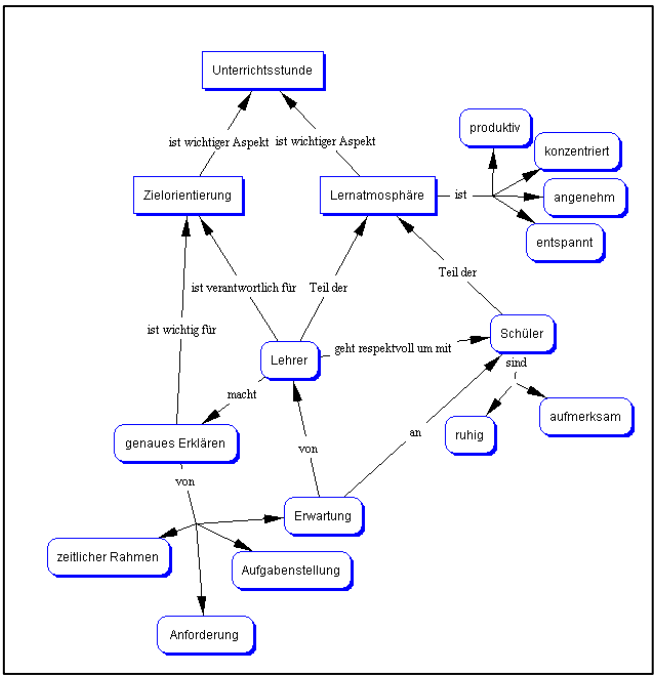


Figure 25. Concept map from a pre-service teacher, assigned the low entry level group regarding the integration of higher order principles (original version and translated English version).



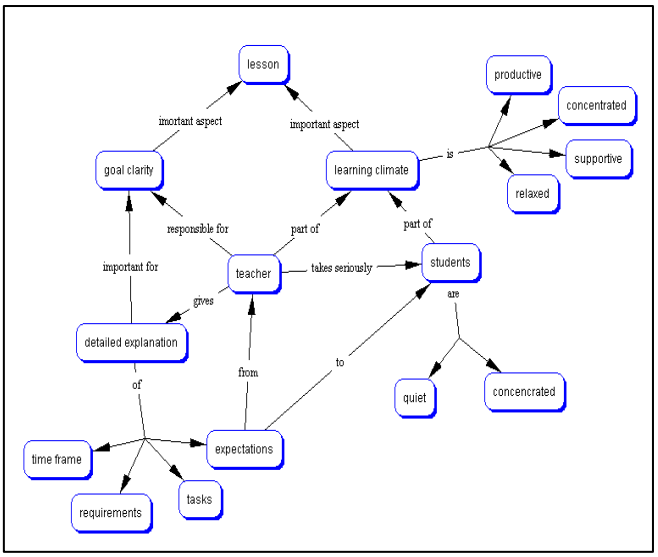


Figure 26. Concept map from a pre-service teacher, assigned to the high entry level group regarding the integration of higher order principles (original version and translated English version).

Before investigating group-specific organization processes and changes in more detail, group differences with regard to pre-service teachers' mean characteristics on gender, age, study term, attended courses, and interest in teaching and learning were tested. Over all conditions, no significant differences have been found (all Z values ranged between -0.24 and -1.32, $.19 < p < .81$). Hence, the two groups were comparable with regard to important learning prerequisites. Likewise, differences in the acceptance of the concept mapping task with regard to interestingness, usefulness and ease of use was tested. Pre-service teachers within the low

entry level group showed a rather high motivation for the concept map assessment (M = 2.89, SD = 0.62), rated the usefulness of the concept map technique on a medium level (M = 2.64, SD = 0.55) and found the concept mapping technique and software easy to handle (M = 3.16, SD = 0.37). For the group with a high entry level regarding the integration of higher order principles, similar values were found for interestingness (M = 2.77, SD = 0.57) and usefulness (M = 2.74; SD = 0.47). The ease of use was for this group a bit more difficult (M = 2.74; SD = 0.25). The two groups of pre-service teachers did not statistically differ in terms of interestingness, Z = - 0.79, p = .43; and usefulness, Z = - 0.41, p = .68. However, a significant difference was found with regard to the ease of use, Z = - 2. 41, p = .02. As the group with the high entry level perceived the concept mapping technique as more difficult to handle than the low entry level group, this aspect cannot be used as an explanation for the different knowledge levels at the beginning of the course on teaching and learning. Thus, it was not taken into account in further analysis steps, however has to be taken in mind.

7.3.4 Group-specific organization processes and changes on the structural level

After identifying pre-service teachers with different entry levels regarding the integration of higher order principles when organizing the selected information in relation to the presented video clip, they are now compared whether they also differ in their other organization processes. Moreover, it is examined, if pre-service teachers with different knowledge entry levels show different learning trajectories and changes over the university-based course on teaching and learning. In the following, the group-specific organization processes and changes are presented for the structure-related organization patterns.

Group-specific organization processes and changes with regard to superstructure

Against the background that structure-related and content-related organization activities complete each other during knowledge organization processes, the hypothesis targeted the effect of pre-service teachers' content-related knowledge organization on their structure-related organization processes. Due to the small sample size, Fisher's exact tests were carried out in order to test for group differences and Bowker tests for changes within each group. Table 26 displays the key descriptive statistics for each entry level group with regard to the type of superstructure at the first measurement point.

Table 26

Types of Superstructure across Both Groups at Pre-Test

	Low entry level group (N =21)		High entry level group (N = 6)	
	n	*%*	*n*	*%*
Person-centric superstructure	8	38.10	3	50.00
Procedure-centric superstructure	4	19.05	-	-
Event-centric superstructure	9	42.86	3	50.00

It was expected that the concept maps of the low entry level group regarding the integration of higher order principles reveals a higher proportion of person-centric superstructure than the high entry level group. Data did not confirm this expectation, Fisher's exact test, p = .47, one-tailed.

In line with the assumption, but with no statistical significant difference, Fisher's exact test, p = .34, one-tailed, the concept maps from low entry level group were characterized more often through a procedure-centric superstructure in comparison to the concept maps from the high entry level group.

When it comes to structuring the information around specific events, it was expected that pre-service teachers with a high entry level regarding the integration of higher order principles also have more concept maps with an even-centric superstructure. However, both groups did not differ statistically, Fisher's exact test, p = .56, one-tailed.

In a second step, pre-post-differences for each group were examined, to see whether pre-service teachers' organization processes with regard to their superstructure changed as a result of the course providing principles in observing and analyzing teaching and learning components in video clips along with directions concerning what they should focus on when observing these components. Table 27 provides an overview about the pre-post changes across both groups. Pre-service teachers entering the course with a comparably low level in knowledge-based organization processes remained relatively stable within their structure-related organization process regarding superstructure. Despite, the Bowker test indicates no significant result, χ^2 (3) = 4.33, p = .23. Similar findings were found for the high entry level group, however, the Bowker test could not be calculated as no procedure-centric superstructure could be identified at time 1, which is a necessary condition.

Table 27

Changes regarding the Type of Superstructures across Both Groups

	Low entry level group (*N*=21)			
	Time 1		*Time 2*	
	n	*%*	*n*	*%*
Person-centric maps	8	38.10	9	42.86
Procedure-centric maps	4	19.05	4	19.05
Event-centric maps	9	42.86	8	38.10
	High entry level group (*N*= 6)			
	Time 1		*Time 2*	
	n	*%*	*n*	*%*
Person-centric superstructure	3	50.00	2	33.33
Procedure-centric superstructure	-	-	1	16.67
Event-centric superstructure	3	50.00	3	50.00

These analyses show that for both groups no changes of the concept map superstructure took place. Thus, as assumed, it seems that structure-related organization processes are something more stable and that restructuring processes need more time than one course in university-based teacher education can provide, even for pre-service teachers who start with a relative good knowledge base. A graphical illustration for changes regarding superstructure for each entry level group is given in figure 27.

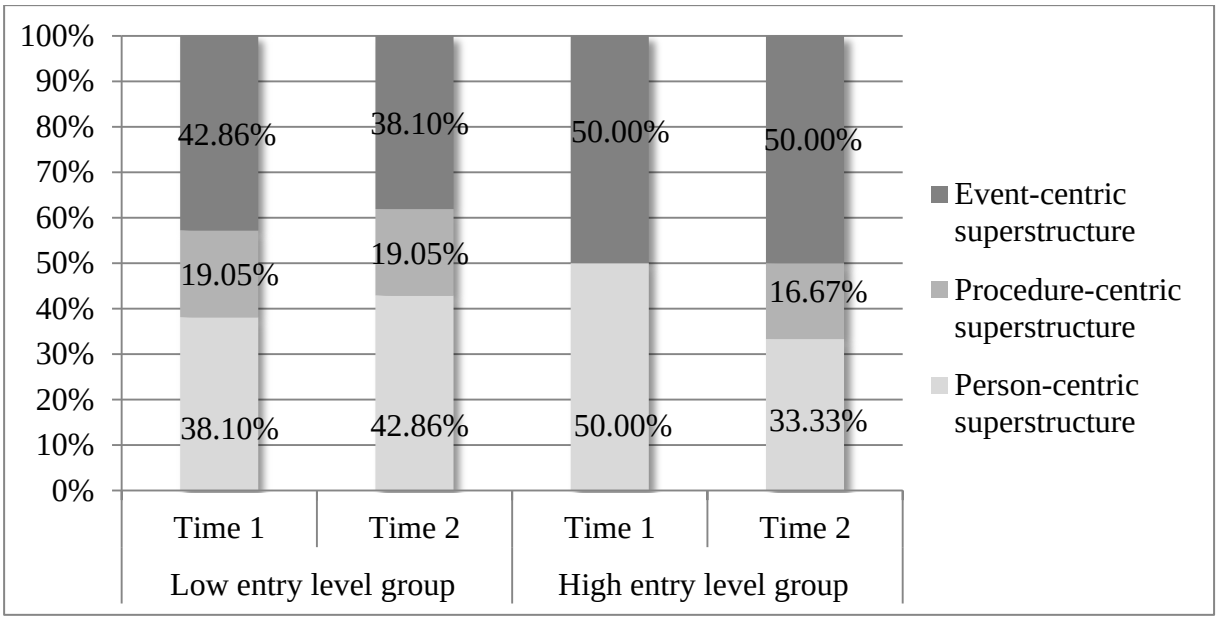


Figure 27. Changes with regard to type of superstructure within both entry level groups.

Group-specific organization processes and changes with regard to Macrostructure

In a next step, the structure-related organization processes with regard to macrostructure units were analyzed from both groups. The number of macrostructure units was compared with a Mann-Whitney-U test at the pre-test and changes across each group were tested with a Wilcoxon test. The type of macrostructure was analyzed descriptively.

As table 28 indicates, pre-service teachers' concept maps from the low entry level group include on average one macrostructure unit more than the concepts maps from the high entry level group, however without a significant difference, U = - 1.38, p = .08, one-tailed.

Table 28

Number of Macrostructure Units within Both Groups at Pre-Test

	Low entry level group (N =21)		High entry level group (N = 6)	
	M	*SD*	*M*	*SD*
Macrostructure units	2.81	1.37	2.00	0.00

Looking not only on the amount of macrostructure units, but also on their type of structure, descriptive analysis at the pre-test reveals that concept maps from pre-service teachers from the low entry level group show not only more macrostructure units but also more single macrostructure units than the high entry level group. With regard to the structure related to

spoke, chain and lattice, similar distributions and frequencies are found. An overview about all coding categories across both groups for the first measurement time is given in table 29.

Table 29

Types of Macrostructure Units within Both Groups at Pre-Test

	Low entry level group (N =21)		High entry level group (N = 6)	
	n	*%*	*n*	*%*
Single	10	16.95	-	-
Spoke	3	5.08	1	8.33
Chain	20	33.89	4	33.33
Lattice	26	44.07	7	58.33

Overall, the comparison of the macrostructure units suggest that pre-service teachers with a low entry level of integrating higher order principles show a greater amount of macrostructure units, however they integrate more unrelated concepts. These results illustrate the assumed knowledge difference between both groups, as schemata defined as organized network of elements rather than as many single and unconnected elements.

Taking pre-post changes over the run of the course on teaching and learning into account, an increase of macrostructure units for both groups is reported in table 30. Across all pre-service teachers, the number of macrostructure units increased on average around one unit. Changes for the low entry level group were not significant, Z = - 1.13, p = .13, one-tailed. In the group of pre-service teachers with a high entry level, there was significant increase in the number of macrostructure units, Z = - 1.86, p = .03, one-tailed.

Table 30

Changes regarding the Number of Macrostructure units across Both Groups

	Time 1		*Time 2*	
	M	*SD*	*M*	*SD*
Low entry level group (*N*= 21)	2.81	1.37	3.43	2.32
High entry level group (*N*= 6)	2.00	0.00	3.00	.89

In order to make statements, whether the increase of macrostructure units within both groups goes along with changes in their knowledge structure, changes within their macrostructures were investigated. Table 31 shows the findings regarding the changes of the structure across the low and high entry level group.

Table 31

Changes regarding the Structure of the Macrostructure Units separated across Both Groups

	Low entry level group (*N*=21)			
	Time 1		Time 2	
	n	*%*	*n*	*%*
Single	10	16.95	16	21.62
Spoke	3	5.08	7	9.86
Chain	20	33.89	31	43.66
Lattice	26	44.07	20	28.17
	High entry level group (*N* = 6)			
	Time 1		*Time 2*	
	n	*%*	*n*	*%*
Single	-	-	-	-
Spoke	1	8.33	5	27.78
Chain	4	33.33	11	61.11
Lattice	7	58.33	2	11.11

The results for the low entry level group show that the amount of single, spoke and chain macrostructure units increased over time. Macrostructures indicating a lattice structure decreased over time. This suggests that these pre-service teachers still show a low level of structure-related organization processes indicated by the increased amount of single macrostructure units at the end of the course on teaching and learning, however the decreased amount of lattice macrostructure and the increase of spoke and chain macrostructure units indicate also a positive qualitative change in their structure-related organization processes.

For the high entry level group, an increase of macrostructure units revealing a spoke or chain structure was found, whereas the amount of lattice-like macrostructure units decreased and equal to the pre-test no single macrostructure units were found. This descriptive analysis suggest that the increase in the amount of macrostructure units over the course goes along

with a positive qualitative change in structure-related organization processes within the high entry level group. These different changes are displayed visually in figure 28.

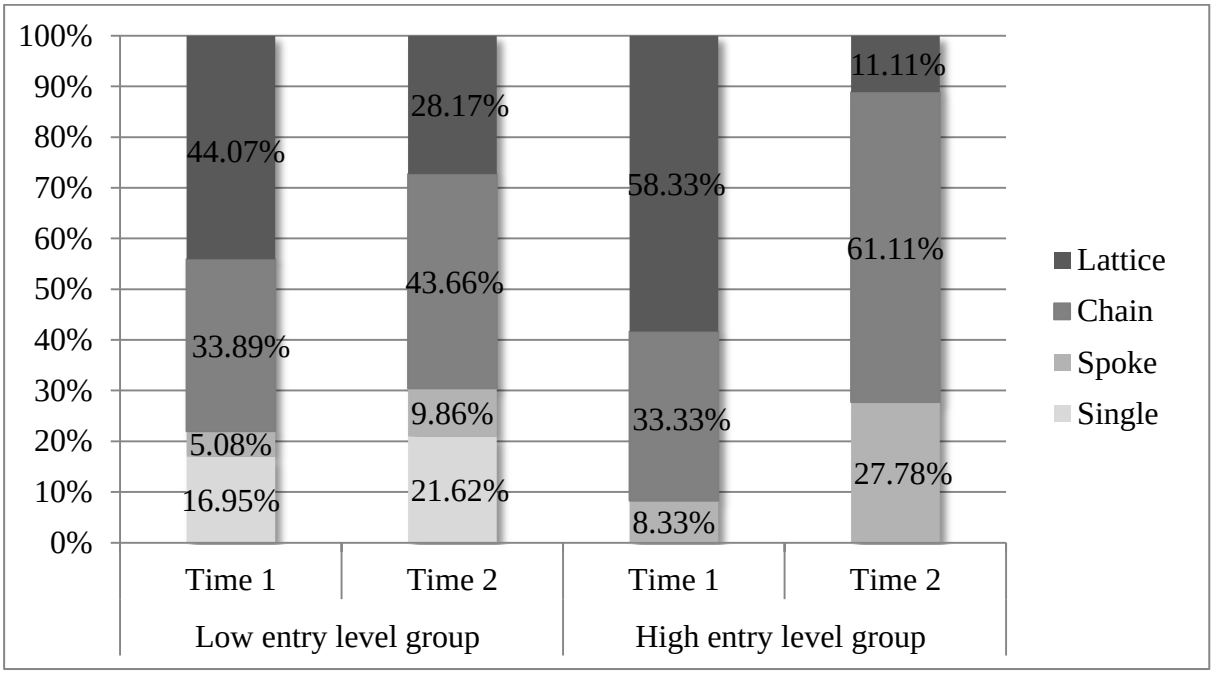


Figure 28. Changes with regard to type of macrostructure within both entry level groups.

7.3.5 Group-specific organization processes and changes on the content level

After outlining the structure-related organization processes across pre-service teachers with different entry levels regarding their knowledge about teaching and learning components, differences and group-specific changes with respect to the content-related organization processes are addressed now.

Group-specific organization processes and changes with regard to semantical links

The semantical relations of both groups were compared with a Mann-Whitney-U test. The findings for the low and high entry level group regarding the integration of higher order principles are reported in table 32.

Table 32

Kind of Semantical Relations within Both Groups at Pre-Test

	Low entry level group (*N*= 21)		High entry level group (*N* = 6)			
	M	*SD*	*M*	*SD*	*U*	p^a
Erroneous relation	1.48	1.60	0.17	0.41	- 2.19	.01
No relation	1.10	1.30	0.83	0.75	- 0.12	.45
Interrelated links						
Structual relation	1.62	2.22	2.00	2.00	- 0.59	.28
Procedural relation	5.43	3.49	5.33	3.88	0.06	.48
Functional relation	1.57	1.83	2.83	1.72	- 1.58	.06
Intrarelated links						
Hierachical relation	4.14	3.23	3.00	2.19	- 0.62	.27

Note. [a] one-tailed.

It is displayed that both groups significantly differ with regard to the number of erroneous relations within their concept maps. Pre-service teachers, showing a low entry level of organizing their maps around higher order principles at the beginning of the course, created on average one more erroneous link than the small group of pre-service teachers, who already integrated higher order principles in their map. Although no statistical significant difference was found, concept maps from the low entry level group revealed also more links, where the relationship was not specified. This underlines the assumption that knowledge is necessary to activate semantical relationships in a correct manner and to avoid misconceptions.

Looking at the interrelated links, it is outstanding that the concepts maps from the low entry level group showed more procedural relations indicating the description of actions, fewer structural links indicating a concrete description of the concepts, and less functional links indicating an instrument-relation than the concept maps from the high entry level group. Although, the mean averages differed not very much from each other and no statistical difference was found. The highest proportion of procedural relations indicates that it was

easier for both groups to specify activity relations than possessive or instrumental relations, which was even more difficult for the low entry level group.

With regard to intrarelated links, it was expected that the low entry level group is less able to define hierarchical relations between concepts in comparison to the high entry level group as the activation of cognitive processes is necessary. In contradiction, the concept maps from the high entry level group revealed fewer hierarchical relations, however with no statistical significant difference. Furthermore, changes over time for the two groups were analyzed (see table 33). It was specifically assumed that the amount of erroneous links in pre-service teachers' concept maps from the low entry level group would decrease over time as they took part in a course fostering knowledge about teaching and learning components and thus their misconceptions will decrease. For the high entry level group, an increase of functional and hierarchical relations indicating a knowledge restructuring process on a micro-level was expected as they already possess first knowledge structure at the beginning of the course.

Table 33

Changes regarding the Kind of Relations across Both Groups

	Low entry level group (*N*= 21)							
	Time 1			*Time 2*				
	M	*SD*	*%*	*M*	*SD*	*%*	*Z*	p^a
Erroneous relation	1.48	1.60	10.51	0.90	1.60	5.72	- 1.34	.09
Nonspecified relation	1.10	1.30	10.85	2.00	1.30	12.65	- 1.48	.07
Interrelated links								
Structural relation	1.62	2.22	11.52	2.86	2.22	18.07	- 1.34	.01
Procedural relation	5.43	3.49	26.44	5.29	3.49	32.83	- 0.15	.44
Functional relation	1.57	1.83	11.19	1.57	1.83	9.94	- 0.18	.43
Intrarelated links								
Hierachical relation	4.14	3.23	29.49	3.29	3.23	20.79	- 1.33	.09

	High entry level group (*N*= 6)							
	Time 1			*Time 2*				
	M	*SD*	*%*	*M*	*SD*	*%*	*Z*	p^a
Erroneous relation	0.17	0.41	1.17	1.17	1.60	8.04	- 1.34	.09
Nonspecified relation	0.83	0.75	5.88	2.00	2.68	13.79	- 0.81	.21
Interrelated links								
Structual relation	2.00	2.00	14.12	.83	.75	5.75	- 1.29	.10
Procedural relation	5.33	3.88	37.65	3.67	1.97	25.29	- 1.07	.14
Functional relation	2.83	1.72	20.00	3.00	2.76	20.69	- 0.27	.39
Intrarelated links								
Hierachical relation	3.00	2.19	21.18	3.83	1.47	26.44	- 0.97	.17

Note. [a] one-tailed.

Overall, 295 links have been identified for the low entry level group at time 1 and 332 links at time 2. For the high entry level group, an amount of 85 semantical links have been found in their first constructed concept maps and 87 semantical links at the second measurement time.

As conjectured, the low entry level group's erroneous links decreased over the term, however not significantly: Around one erroneous relation less was integrated in the concept map at the post-test comparing to the concept map at pre-test. Furthermore, but without a statistical significance, the amount of not specified relations increased over time with a mean average of one relation. With regard to interrelated links, a significant increase of structural relations was found, whereas procedural relations decreased and functional relations remained stable, both results are not significant. As the amount of hierarchical relations from pre- to post-test decreased within the low entry level group, they still show a low-level of content-related organization processes.

For the group of pre-service teachers, starting the course with a relative high entry level regarding content-related organization processes, table 33 indicates that their content-related knowledge organization with regard to semantical complexity was not sustained over the

course, indicated by the increased amount of erroneous relations and the same amount of not specified relations as the low entry level group at measurement time 2. However, in contrast, the amount of functional and hierarchical relations increased over time indicating some kind of tuning and refining processes. All changes are not statistically significant. In figure 29 the distribution of semantical links at pre- and post-test are illustrated for both groups.

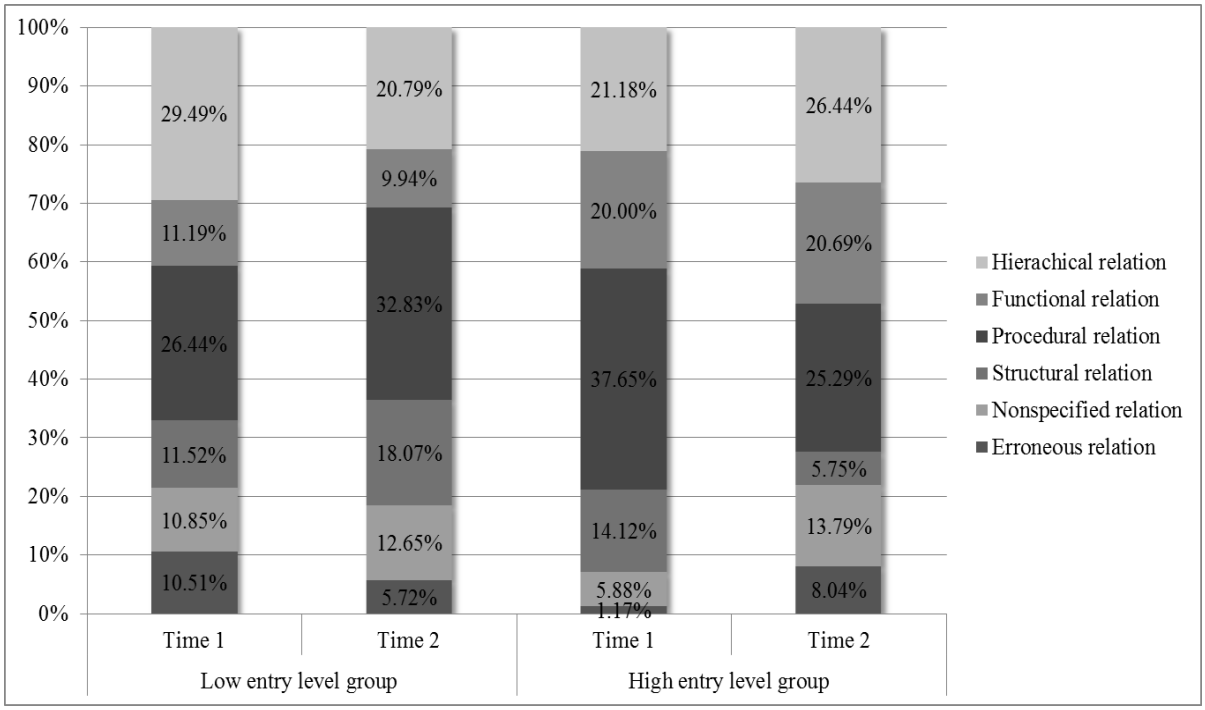


Figure 29. Changes with regard to type of semantical links within both entry level groups.

Group-specific changes with regard to the integration of higher order principles

Within the final analysis, changes over the course with regard to the integration of higher order principles for pre-service teachers with different entry levels regarding these content-related organization activities were analyzed descriptively. It was assumed that the amount of macrostructure units including higher-order principles increase for pre-service teachers starting with a comparable low level of knowledge-based information organization, as they might profit most from theoretical knowledge input. Overall, it was expected that pre-service teachers still show more macrostructure units, which do not include higher-order principles as knowledge organization around specific schemata is mostly a cognitive characteristic of expert teachers. In table 34, the results of the descriptive analysis are summarized for each group, including the distribution of frequencies and percentages of macrostructure units of the pre- and posttest.

Table 34

Changes regarding the Integration of Higher-Order Principles over all Macrostructure Units across Both Groups

	Low entry level group (*N*=21)			
	Time 1		Time 2	
	n	*%*	*n*	*%*
No integration of higher order principles	56	94.92	62	86.11
Integration of higher order principles	3	5.08	10	13.89
	High entry level group (*N*= 6)			
	Time 1		Time 2	
	n	*%*	*n*	*%*
No integration of higher order principles	4	33.33	13	72.22
Integration of higher order principles	8	66.66	5	27.78

As assumed, pre-service teachers entering the course with a relative low level of knowledge-based information organization, indicated by only 5% macrostructure units including higher order principles, integrated at the end of the course more knowledge-based macrostructure units (14%) in their concept maps. In contrast, pre-service teachers with a comparable high entry level, indicated by 67% macrostructure units including higher order principles, organized the selected information from the video clip after the course less around higher order principles (28% of all macrostructure units). However, this amount is still higher than for the low entry level group. Overall, these findings show that changes in knowledge organization around higher-order principles depend on pre-service teachers' entry level and that pre-service teachers with a low entry level seem to develop during the course on teaching and learning, even if they show at the end still lower capacities than the high entry level group. Besides, the results for the high entry level group contribute to the assumption that changes in knowledge organization processes are not always linear and might be also characterized through phases of regression. Figure 30 illustrates the different changes regarding the integration of higher order principles for both groups.

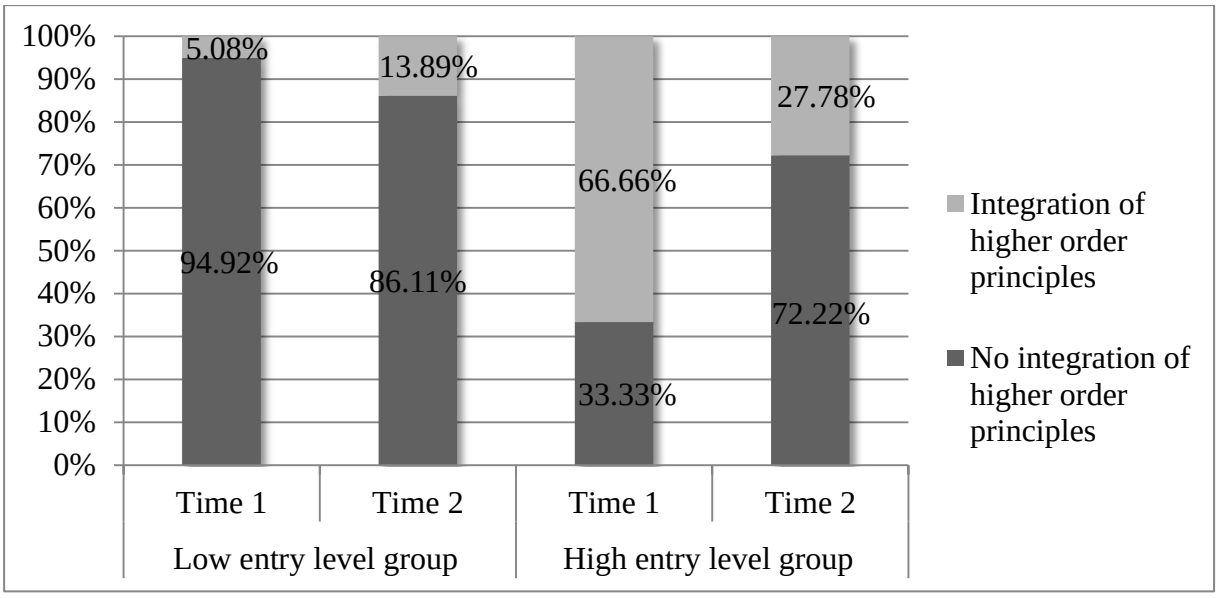


Figure 30. Changes regarding the integration of higher order principles within both entry level groups.

7.4 Discussion

Against the backdrop of providing new information for the design of learning environments in teacher education, Study 2 aimed to describe pre-service teachers' organization activities regarding specific teaching and learning components during phases of knowledge acquisition in the context of observing a pre-selected video clip. The video, which was used to activate pre-service teachers' cognitive processes in a contextualized way and contained specific information on goal clarity and learning climate based on expert judgements, was combined with the assessment tool of concept mapping. This cognitive research technique was newly applied to research on professional vision, as so far no statements about pre-service teachers' organization processes in this context could be made due to a lack of appropriate methods for externalizing knowledge organization. Thus, it was also one goal of this study to identify components, which can be used on the basis of empirical research to describe the nature of pre-service teachers' organization processes. Thereby, it was attempted to develop coding frameworks to elicit these organization components within pre-service teachers' concept maps. Furthermore, the concept maps were used to identify pre-service teachers with different entry levels regarding knowledge about goal clarity and learning climate and to compare them within their organization processes as well as to investigate group-specific changes during a university-based course on teaching and learning.

The first research question dealt with structure-related and content-related organization processes, activated when pre-service teachers observe a specific video representing the

components of goal clarity and learning climate at the beginning of the course. The findings regarding structure-related organization processes reveal firstly that pre-service teachers show different foci when they are engaged in information selection and omission processes, elicited through different types of superstructure within their concept maps. Thereby, some kind of intentional information organization was visible as they tried to organize information related to specific events of teaching and learning. However, they still focused on details and salient features and objects when structuring the selected information form the video clip, which thus indicates a more surface organization approach. Secondly, it was found that pre-service teachers tried to organize the single information pieces into more integrated macrostructure units. These units mostly reveal a lattice-like macrostructure indicated through many, however, not always meaningful links between single information pieces. These results are in line with previous work from expertise research suggesting that pre-service teachers show different patterns on what they focus when observing a classroom situation and that they focus less on specific events rather than on salient details (e.g. Carter et al., 1988; Livingston & Borko, 1989). This indicates that at the beginning of the course pre-service teachers' knowledge structure about teaching and learning components is mostly organized according to surface characteristics and includes different types of map structures aiming to represent the content structure of the video clip on teaching and learning components. This corresponds also to Marton and Saljö' s study (1976a), which revealed that students show different ways of understanding the intentional content of a learning material and in turn, also underlines the importance to provide precise information on the content of the learning material (in this case on the video clip).

Findings regarding pre-service teachers' content-related organization processes contribute to the assumption that pre-service teachers' knowledge structure in the field of the two teaching and learning components at the beginning of the course is not very organized yet. In this context, the data reveal only a small amount of higher-order principles on teaching and learning components integrated in the macrostructure units. Secondly, it contributes to the assumption that pre-service teachers cannot be assumed as a homogeneous group regarding the quality of their knowledge structure about teaching and learning components (Stürmer, Seidel et al., 2013) as diverse types of semantical links including different semantical complexities and misconceptions were found in pre-service teachers' concept maps.

Besides, the results of the first research question suggest that the combination of video and concept mapping is a promising approach for assessing pre-service teachers' organization activities in a contextualized and authentic situation. The concepts mapping technique

captured how pre-service teachers reduce complex information within an authentic classroom situation and construct relationships between concepts as well as how they labeled the semantical relationships. This indicates not only what knowledge pre-service teachers hold, but also how knowledge in the domain of teaching and learning might be arranged in pre-service teachers' mind (Winitzky et al., 1994). Furthermore, the analysis of the patterns of concepts and links within pre-service teachers' concept map provided a method for identifying their personal relevance and thoughts that generally remain private to themselves what in turn, may help to effectively suggest learning goals for teacher education courses in the domain of teaching and learning (Kinchin et al., 2000). Another important fact in this line is that the concept mapping technique received a high acceptance among the participants necessary that pre-service teachers are motivated to engage in cognitive processes (Stracke, 2004). Through the use of a video clip, where experts provided information on the types of aspects in the studied domain that are represented in the video, the correctness of pre-service teachers' organization processes could be also taken into account. Thus, the mixed-method assessment task has potential to pinpoint pre-service teachers' existing understanding and knowledge organization at the beginning and might provide a means of illustrating developmental changes and pathways over the time of university-based teacher education. Furthermore, this technique seems promising to gain insight into differences in pre-service teachers' knowledge structure and to contextualize it (Ruiz-Primo-Shavelson, 1996).

The results from the second research question underlines this advantage of concept mapping, as it was possible to identify pre-service teachers with different entry levels regarding their knowledge about the teaching and learning components under study. In line with previous findings on pre-service teachers' knowledge activation when analyzing classroom situations without any theoretical input (e.g. Schwindt, 2009; Star & Strickland, 2008; Stürmer, Seidel et al, 2013), only around one quarter of pre-service teachers could be identified who integrated higher order principles regarding goal clarity or learning climate in their concept maps at the beginning of the course and thus, showed a rather high entry level. This contributes to the conjecture that the development of higher order knowledge structures have to be supported in teacher education, especially as they are relevant to structure and analyze classroom situations in a professional way (Stürmer, Könings et al., 2013).

To answer the third research question, group-specific organization processes and changes from pre-service teachers with low and high entry levels regarding the integration of higher order principles as one indicator for the quality of their knowledge organization were investigated. In general, the analysis of concept maps illustrates differences between both

groups and trajectories over time. Though the group-specific organization processes and changes were mostly statistically nonsignificant, the identification of fine-grained differences is provocative and promising for continuing research, since it may impact the design of pre-service teacher centered courses (Stürmer, Seidel et al., 2013).

The results of research question 3a regarding the structure-related organization processes of the low entry level group reveal that the pre-service teachers attempted to intentionally structure the selected information within their concept map according to teaching and learning events at the beginning of the course. This structure-related organization pattern sustained over time. The concept maps from the high entry level group showed similar superstructures, however with a little higher proportion of concept maps structured on an intentional level. Related to that, it is particularly interesting that also for the high entry level group no notable changes occurred over the course. These results might suggest that it is not so easy for pre-service teachers to change the way of organizing the selected information towards the intentional content of the presented material. As exact features and particular effects of the course were not themselves objectives of this study, it is difficult to say, if the course failed to support pre-service teachers in engaging in this organization processes. However, it might be that even if courses including instructional aids, such representing video-based examples and writing summarizations of the learning content, the engagement in deep-level processes of structuring and restructuring need more time than one term in university can provide (Winitzky et al., 1994). Another interpretation might be, that pre-service teachers tend to be overwhelmed by the complexity of the assessment which combines a (videotaped) classroom situation with concept mapping and thus, show difficulties in identifying the information needed for organizing the content and integrating relevant aspects. This is in line with experimental research studying the impact of the learning material on organization processes. It was shown that learners' familiarity with the presented material has an influence on the quality of their organization processes (Kintsch & Greene, 1978; Schnotz, 1982). Taking into account that pre-service teachers mostly had no experience with video-based learning and concept mapping before participating in this study and considering that especially the high entry level group rated the handling with the concept mapping technique as not so easy, this might be a possible explanation. Also Beyerbach & Smith (1990) reported in their study that the assessment tool of concept mapping has to be introduced very well. In order to specify the concrete mechanisms, however, future research is needed, especially as the results were statistically nonsignificant.

Furthermore, the results of research question 3a reveal, in line with the hypothesis, different macrostructures within both groups as well as illustrated different developmental pathways over the course. Pre-service teachers starting with a comparable low knowledge entry level showed at the beginning a greater amount of macrostructure units including only single and unconnected elements than pre-service teachers from the high entry level group. Over time, the organization processes on this level changed within both groups, however differently. The trajectory of the low entry level group can be described as nonlinear as the amount of single macrostructure units within their concept maps increased even more, however a decreased amount of lattice-like macrostructure, and an increase of spoke and chain macrostructure units was also found. In contrast, for pre-service teachers with a high entry level, a quality change in terms of an increased number of spoke or chain structures and a decreased number of lattice-like macrostructure units was found. Thus, it seems like that pre-service teachers with already existing and applicable knowledge structures at the beginning of a course on teaching and learning benefitted from the video-based course and reflection tasks in terms of rearranging their knowledge structure on a structural level in the direction towards expert-like knowledge organization (Stürmer, Könings et al., 2013).

Finally, the content-related organization processes and their changes over time were compared to answer research question 3b. Although pre-service teachers' organization processes from the low entry level group revealed no great changes towards expert-like semantical knowledge representation indicated by a decreased amount of hierarchical relations over time, less misconceptions were found after the course. Interestingly again, the high entry level group showed a vice versa change. Their maps revealed more erroneous relations combined with more expert-like hierarchical relations at the end of the course than at the beginning. Similar changes were found on the level of integrating higher order principles. The low entry level group showed a positive development as they organized their concepts maps at the end more around higher order concepts related to goal clarity or learning climate. The other group of pre-service teachers was not able to remain on their high entry level, however, still outperformed the other group of pre-service teachers.

In this context, the question arises what happened that pre-service teachers showing already some kind of knowledge about teaching and learning at the beginning have not improved within their content-related organization processes, however showed some kind of qualitative changes on the structural level, and for pre-service teachers with a rather low knowledge base at the beginning a different change occurred? Although it is difficult to identify the exact reasons that led to these results, because different challenges pre-service teachers are

encountered with during phases of knowledge acquisition and specific effects from the course were not themselves objects of the investigation, three reasons might contribute to explain these results. First, it might be that changes in pre-service teachers' knowledge structures are not always smooth and linear resulting in increasing complex and structured concept maps. For example, Winitzky and colleagues (1994) found in their study on long terms effects of a teacher education program on pre-service teachers' knowledge structure for classroom management regressions from time 1 to time 2, and then increases at time 3 and 4. Furthermore, considering that a qualitative change of structure-related organization processes is only possible after a certain amount of knowledge has been acquired (Vermunt & Verloop, 1999), it might be that pre-service teachers' concept maps develop first on the content-related level. However, more empirical research about cognitive developmental pathways is needed to account for this interpretation (Renkl, 2012).

Second, the methodology differed from that used in other studies, assessing organization processes within an authentic and dynamic situation by using a videotaped classroom situation rather than static text material. In line with *Cognitive Load theory* (Paas, Renkl, & Sweller, 2004; Sweller, 2011), pre-service teachers – irrespectively of their entry knowledge level – might be extrinsically cognitive overloaded by this assessment procedure and thus, might not be able to engage in qualitative high content-related and structural-related organization processes simultaneously. Especially, as the course objective was not mainly on supporting the application of organization strategies.

Finally, it might be also that the video-based course including elements of reflection caused distinct differences in pre-service teachers' learning processes (Blomberg, Sherin, et al., 2013; Stürmer, Könings et al., 2013). Pre-service teachers starting the course with a rather low knowledge level might have benefited in terms of acquiring applicable knowledge in the field of teaching and learning necessary for elaborative content-related organization processes (Stürmer, Seidel et al., 2013). Although, pre-service teachers with a high entry level could not be supported to extent their knowledge base and thus, show minor abilities to integrate higher order principles and semantical complex links in their concept maps – nevertheless this group of pre-service teachers still showed a higher knowledge level at the end than the low entry level group – it seems that the course helped them to rearrange their existing knowledge structure indicated through a qualitative change of structure-related organization processes. Furthermore, it might be like Lehtinen (1992) concluded in his study with students at school, that the learning environment or the instructional strategies are not always able to support "good" students' deep-level processing when they are themselves not willing to engage in a

deeper understanding of the content over time. However, and as already stated, more research regarding processes of their cognitive development is required; particularly as the high entry level group comprised only six pre-service teachers and results were mostly nonsignficant.

In a nutshell, the findings highlight how important it is to study not only the quantitative nature of pre-service teachers' knowledge but also how their knowledge is organized and structured during information selection and processing, and to do this on a micro-level. Through the use of multiple assessments of knowledge organization assessed with concept mapping at two measurement points, it was possible to discover specific patterns of their organization processes and to investigate differences between pre-service teachers' learning processes at a fine grained level. These differences illustrate the importance of considering individual differences of pre-service teachers when embedding elements of approximations, representations and decompositions of practice in teacher education courses. In terms of organization processes investigated in this study, the findings indicate that structure-related and content-related organization processes need to be fostered in different ways as well as pre-service teachers' prior knowledge has to be taken into account. Besides, the study shows promises in adapting methodologies from different research areas in order to gain more insight into the construct of professional vision and underlying cognitive processes. Nevertheless, there are a number of limitations of the current study, which are important to discuss as well.

As this study was designed as an exploratory investigation of pre-service teachers' organization processes in the context of professional vision through the use of concept mapping, the generalizability is limited. This is firstly caused due to the low and not randomly selected sample size and the use of one specific videotaped classroom situation. However, the low *n*-problem is unlikely to go away, given the phenomena under study. The analysis of cognitive structure proves to be complex, time-consuming and thus, makes the use of large groups enormous difficult. Therefore, future research is needed to substantiate these results (e.g. using randomly selected pre-service teachers and a set of other videos). As well, it is utmost important to study pre-service teachers' organization processes using this approach in different settings and design variations. For example, including a control group would help to gain a systematical insight into the impact of the course on teaching and learning on organization processes. However, as the study took place within a teacher education program, where the course was obligatory and preparatory for the following practical phase, an experimental setting was in this case ethically not reasonably. Nevertheless, the naturalistic setting has a high degree of ecological validity and is thus, relevant for practical innovations

(Kember, 2003). Thereby, an extension of the present study to a longitudinal study with more than two measurement points would be useful to study if and how group-specific organization processes develop over the end of the course.

A second limitation within the current exploration of pre-service teachers' organization processes was the focus on one domain. The content of specific teaching and learning components was selected, because of its importance to pre-service teachers to know what constitutes effective teaching and learning and the fact that teacher education courses in this domain are still under investigated (König & Seifert, 2012). However, there are many other relevant knowledge domains, which might reveal different organization patterns as the degree of structure of the domain influences knowledge organization and growth (Ruiz-Primo & Shavelson, 1996). For example, the domain of teaching and learning components is relatively ill-structured and fussy in comparison to other areas (e.g. content knowledge in Physics). To improve the understanding about pre-service teachers' organization processes and the development of cognitive structure across the teacher education program, future research studies on domain-specific effects are needed. In turn, if pre-service teachers' learning proceeds differently, then studies on appropriated instructional strategies have to be conducted as well (Blomberg, Sherin et al., 2013; Seidel et al., 2013). In addition, I want to explicit about the fact that pre-service teachers with different entry levels regarding the integration of higher order principles were identified and contrasted for this study, but I am aware that there might exist many other differentiating variables between pre-service teachers and prerequisites, which might have influenced their change and knowledge organization processes as well. Specifically, pre-service teachers' motivational and affective orientation towards the knowledge domain might contribute to the explanation of the quality of their organization processes (Krapp & Prenzel, 1992; Prenzel et al., 2000). In future research, it would be interesting to study the influence of potential moderating prerequisites, like pre-service teachers with different motivational characteristics.

In addition, the study was designed to gain insight into pre-service teachers' organization processes using the exploratory assessment approach of concept mapping conceived as a combination of a task, a response format and a scoring system. So far, concept maps were attributed as a promising alternative assessment method in cognitive research as they are interpreted as representing important aspects of the organization of concepts in learners' mind (cognitive structure). Against this backdrop, the study was the first applying this technique to the research area of professional vision. Thus, specific decisions on the task, response format and scoring system had to be made and adapted to the study context, being aware that this

might include problematic aspects and restrictions. In the context of providing a basis for interpretations at the individual level and on interindividual differences of pre-service teachers' knowledge structure including their information selection and construction processes, a low-directed mapping technique (only two concepts were presented) were chosen. In this line, every concept map was highly specific which was regarding the research aim very positive, however caused on the other side problems with coding and the technical quality. Specifically, the coding of the categories 'macrostructure' and 'semantical relations' was very time-exhaustive and partially difficult, which might be thus, the reason for the low interrater-reliabilities. Moreover, to apply this new assessment approach in future studies, it should be considered to make more restrictions regarding the task and response format. However, it has to be explored whether constraints like providing labels for the links or terms to use within the nodes still provide the same information values as the current concept mapping technique. At least, it has to be checked whether it suits the research purpose.

Another important aspect, which should be target in future studies, is related to the validation of the analysis approach/coding system. This seems to be specifically relevant against the background that most of the findings were statistically non-significant. For example, the comparison of different expertise groups in the domain of teaching and taking not only their formal knowledge (comparison with researchers) but also their practical knowledge (comparison with experienced teachers) into account would be an important research activity. Furthermore, pre-service teachers ranging in their experience with the technique of concept mapping should be compared to investigate also the role of concept mapping experience more systematically. The current sample was very homogenous with respect to their prior experience; almost none of them had worked with concept maps before. Especially, as a first analysis in this study revealed that pre-service teachers differ with regard to their estimation of the ease of use regarding the applied concept mapping technique. Also the comparison to other measures of pre-service teachers' cognitive processes (e.g. *Observer Tool*) could add more information on the validity of the coding system. However, it has to be considered that so far, at least to my knowledge, no other instrument in the context of professional vision captures organization processes. Besides this validation check, it would be interesting to differentiate the coding category of higher order principles with regard to goal clarity and learning climate. This would allow a deeper insight into content-related organization processes, like for example Study 1 could show that the activation of elaboration processes in the area of learning climate was more difficult for pre-service teachers.

Finally, it would be highly desirable to examine the effects of pre-service teachers' organization strategies on their learning outcomes in the sense of their actual teaching action. However, at least in German teacher education, where independent teaching occurs only after the completion of the first phase of teacher education at university, and where teaching in the practicum is limited, such an investigation might be difficult. Considering the infinite number of complex processes involved in authentic classroom teaching, standardized tools would be necessary to test whether pre-service teachers' knowledge organization in one domain is directly related to their teaching performance in the same content domain (Shavelson, 2010). In this context, other examples of "approximations of practice", like microteaching events (Zeichner, 2005), might not only show potential as a learning tool but also suit research purposes with regard to investigate this relation (Shavelson, 2012). Against the backdrop that this study is embedded into the context of the *Observe* project, where such standardized teaching situations for assessment reasons have been developed in the latest time (Seidel et al., submitted), the relation between cognitive learning activities and teaching action indicated as learning outcome could be part of future research. Moreover, studying these on the individual level would add deeper insight into the translation of cognitive processes into real actions within pre-service teachers as the current findings suggest that individual differences regarding organization processes exist.

To conclude, Study 2 shows that it is possible to investigate pre-service teachers' organization processes in a concrete situation through the combination of different contextualized and cognitive assessment approaches. This adds new value to the exploration of pre-service teachers' cognitive learning processes in the context of professional vision. The study provides first evidence that the technique of concept mapping shows potential to be used as an alternative authentic assessment of pre-service teachers' knowledge structure and identified relevant criteria for analyzing pre-service teachers' organization capacities. Moreover, the findings underline the need to carefully design teacher education courses including elements aiming to foster structure-related and content-related organization processes, specifically acknowledging the heterogeneity of the target learner group and the learning goals at hand.

8 General Discussion

The current work, which was carried out in the context of the DFG-project *Observe* (Seidel et al., 2009; Seidel & Stürmer, 2014) to learn more about initial knowledge acquisition phases in the field of teaching and learning in university-based teacher education, represents a first research activity on pre-service teachers' cognitive learning processes with regard to specific teaching and learning components assessed with a mixed-methods approach. The exploratory character is related to diverse aspects of the thesis, including theoretical considerations on the analysis of cognitive learning processes, methodological approaches to assess these processes in a contextualized way, and in providing first results on pre-service teachers' deep level processes of elaboration and organization in the domain of general pedagogical knowledge. In this line, detailed coding frameworks have been developed within both studies and an alternative assessment approach was applied and tested within a contextualized and authentic teaching and learning situation in Study 2. Based on that, findings on pre-service teachers' capacities regarding their elaboration and organization processes could been presented, which provide a promising basis for future research in the context of professional vision.

In the next sections, the two studies conducted within in this thesis will be synthesized and discussed according to following issues and outlines: First, in section 8.1 I will summarize and discuss the findings of Study 1 and 2 in the context of the main research questions. Afterwards, in section 8.2 I will address methodological aspects regarding the assessment of pre-service teachers' cognitive learning processes in the context of professional vision. Furthermore, in section 8.3 I will outline the theoretical and practical relevance of the study results. Finally, I will target future research questions in section 8.4.

8.1 Discussion of central study findings

The focus of the present thesis built the investigation of pre-service teachers' cognitive learning processes in the context of teaching and learning through a contextualized mixed-methods approach. Against the backdrop of cognitive approaches on learning and knowledge acquisition, pre-service teachers' cognitive learning activities regarding elaboration and organization are crucial to develop integrated and complex knowledge about effective teaching and learning components, as they impact the selection of relevant information as well as their understanding and transfer to real classroom situations. As the nature of teacher knowledge is regarded as situational and contextualized, distal indicators, such as grades or the number of courses taken as well as self-assessments through questionnaires do not allow

drawing conclusions on pre-service teachers' concrete cognitive capacities in a real situation (Artelt, 2000a; Lind & Sandmann, 2003; Voss et al., 2011). Thus, cognitive learning activities in this thesis have been studied in the context of professional vision as the ability to notice and reason about relevant classroom situations based on knowledge about teaching and learning components is considered as a proximal indicator for occurring cognitive learning activities. Therefore, research in this venue uses videotaped classroom situations to activate and assess these processes. Based on qualitative and quantitative studies on (pre-service) teachers' professional vision, components for analyzing pre-service teachers' elaboration processes indicated through their knowledge activation could be derived. Because of some uninvestigated aspects (e.g. activation of knowledge in the interplay of noticing and reasoning) and methodological restrictions (e.g. no validation through mixed-method approaches), new aspects have been considered and integrated into the analysis approach.

For the investigation of pre-service teachers' organization processes, a new assessment and analysis approach was established, as so far, at least to my knowledge, no study in the context of professional vision has focused on that before. Organization processes in the context of observing classroom situations refer not only to information omission and selection, but also to meaningful structure-related and content-related information abstraction and organization as models from cognitive psychology research point out. Therefore, first attempts have been made in transferring indicators and an assessment tool used in cognitive psychology to elicit knowledge organization and structure to the study context.

Against the backdrop of these outlines, the exploratory study was driven by two main research question, which were:

a) To what extent do pre-service teachers report on elaboration and organization cognitive learning processes in the context of professional vision?

b) Is there indication that alternative measurement and analysis approaches yield valid and reliable information for assessing pre-service teachers' cognitive learning processes in the context of professional vision?

To answer these questions, two empirical studies have been conducted with the following more specific research questions:

1. How can the nature of pre-service teachers' elaboration processes in the context of professional vision be described?

2. Is the qualitative analyses a valid approach for measuring pre-service teachers' elaboration processes?
3. How can the nature of pre-service teachers' organization processes in the context of professional vision be described?
4. Is there an indication that an applied concept mapping technique represents a reliable and valid assessment method to assess pre-service teachers' organization processes?
5. What are group-specific differences between pre-service teachers with different knowledge entry levels regarding their organization processes and how can group-specific changes throughout an one-term course on teaching and learning be described?

In the following sub-sections, I will integrate the results of the two empirical studies to answer these specific questions. Thereby, I will begin with addressing the nature of pre-service teachers' cognitive learning processes (question 1 and 3) in section 8.1.1 and 8.1.2. Afterwards, I will address the technical quality of the applied asessment approaches (question 2 and 4) in section 8.1.3 and 8.1.4, before I end with the outlines on group-specific differences and changes regarding pre-service teachers' organization processes (question 5) in section 8.1.5.

8.1.1 Nature of pre-service teachers' elaboration processes

The answer to the first question on the nature of pre-service teachers' elaboration processes with regard to specific teaching and learning components in the context of professional vision is helpful for knowing pre-service teachers' capacities to apply elaboration strategies, like activating prior knowledge. They are necessary in highly dynamic classrooms with concurrent interactions among multiple persons to select and process relevant information about teaching and learning processes. Therefore, within Study 1, 109 pre-service teachers observed and commented on the first video clip of the *Observer Tool*. For this clip, experts in the field of teaching and learning research agreed that the two pedagogical strategies of goal clarity and learning climate can be noticed and reasoned. The quality of their knowledge activation during noticing (information selection) and reasoning (information processing) with regard to goal clarity and learning climate as indicator for their elaboration capacities were assessed by analyzing pre-service teachers' written comments on an open question with a qualitative content analysis approach. Analysis criteria have been established considering literature on cognitive psychology research and knowledge in the domain of teaching and learning. Furthermore, based on expertise research in the field of professional vision different

characteristics of each coding framework have been identified, which indicate different capacities with regard to the components of noticing, depth and content of reasoning (see section 6.2.3). In order to describe pre-service teachers' capacities in noticing, reasoning and in their interplay as indicator for their elaboration processes during information selection and processing, all codes were transferred and aggregated on the level of pre-service teachers as analysis unit.

The results show that pre-service teachers were able to notice quite a number of events with regard to the two teaching and learning components (overall 53% of analysis units per pre-service teacher). This indicates that pre-service teachers, who are half-way through their initial university-based teacher education with having passed on average three courses on teaching and learning have acquired relevant knowledge and are able to engage in elaboration processes necessary to select relevant information from authentic classroom situations. Nevertheless, as pre-service teachers still noticed many irrelevant aspects, it seems that the engagement into elaboration processes during information selection is not per se an easy task for pre-service teachers. This fact might be even more obvious for the process of information-processing looking at the analysis of the depth of pre-service teachers' reasoning. Most of the pre-service teachers (73% concerning goal clarity; 89% concerning learning climate) in this study struggeled to activate prior knowledge concerning the relevant principles when reasoning about relevant noticed events. In addition, this finding might contribute to the assumption that the engagement in elaboration processes is not only specific to the domain, but also topic-specific as knowledge activation related to learning climate was more difficult compared to goal clarity in this study. Further data analysis on the content of pre-service teachers' reasoning indicates that it is also difficult for pre-service teachers to take contextual specifities of teaching and learning situations into account when activating prior knowledge. This is related to the fact that pre-service teachers, who noticed relevant information on goal clarity and learning climate in the video are mostly not able to match the judgement of experts in the field of teaching and learning in their reasoning about those events (goal clarity: 63% no agreement, 37% agreement; learning climate:74% no agreement; 26% agreement). Also for this coding category, the topic-specific character of elaboration processes is outstanding. Finally, through investigating pre-service teachers' capacities in the interplay of noticing and reasoning in order to make statements about their combined capacities, it was found out that most of the pre-service teachers are able to engage in elaboration processes during information selection (goal clarity: 74%; learning climate: 73%); however, the remaining quarter of pre-service teachers do not show any capacities to engage in elaboration activities

during information processing. When looking closer at the group of pre-service teachers who show elaboration activities during information selection and processing, it was remarkable that the engagement in elaboration during information processing while simultaneously considering the situation specificity indicated by matching the interpretations of experts causes difficulties to pre-service teachers. Only around 5% of them were assigned to the highest level of noticing and reasoning. As already found within all the other analyses, pre-service teachers show higher capacities with regard to elaborating on the highest level on goal clarity (6%) than on learning climate (4%).

Overall, these study results replicate previous research on teacher expertise analyzing pre-service teachers' noticing and reasoning as an proxy for cognitive learning activities during information selection and processing (Gold et al., 2013; Oser et al., 2009; Sabers et al., 1991; Sherin & van Es, 2009). Without instruction, pre-service teachers show difficulities to direct attention towards relevant teaching and learning aspects (Star & Strickland, 2008), and to activate knowledge about teaching and learning to come to the same explanations and predictions as experts (Stürmer, Könings et al., 2013). Furthermore, they often follow their intuitive and naive assumptions about teaching (Hammerness et al., 2002) and are in danger of making fast judgments and overgeneralizations (Schwindt, 2008). Wiens and colleagues (2013) found out that pre-service teachers identify some effective teaching strategies (e.g. classroom organization) more often in video clips than others (e.g. instructional support). In this study, similar findings were found for the instructional strategies of goal clarity and learning climate. This contributes to the theoretical assumption that elaboration processes are not only domain-specific but also topic-specific. Above that, the findings on the interplay of noticing and reasoning are in line with a qualitative small-scale study from Barnhart and van Es (2012), showing that pre-service teachers' sophisticated analyses and reasoning about student ideas require high sophistication in noticing student ideas. However, high sophistication in attending to student ideas did not guarantee more sophisticated interpretations. In this context, the capacity to notice and to select relevant information through the activation of professional knowledge seems to be a relevant premise for the interpretation of classroom situations. The fact that relevant teaching and learning events were often misinterpreted even when pre-service teachers activated professional knowledge, the study provides a central hint for the design of teacher education courses. Accurate elaboration activities are required to process information in the complexity of classroom life while simultanously understanding relevant teaching and learning details.

The findings of Study 1 reveal that pre-service teachers 1) already show capacities to engage in elaboration activities during information selection processes regarding specific teaching and learning components, and 2) have greater challenges during information processing to activate the cognitive learning process of elaboration. Furthermore, it seems that pre-service teachers' elaboration processes in the context of teaching and learning components are topic-specific.

8.1.2 Nature of pre-service teachers' organization processes

Insights into the nature of pre-service teachers' organization processes with regard to specific teaching and learning components in the context of professional vision were given in Study 2. This was examined against the theoretical assumption that pre-service teachers, who organize information into coherent and integrated structures of the domain-specific knowledge, are more effective in terms of applying this knowledge in real classroom situations as it is easier for them to access the knowledge and to cope with the dynamic demands of teaching. The data collection took place within the context of an obligatory course on teaching and learning, which provided knowledge on the design of effective learning environments in school and included instructional elements related to the concept of "representations, decompositions and approximations of practice". The sample group of 27 pre-service teachers participated voluntarily and showed comparable characteristics to the full course cohort (69 pre-service teachers). At the beginning of the individual and exploratory assessment sessions, which combined video with concept mapping, each pre-service teacher first received a theoretical introduction and was trained on the concept mapping technique. Afterwards, a pre-selected video clip from the *Observe* project representing the two teaching and learning components of goal clarity and learning climate based on expert agreement was shown to the pre-service teachers with the opportunity to take notes. In a next step, pre-service teachers were encouraged to construct a concept map on the computer using the two nodes of "goal clarity" and "learning climate". The concept maps created at the beginning of the course were analyzed qualitatively to get a first insight into pre-service teachers' organization strategies. The coding frameworks were developed based on theoretical models on knowledge organization, research on organization strategies, and domain-specific knowledge about teaching and learning components and were adapted to the study context (see section 7.2.5). The coded data was analyzed descriptively on the structure-related and content-related level. Furthermore, different non-parametric tests were applied.

The findings regarding the nature of the structure-related organization processes revealed that pre-service teachers show three different foci when structuring the incoming information from the video, which appear to differ also in their depth (surface vs. intentional): person-centric, procedure-centric, and event-centric. Almost half of the pre-service teachers (N = 12) showed intentional information organization, as they tried to organize the information related to specific events of teaching and learning. The other half of pre-service teachers showed a more surface-oriented organization approach, indicated by person-centric (N = 11) and procedure-centric (N = 4) concept maps. Furthermore, it was found that pre-service teachers tried to organize the single information pieces into more integrated units. Hereby, different content structures were found, which appeared mostly as lattices and depended on the type of concept map.

The analysis of pre-service teachers' content-related organization processes revealed that the information pieces were mostly not organized and integrated into higher order principles regarding goal clarity and learning climate (85% no integration of higher order principles). Furthermore, the content-related analysis of the labeled links indicating the semantical complexity and correctness of the drawn relationships resulted in a variety of semantical links with different qualities. Overall, mostly action-related links (36% of all links) were found. Besides, pre-service teachers were already able to create links similar to those of experts, indicated by the second largest group of hierarchical relations (26% of all links). Furthermore, pre-service teachers created links indicating a functional (12% of all links) and structural relation (11% of all links). In conclusion, two types of semantical relations between concepts as characterized by Klix (1984a) could be identified: interrelated and intrarelated links (see section 2.2.2). In sum, more interrelated links were found as the complexity to develop intrarelated concepts is higher than for interrelated concepts. However, also 8% erroneous relations and 7% not specified relations were identified within pre-service teachers' concept maps. These content-related findings underline that pre-service teachers' macro-operators of abstraction and construction are not very elaborated, and show an unsophisticated knowledge structure at the beginning of a course.

As, to my knowledge, no previous study has analyzed pre-service teachers' organization activities in the context of structuring videotaped classroom situations, the results can only compared to (experimental) studies in other fields, such as organization capacities during text summarization (Ballstaedt, 2006; Hidi & Anderson, 1986; Schnotz, 1982). However, this seems to be justified since in written documents learners also have to reduce and structure the amount of information in order to understand and memorize relevant information. The current

findings higlight that pre-service teachers show different patterns on how they select, structure, and organize content when analyzing classroom situations and possess different information structuring capacities already at the beginning of the course. These cognitive operations and techniques employed to achieve information reduction are similar to those reported in research on text comprehension and summarization, and where developmental differences are underlined as well (Hidi & Anderson, 1986). One important cognitive operations within text organization refers to the selection process in which information is evaluated for inclusion in the summary, and where low abilities are characterized by little or no sense for information with high textual relevance. A second reported process is the condensation of information by chunking small text information pieces into more general concepts. A good summary requires in this context a transformation of the original text propositions through the identification of major topic sentences. The organization activities applied to make sense out of a video representing specific teaching and learning situations are thus, closely related to cognitive processes identified in producing text summaries. Besides, the findings on pre-service teachers organization capacities are also closely related to study findings on novice teachers' capacities in categorizing classroom situations based on their professional knowledge (Schwindt, 2008; Stürmer, Könings et al., 2013). It was shown that higher order knowledge structures indicated through the application of higher order principles are necessary to make sense out of authentic classroom situations regarding effective teaching and learning processes. The findings on pre-service teachers' organization processes contribute to this assumption.

Within Study 2 the nature of pre-service teachers' organization processes could be conceptualized with a distinction in structure-related and content-related organization patterns. The findings reveal within both organization processes that 1) pre-service teachers at the beginning of a course mostly struggle to select and organize information towards the intentional content of the presented video material, and 2) multiple ways and variations exist on how pre-service teachers structure information in the domain of teaching and learning.

8.1.3 Technical quality of the measurement approach regarding pre-service teachers' elaboration processes

A second aim of this thesis is to provide new analysis approaches for research on cognitive learning processes in the context of professional vision. Therefore, it was also necessary to target validity aspects of the qualitative analysis approach applied in Study 1 to describe pre-service teachers' elaboration processes. In this context, the 109 pre-service teachers have not only commented on the pre-selected video-clip through written responses, but also completed 36 video related standardized rating items integrated into the *Observer Tool*, which assessed their elaboration processes regarding reasoning within a standardized format. Through this procedure, the results of the qualitative analysis on elaboration processes during noticing and reasoning could be compared to the second, quantitative measure of elaboration processes during reasoning. Pre-service teachers' reasoning scores assessed by the standardized format (total, description, explanation, prediction) were calculated based on the percentage agreement with an expert rating and were then correlated with the qualitative analyses. First of all, it was found that the quantitative findings, with pre-service teachers matching around 30% of experts' answers on the standardized rating items, are comparable to results from previous project studies using different samples and study designs. In the study from Seidel & Stürmer (2014), a mean value of 37% correct answers was found, whereas Stürmer, Seidel and colleagues (2013) reported 33% agreement with experts at the beginning of the theory-practice term, and 36% at the end of the term. Thus, the participating pre-service teachers can be considered as a representative sample group. In a next step, the two measurement approaches were correlated to validate the qualitative analysis. Thereby, a significant positive relationship between both measures was found for goal clarity, although it was small ($r = .21$). This means that pre-service teachers showing higher capacities in their engagement in elaboration processes during noticing and reasoning assessed within the qualitative approach also scored higher in the quantitative measure of elaboration during reasoning. Discussing this video-based mixed-method approach in the context of current research activities on elaboration activities is challenging, since previous studies have not applied such a contextualized combined methodology approach. Most of the time self-assessments through questionnaires are used (Artelt, 2000a; Wild, 2000). Nevertheless, they can be compared to other approaches in the context of professional vision, which take the claims to consider the situated nature of teacher knowledge within the assessment of cognitive processes into account. First of all, it was already outlined that Study 1 could replicate findings from either qualitative or quantitative studies within each assessment format. Moreover, both

methodologies were combined and the validation check was sufficient. The applied methodology approach is even more promising when comparing it to the study from König, Blömeke, Klein, Suhl, Busse, and Kaiser (2014), who assessed noticing via standardized rating items and reasoning through an open answer format and found no significant correlation between pre-service teachers' capacities assessed within both measures. Thus, the developed coding schemes provide besides some restrictions (e.g. domain-specifity, relatedness to one video clip), encouraging hints for the development of contextualized assessment approaches regarding the analysis of teachers' elaboration activities.

The findings of study 1 provide first promising evidence that the implemented coding frameworks can be used as a valid qualitative analysis approach to investigate pre-service teachers' elaboration processes during information selection and processing regarding specific teaching and learning components in the context of professional vision.

8.1.4 Technical quality of the measurement approach regarding pre-service teachers' organization processes

In order to assess pre-service teachers' organization processes in the context of professional vision, it was necessary to establish a new assessment and analysis approach, as up to now no appropriate measures were available. In Study 2, advantages have been made from the use of video to activate cognitive processes in an authentic and situated way, and from the method of concept mapping to elicit knowledge structure and organization. Therefore, both tools have been applied exploratorily to the small-scale study on pre-service teachers' organization processes. Through the use of a pre-selected video clip from the *Observe* project, where experts provided detailed information on the content of the shown classroom situation, a valid and reliable baseline for assessing organization processes and analyzing them in pre-service teachers' concept maps could be introduced. Regarding the concept mapping technique, a more unknown territory was entered as decisions about the assessment task, response format and the coding system had to be made based on findings from other research fields or experiemental studies. As a consequence, it is utmost important to answer questions regarding the reliability and validity of the applied concept mapping technique. The issue of reliable coding scores assigned to pre-service teachers' concept maps was addressed by different aspects in the study. First of all, the coding frameworks were worked out – as suggested by Ruiz-Primo and Shavelson (1996) – based on theoretical assumptions and empirical research; in this context on knowledge representation models and organization learning activities in the

light of expertise research. Findings about knowledge about effective teaching and learning components were also considered in the development process. Secondly, the data was not coded by only one rater, but by a research team including two people who trained together on the specific coding frameworks before scoring the concept maps. Furthermore, all concept maps and categories were coded by each rater independently. On this basis, inter-rater agreements in percentages and/or Cohen's Kappa between both raters were calculated for all categories at both measurement times (see section 7.2.5). Satisfying reliability was ensured for the codings 'type of superstructure', 'macrostructure units', 'integration of higher order principles', however the inter-rater agreements for the categories of 'type of macrostructure unit' (time 1: 70%; .53; time 2: 61%; .47) and 'semantical relations' (time 1: 68%; time 2: 74%) were not sufficient. This has to be taken in mind in future research activities by rethinking these exploratory codings and for training on them. However, these findings are in line with Ruiz-Primo and Shavelson's (1996) summarization of studies providing information on reliability, where reliability coefficients that base on counts (e.g. nodes) appeared to be higher than for scoring criteria related to quality aspects (e.g. kind of semantical relations).

One validity aspect (known group differences) of the applied assessment approach in Study 2 was targeted by examining different entry levels regarding knowledge about the teaching and learning components of goal clarity and learning climate. A second validity issue (instructional sensivity) was tapped by applying a pre- and posttreatment design. The nature of pre-service teachers' organization processes on the content level regarding the integration of higher order principles at the beginning of the course was used to identify pre-service teachers with different entry levels regarding their knowledge organization. Analysis of the data as described in Study 2 showed that concept maps with low and high qualities regarding the integration of higher order principles could be found. Most of the pre-service teachers (78%; 21 pre-service teachers) were categorized to the low entry level group as their concept maps do not reveal an information organization around higher-order principles at the pre-test. The remaining six pre-service teachers (22%) were assigned to the high entry level group as their concept maps revealed an information organization in accordance to higher-order principles. This proportion is similar to the study from Stürmer, Seidel and colleagues (2013), who investigated different entry levels regarding pre-service teachers' professional vision abilities and assigned 25% of 109 pre-service teachers to the low entry level group. Therefore, the applied concept mapping technique seems to be valid for differentiating groups of pre-service teachers ranging in their entry level regarding teaching and learning components. Furthermore, changes within both groups of pre-service teachers regarding their organization

processes after taking part in the course on teaching and learning could be identified and show similar pathways than pre-service teachers in Stürmer, Seidel and colleagues' study (2013). This fact contributes to the instructional sensitivity of the concept mapping technique. As noted earlier in the theoretical sections, concept maps have been used more as learning tools than for assessment purposes. As a consequence, past research has barely addressed issues regarding the technical qualities of concept maps (Ruiz-Primo-Shvalson, 1996; Stracke, 2004). Even more difficult to find are studies reporting on these information while focusing on pre-service teachers' knowledge organization and combining concept mapping with a video task. Therefore, the findings of the current study add promising value to the use of video in combination with concept mapping as a valid and reliable alternative assessment approach to investigate pre-service teachers organization processes in the knowledge field of teaching and learning.

The methodology approach of video in combination with concept mapping shows potential to provide valid information about pre-service teachers' organization processes regarding the knowledge domain of teaching and learning components and their development over time. This methodology approach captures, how pre-service teachers reduce complex information within an authentic classroom situation and construct relationships between concepts as well as how they labeled the semantical relationships indicating the capacity of their organization processes. This approach helps to assess organization learning processes in action; nevertheless, future research is needed to work on the reliability of the exploratory study approach and to validate the results.

8.1.5 Group-specific differences and changes in pre-service teachers' organization processes

The large variety in the organization activities within pre-service teachers – as described in study 2 and summarized above (section 8.1.2) – showed that a more differential perspective is necessary to gain a deeper insight into pre-service teachers' organization activities. Furthermore, to see trends in differential changes in the rather low capacities at the beginning of the course, a second measurement point with the same procedure at the end of the course on teaching and learning was set up. Therefore, nonparametric tests were conducted to compare two groups of pre-service teachers differing in their entry level regarding the integration of higher order principles of goal clarity and learning climate regarding their organization patterns, and to investigate group-specific trajectories over time. In this line, the category of 'integration of higher order principles' at the beginning of the course was used to

identify pre-service teachers with different entry levels regarding their knowledge organization.

Overall, Study 2 could illustrate differences between both groups and trajectories over time. However, on a fine grained level, sometimes against the assumptions and mostly with non-significant findings. The results regarding differentiating organization processes on the structural level at time 1 illustrate that pre-service teachers with a low entry level organized the information from the video clip slightly more on the surface indicated by a higher proportion of person- and procedure-centric concept maps. Besides, they showed a greater amount of unrelated concepts than pre-service teachers with a high entry level regarding the integration of higher order principles. Considering differential changes over time, the results for both groups showed no great changes in the type of concept map (person-centric, procedure-centric, and event-centric) indicating that it might be not so easy for pre-service teachers to change the way of organizing the selected information towards the intentional content of the presented material in a short period of one study term. In contrast, different and non-linear changes were found in their structure-related organization regarding the macrostructures of their concept maps. At the beginning, pre-service teachers with a comparably low knowledge entry level showed a greater amount of macrostructure units including only single and unconnected elements than pre-service teachers from the high entry level group, which increased even more over time. Nevertheless, a decreased amount of macrostructures including diverse connected information pieces and an increase of sequenced and structured macrostructure units was also found. Pre-service teachers with a high entry level showed an increased number of sequenced and structured units and a decreased number of unmeaningful connected macrostructure units at the end of the course. In sum, these results display that in a video-based course on teaching and learning different changes in pre-service teachers' structure-related organization processes depending on prior knowledge may take place, in favor of pre-service teachers with a high entry level. Analysis of the differing content-related organization processes and their changes over time revealed a vice versa result indicating that pre-service teachers with a low entry level might have benefited from the course on teaching and learning. This assumption is related to the fact that less misconceptions and an increased amount of higher order principles were found in their concept maps assessed at measurement point 2. On the other hand, pre-service teachers with a high entry level regarding the integration of higher order principles were not able to remain or increase their capacities – nevertheless they still outperformed the low-entry level group – as

well as their maps revealed more erroneous links at the end of the course in comparison to the beginning.

Although previous research on (differential) changes in pre-service teachers' knowledge representation in the domain of general pedagogical knowledge during university-based courses on teaching and learning has not specificly focused on organization activities, the present findings can be integrated im some ways in the current research literature on the acquisition of general pedagogical knowledge and professional vision in teacher education (König & Seifert, 2012; Stürmer, Könings et al., 2013). The study from Stürmer, Seidel and colleagues (2013) showed that a video-based course on teaching and learning can support pre-service teachers in acquiring conceptual knowledge on teaching and learning indicated through more correct answers on rating items tapping pre-service teachers' ability to reason about relevant classroom situations; differential effects on pre-service teachers' learning trajectories depending on their entry level were also found. Furthermore, it could be shown that using prompted learning journals in teaching and learning courses supports the engagement into meaningful cognitive activities (Schäfer et al., 2012). The current results illustrate that this also seems to hold for pre-service teachers' organization activities assessed with concept mapping. In the study from Stürmer, Seidel and colleagues (2013), especially pre-service teachers with a low knowledge entry level benefited from the provided learning opportunity. Also in this study, pre-service teachers with a rather low knowledge entry level gained from the course in terms of more integrated higher order principles and less misconceptions in the end of the term. The change within the high entry level group was more characterized by a restructuring process on the structural level. Previous studies, using concept mapping to elicit knowledge structure in teacher education report similar restructuring processes (Röhler et al., 1988; Wintzky et al., 1994). However, group-specific learning trajectories depending on the knowledge entry level were firstly shown in this study, which provides evidence for the need of learner-centered teacher education courses to foster organization processes.

The findings from Study 2 indicate that 1) pre-service teachers show different organization capacities when they enter a course on teaching and learning, which impact also differential trajectories over time, and 2) pre-service teachers with a relative high knowledge entry level positively changed their structure-related organization processes during the video-based course on teaching and learning and pre-service teachers with a rather low knowledge entry level benefited from the course in terms of their content-related organization processes.

8.2 Methodology considerations

The present work investigated pre-service teachers' cognitive learning processes with regard to specific teaching and learning components in the context of professional vision. This was based on the assumptions that pre-service teachers' elaboration and organization activities become visible through their ability in noticing and reasoning about classroom situations targeting goal clarity and learning climate, as underlying cognitive processes influence the perception of classroom events (Bromme 1992). Furthermore, as video has become a prominent tool in research on teachers' professional vision (e.g. Santagata & Angelici, 2010; van Es & Sherin, 2002), the often claimed requirements when measuring cognitive processes of teachers (e.g. contextualization and authenticity of the task) could be taken into account. Besides, qualitative and quantitative research studies have provided a sound basis for studying pre-service teachers' professional vision. Against this backdrop, specific videotaped classroom situations were used in this work to activate pre-service teachers' cognitive learning processes and criteria-based cognitive psychology research and expertise research in the field of professional vision have been developed to analyze them. Furthermore, written comments and standardized rating items were used to study elaboration processes as well as a tool from cognitive psychology research was newly adapted to the study context of pre-service teachers' organization processes.

After summarizing the main findings achieved by these methodology proceedings in the previous section, I will address some of these issues in the current section particularly. Thereby, I firstly comment on the use of video to activate cognitive learning processes (section 8.2.1), followed by a critical discussion of the applied methodology proceedings to elicit elaboration processes (section 8.2.2) and organization processes (section 8.2.3).

8.2.1 Comments on the methodological proceeding to use video for analyzing pre-service teachers' cognitive learning processes

Cognitive learning activities with regard to deep-level processing have been described as being central to pre-service teachers' knowledge acquisition in the context of information processing (see section 2.3): Elaboration processes are assumed to foster the assimilation or accommodation of knowledge. Reductive/organization processes are considered to help condensing and organizing the new cognitive structures. Therefore, it seems important that pre-service teachers engage in elaboration and organization activities to acquire complex knowledge about teaching and learning components in university-based teacher education. To explore pre-service teachers' capacities regarding the engagement in these cognitive learning

processes, however, diverse difficulties appear given the phenomena under study. Deep cognitive learning processes are related to "insight the head" strategies (Kardash & Amlund, 1991) and are thus, not observable from the outside. Furthermore, they need to be activated in a concrete situation, what implies that their activation is context bound and situation-specific. These outlined characteristics had consequences on the method used for studying pre-service teachers' cognitive learning activities in a valid and reliable way.

Since a while, videotaped classroom situations have achieved a valuable position in research on teacher cognition as medium to elicit and activate cognitive learning processes (e.g. Kersting 2008; 2010). Video has the advantages of providing an authentic situation, where (pre-service) teachers have to activate specific knowledge in order to analyze the classroom situation in a meaningful way. The investigation of pre-service teachers' analysis of a videotaped classroom situation targeting teaching and learning components provides the opportunity to investigate if they are able to activate and transfer knowledge about teaching learning components to authentic classroom situations (Stürmer, Könings, et al., 2013). Furthermore, the quality of teachers' analysis skills can be explored (Kobarg, 2009; Schwindt, 2008). These advantages of video can also help to overcome the critiques raised about the assessment methods applied in research on learning strategies, where self-assessment through questionnaires is the dominant methodology approach applied and thus, their assessment take place out of a concrete learning situation (Artelt, 2000a ; Lind & Sandmann, 2003). Furthermore, data collected with questionnaires mostly do not take the quality of activated learning processes into account (Leopold & Leutner, 2002). In this venue, the use of video was considered as an appropriate medium to bring pre-service teachers in a concrete learning situation, where they have to engage in elaboration and organization activities, and where for the situation-specific nature of teacher knowledge could be accounted for.

In this context, specific decisions on the kind of video material used were made as the type of video has effects on the cognitive processes getting activated (e.g. Kleinknecht & Schneider, 2013). The video selection within this study was made based on current research findings and take aspects into account, which are relevant for stimulating pre-service teachers, however, do not cognitively overload them (see section 4.2.1). For example, the chosen video material consisted of classroom situations from unknown teachers as they are considered to provide a safer environment for pre-service teachers to explore teaching and learning processes than watching their own first teaching experiences (Sherin, 2004) and thus, might be also more useful for activating their cognitive processes. Nevertheless, it has to be questioned at this point, if the analysis of their own teaching might be also suitable for this research purpose, as

the video may not feel so distant to them (Seidel et al., 2011) and in turn, they might be also more motivated and interested, which are necessary conditions for the application of deep level strategies (Schiefele et al., 1995). Another characteristic of the chosen video material was that edited and shorter classroom sequences with provided background information were selected. This decision based on empirical research that shorter video clips may prevent cognitive overload and passive behavior, what might be the case when pre-service teachers observe an entire lesson with many occurring interactions at the same time (Brophy, 2004b; Seago, 2004). Thereby, sequences were chosen on the basis of teaching effectiveness research and thus, teaching instructions that are particular relevant for student learning stood out; in this case the components of goal clarity and learning climate. Through this selection procedure, it was possible to activate content and situation specific cognitive processes. However, this narrow focus also causes that the complexity of classroom situations had to be given up, and other relevant teaching and learning components that occur in complex classroom environment were not captured. Furthermore, the interpretations drawn from the use of these pre-selected video clips are restricted to the study context. Future studies in the context of the *Observe* project could thus, add new information on the current findings by including video clips focusing on other relevant teaching and learning components (e.g. teacher support).

Finally, in order to have objective information, if the chosen video sequences indeed represent the two teaching and learning components under study – necessary for the later analysis of pre-service teachers' capacities, experts in the field of teaching and learning were involved in the video selection process. Although, it can be critically mentioned that other expert groups (e.g. experienced teachers) might have commented differently on the chosen sequences regarding the specific teaching and learning components, this video selection approach seems to be appropriate since the experts came from the field of educational research and teacher education and were experienced in the analysis of lessons regarding the teaching and learning components under study.

8.2.2 Comments on the methodological proceeding to elicit pre-service teachers' elaboration processes

First of all, the assessment conditions of Study 1 have to be discussed, as they are highly important for investigating cognitive learning processes like elaboration. In this study, pre-service teachers had to takes notes immediately after they observed a video clip targeting goal clarity and learning climate. Therefore, a close and temporal connection to the learning

situation was given. Furthermore, experts provided detailed information on the content of the video clip and thus, a good definition and description of the assessment material was available. Furthermore, the video clip was stimulating, however not too complex. Other qualitative studies on cognitive learning processes report similar study proceedings (e.g. Lethinen, 1992; Wirth, 2005). Although, cognitive learning processes are domain-specific and thus, the assessment approach has to be adapted to the knowledge domain under study, it can be assumed that the assessment conditions build a sound basis for investigating pre-service teachers' elaboration processes in the context of teaching and learning components.

In Study 1, pre-service teachers were asked in an open question to write down what they had observed. The question did not specifically prompt to comment on the teaching and learning components, as it was one aim to describe pre-service teachers' capacities to engage in elaboration processes without any further support or instruction. In this light, it can be discussed, whether a prompted question targeting goal clarity and learning climate would have been helpful as a strategy activator for their elaboration activities (Berthold et al. 2007; Glogger et al., 2009; Nückles et al., 2009). Especially, as expertise research points out that novices like pre-service teachers often already hold certain deep processing strategies, however, lack the spontaneous application of them (Hübner et al., 2007). Therefore, it cannot be ensured that pre-service teachers indeed engaged in elaboration activities as good as possible while analyzing the classroom situation. Pre-service teachers might be also limited in their activation of elaboration processes, as only one video clip was used and where only specific events regarding goal clarity and learning climate were outstanding. One possibility, to assess their capacities more precisely, would be to integrate more video clips. This could also help to overcome the barrier that pre-service teachers' activation of prior knowledge is not only dependent from the situations related to goal clarity and learning climate shown within one videotaped classroom sequence. However, it has to be kept in mind that pre-service teachers might then be cognitivly overloaded by the assessment, as they do not have many experiences in observing classroom situations.

Pre-service teachers' written observations were analyzed based on a developed coding scheme to assess their noticing and reasoning regarding the two teaching and learning components, indicating their capacities to activate knowledge and in turn, their elaboration processes. Over all categories, satisfying inter-rater agreements were achieved and the validation check with the standardized format was promising. Nevertheless, it has to be questioned, whether the chosen assessment approach of written comments really measures pre-service teachers' elaboration processes. Especially, as factors, which might have influenced the length and

quality of their writing have not been taken into account in the analysis. Other methods, like the use of think-a-loud protocols while pre-service teachers analyze the videotaped classroom sequence could be helpful to overcome barriers like pre-service teachers' motivation to comment extensively on the clip or their articulateness during writing. Through this procedure also a detailed insight into facultative elaborations and not only into necessary elaborations (Mandl et al., 1986) might be possible. However, also this verbal method does not guarantee that pre-service teachers make their cognitive processing overt. Given the phenomena under study, the assessment is always related to some problematic issues. In this context, written or verbal documentations are indeed one of the few options to make pre-service teachers' cognitive learning processes of elaboration somehow explicit (Ericsson & Simon, 1980). Finally, it can not be excluded that the applied qualitative and quantitative measurement approaches regarding pre-service teachers' elaboration processes really measure the same cognitive processes. Although a rather low significant correlation was found, the study demonstrate that future studies should precisely take different approaches regarding the assessment of cognitive processes into account (König et al., 2014).

8.2.3 Comments on the methodological proceeding to elicit pre-service teachers' organization processes

In order to describe pre-service teachers' organization processes in the context of analyzing classroom situations representing goal clarity and learning climate, the questions that aroused at the beginning were: What are relevant criteria for knowledge organization and how could they be made explicit? So far, no studies in research on professional vision have provided detailed information on that, especially not for the field of teacher education. The proceedings of previous studies were related to the measure of teachers' performance in an ill-structured situation and then, inferential leaps on their underlying knowledge organization were made (Leinhardt & Greeno, 1986; Livingston & Borko, 1989); often within an expert-novice study design (Carter et al., 1988).

Within Study 2, an alternative methodology approach from cognitive research used to make cognitive structures directly visible, was adapted. Besides, it was attempted to derive relevant criteria to study pre-service teachers' organization processes in the knowledge domain of teaching and learning. Basis for the analysis criteria, which should describe capacities in organization processes, build assumptions from knowledge representation models based on the expert-novice paradigm and from learning strategy approaches (see sections 2.2., 2.3). Reasons for that are related to teacher education research in the context of developing expert-

like professional vision (e.g. Gold et al., 2013; Stürmer, Könings et al., 2013; Wiens et al., 2013). Pre-service teachers' organization processes in the context of teaching and learning must be therefore, characterized as a selection of information, which represent relevant events regarding this knowledge domain and are then, interrelated in a meaningful way and integrated into higher order principles. As the organization of complex knowledge structures is also not characterized as a basket of single facts, rather as an integrated and meaningful network of concepts within current knowledge representation models, characteristics of a complex knowledge organization derived form that models were adapted to the analysis of pre-service teachers' organization processes. Furthermore, as learning strategy approaches propose that organization activities are related to the processes of omission and selection of information, and to structure-related and content-related abstraction like the ones also necessary for analyzing videotaped classroom situations, these assumptions were integrated in the analysis criteria of this study. Knowledge derived from models and research on teaching and learning regarding goal clarity and learning climate was used to define and differentiate content-related processes more precisely. Against these statements, it seems to be justified to transfer these indicators to the current study. However, as this was a first exploratory study, some adjustments should be considered due to low interrater reliabilities and for providing a deeper insight into content-related processes regarding each teaching and learning component under study. Furthermore, it should be tested how the content structure of knowledge in the domain of these components is indeed represented, for example through studying the concept map of an expert in this knowledge field. In this light, however, the question of who is an expert has to be discussed beforehand (Acton et al., 1994). Finally, the developed criteria are related to a very specific knowledge domain and on one video clip focusing on it. Therefore, the transfer to other knowledge-based analysis forms of videotaped classroom situations requires a careful reconsideration, if the developed coding categories are also appropriate to elicit the content structure of another knowledge domain (Ruiz-Primo & Shavelson, 1996).

In order to study the developed criteria indicating pre-service teachers' organization processes, concept mapping was tested as a new assessment tool. Concept maps are regarded as learners' external representations of how central concepts in one subject area are mentally organized and linked to each other. Hence, this method was assumed to fit the research purpose of the current study. Nevertheless, the assessment of cognitive processes always includes some limitations, so did concept mapping. It has to be questioned, whether the applied approach was able to elicit pre-service teachers' organization processes with regard to goal clarity and learning climate in a comprehensive manner, especially as different factors

might have influences pre-service teachers' capacities to organize relevant information in their concept maps. It can be hypothesized that pre-service teachers, who are used to the tool of concept mapping and acquainted with the software, do not need so much cognitive capacities to focus on the concept mapping technique than unexperienced pre-service teachers need (Sweller et al., 1998). Thus, experienced concept mapper can concentrate on the quality of their concept maps and in turn, are engaged in better organization processes. In order to ensure that pre-service teachers' capacities were not restricted by the computer based concept mapping technique in this study, a very user friendly software was used ('EasyMappingTool') and an introduction and training phase was included into the assessment procedure. Furthermore, the data gathered with the questionnaire on the acceptance on the concept mapping technique shows that pre-service teachers had no greater problems to handle the concept mapping technique, although some differences between pre-service teachers occurred and all pre-service teachers were not very experienced in the use of concept mapping (see sections 7.2.2; 7.3.3).

With respect to the concept mapping task, it could be discussed whether it was appropriate for pre-service teachers with a limited knowledge base. In the current study, pre-service teachers were very open in their concept map construction as only two concepts (goal clarity, learning climate) were provided. In turn, the final concept maps differed enormous from each other. The decision towards this technique was made based on experimental research showing that "construct-a-map-by-yourself" technique is better able to reflect differences among learners' knowledge structure than a "fill-in-a-map" technique. A study design with a more restricted concept mapping task combined with interviews after concept map construction could help to reduce coding afford and reliability problems, caused by the variety of diverse concept maps, while simultaneously maintain the different and individual character of pre-service teachers' organization processes. Nevertheless, this method is time extensive as well.

8.3 Implications

Deep cognitive learning activities have been outlined as important parts of knowledge acquisition phases in teacher education in order to develop integrated and complex teacher knowledge in the domain of general pedagogical knowledge. This implies that the quality of pre-service teachers' cognitive learning process during university-based teacher education largely depends on their capacities to engage in elaboration and reduction or organization processes. Although this description is true for all fields of higher academic learning, results from other professional domains cannot automatically be transferred to the domain of learning

to teach from a general pedagogical point of view. Therefore, the current thesis gave a clearer picture about deep cognitive learning activities pre-service teachers actually undertake with regard to teaching and learning components, as one relevant part of general pedagogical knowledge. Thereby, the available methodology approaches for assessing them in a contextualized way were expanded. The findings point out that pre-service teachers already show some kind of elaboration activities, however mostly during information selection, and that these activities are biased by personal, naive experiences and assumptions. Moreover, it was found that pre-service teachers organize selected information in relation to the structure and content of the presented video more on a surface than on an intentional level, and had difficulties to integrate relevant information into higher order principles. Furthermore, the results revealed that providing pre-service teachers with the opportunity to engage in meaningful cognitive learning activities of organization through a teaching and learning course, fostering active knowledge construction is not a sufficient condition for all pre-service teachers to develop their capacities. In this line, the work has several implications for research on professional vision and cognitive processing activities in teacher education as well as on the educational practice in teacher education, which I will address now.

A first theoretical implication targets the need for contextualized assessment conditions in the study on cognitive learning activities in the domain of general pedagogical knowledge. In particular, the present work provides an alternative assessment approach to study organization processes in relation to a concrete and authentic task by its use of video in combination with concept mapping. In this regard, the thesis also provides empirical evidence that comprehensive information about the content of the video material used is necessary when analyzing pre-service teachers' cognitive learning activities through a video-based assessment-approach.

A further implication concerns the importance of integrating the analysis aspect of content of reasoning into existing analysis frameworks in the study of (pre-service) teachers' professional vision. Study 1 showed that it is not sufficient to activate professional knowledge in order to show expert-like reasoning abilities rather the knowledge also has to be adequate applied to the specific situation. Moreover, relevant criteria for the analysis of knowledge organization have been identified, which can be used as baseline for future research on knowledge organization in the context of developing professional vision.

Despite that, the study results have implications for the design of teacher education courses and video-based learning tools; specifically for fostering the two components of professional

vision (noticing and reasoning) in their interplay, and the engagement of pre-service teachers into deep cognitive processing activities.

First of all, it was found that noticing and reasoning about effective teaching and learning components – used as proximal indicator for occurring cognitive learning activities – is a challenging task for pre-service teachers. This is particularly the case for interpreting classroom situations like experts, while simultaneously connecting it to existing knowledge and integrating noticed information into higher order concepts. This highlights one time more the need for teacher education courses to combine theory with practical elements. Pre-service teachers need theoretical input in order to refer to significant classroom events while simultaneously need opportunities to apply their knowledge they have learned, because otherwise they might be confirmed and caught by their beliefs. For instance, the use of video sequences might not only be helpful as assessment tool, but also to achieve those learning goals (Stürmer, Könings, et al., 2013). In this regard, adequate instructional methods and learner-centered activities are suggested, as video only realizes its full potential in well-conceptualized learning environments (Krammer et al., 2006). For example, video-based learning environments using instructional activities that are similar to expert-novice research methods and tasks, like using experts' observations of the same video clips as guide and feedback to pre-service teachers' observations, might be based on the current findings fruitful to facilitate pre-service teachers in developing expert-like noticing and reasoning skills (Fadde, 2009). Such an expert feedback approach can be beneficial for pre-service teachers to activate the specific knowledge piece they need to notice and reason about a specific situation representing important teaching and learning aspects and to overcome difficulties caused by the phenomena of inert knowledge (Renkl et al., 1996). Expertise-based training might be even more supportive, when comments from different experts are used (Fadde & Sullivan, 2013). In this context, it seems also important to make careful decisions about the kind and content of video material to use for fostering pre-service teachers' noticing and reasoning skills (Ballstaedt, 2006; Mousavi et al., 1995). Based upon the current thesis, the use of video sequences that are selected in congruence to current findings from teaching effectiveness research and are validated by experts in this field can be suggested as the theoretical knowledge gained in the course can be directly aligned to the presented video clips. Furthermore, it is ensured that effective teaching and learning components are indeed represented in the videotaped sequences. Finally, these clips also can function for the assessment of pre-service teachers' learning outcomes in accordance to the way how they were fostered through the video-based learning environment (Blomberg, Renkl et al., 2013).

Secondly, the results from the current work underline the importance of implemanting "process-oriented instruction" (Vermetten et al., 1999) or "activating instruction" (Lonka & Ahola, 1995) not only in the school context, but also in teacher education. For teacher educators, this implies teaching domain-specific knowledge in congruence with instructional effort which explicitly focuses on pre-service teachers' learning processes and their deep level strategies. With regard to organization processes, it can be said – although Study 2 was not designed in a way that it could be exactly answered what specific effects the video-based course had or did not have – that providing just the opportunity to engage in meaningful learning activities, for instance through activities of video reflection or journal writing, is not sufficient. Although pre-service teachers who are not in their first study year – like the sample groups in this thesis – are used to academic learning conditions, they are beginners in the process of learning to teach in which they have to combine several learning experiences. Thus, like their future students, they need direct and activating support and guidance in their learning (Vermetten et al., 1999). In this context, research on the focused teaching and learning component of goal clarity provides knowledge about effective teaching strategies for student learning, which can also be transferred to university settings and pre-service teachers' learning. In this line, instructional strategies such as a clear and transparent communication of the learning goals, structuring the course lecture towards those learning goals, and the use of advanced organizers can be recommended for university teachers to support pre-service teachers in their elaboration activities as the activation of prior knowledge is possible. Furthermore, it helps pre-service teachers to integrate and organize new information into existing knowledge structures and to select relevant information, which is in line with the learning goals. Within the design of instruction, different capacities should be taken into account considering that pre-service teachers in this study differed in their cognitive activities. Particularly, pre-service teacher-specific teaching strategies will be needed to support them in their engagement into meaningful cognitive learning activities, which will be dependent on what kind of change pre-service teachers have to make and on their specific knowledge background. Across all these suggestions, the role of teacher educators at universities in identifying pre-service teachers' individual needs and choosing the specific instructional strategy to support pre-service teachers within their deep level processing is highlighted. In this line, issues concerning university teachers' professionalization should be addressed as well (Johannes & Seidel, 2012).

Another recommendation following from the current work targest the issue of making pre-service teachers aware of how they learn as a starting point to change their cognitive activities

(Wild, 2005). Concept maps as used in Study 2 can be recommended as an effective assessment tool to elicit for example their understanding and misconceptions. Furthermore, prompted learning journals as used in the context of Study 2 could also be added with theoretical background about cognitive learning activities to provide them with an overview of activities related deep level processing, as pre-service teachers also need to know what options they have to acquire knowledge in an effective way. These elements could be also integrated in general "learning skill interventions", which might be especifically useful for pre-service teachers with low capacities in deep level processing and knowledge application (Wild, 2005). However, these trainings have to be carefully developed and checked whether they suit the affordances of the particular domain in which teacher knowledge should be acquired.

8.4 Future research

Besides giving answers, the current work also raises many new questions. The research was carried out in two exploratory study designs and was descriptive in nature. Therefore, the most important future research activity targets the replication and validation of these findings, for instance by using different video clips and other sample groups as well as combining the applied assessment approaches with other instruments measuring cognitive learning activities.

This thesis focused on the description of pre-service teachers' cognitive learning processes with regard to teaching and learning components. To provide more information about supportive learning conditions for pre-service teachers' deep level processing, intervention studies using experimental designs are particularly needed. For example, contrasting instructional approaches including specific effective instructional aids (e.g. implementing goal clarity) or learning tools (e.g. concept maps) for the engagement in meaningful cognitive activities compared to a control group with no specific implementation of instructional aids could advance the understanding about the specific effects instructional approaches have on meaningful knowledge acquisition in teacher education. Furthermore, it should be tested whether differential effects can be found for pre-service teachers with different cognitive prerequisites. This kind of knowledge might help to address pre-service teachers' individual needs and to provide an empirical basis for the design of professional development courses for teacher educators.

The current studies were carried out at one and two measurement points respectively. To get more insights in how pre-service teachers develop as meaningful learners, it is necessary to follow them over a longer period of time (Vermetten et al., 1999). Since university-based

teacher education in Germany takes four to five years, it would be interesting to set up a longitudinal study in this context. In this way, more information about different learning trajectories can be given and how they are influenced by contextual factors. Moreover, as the current study focused on cognitive activities in the context of general pedagogical knowledge as one essential part of teacher knowledge, assessing pre-service teachers' learning activities with regard to subject matter and content pedagogical knowledge would be another future research path to follow. Thereby, knowing whether their capacities are domain-specific or more stable across diverse knowledge fields could give more insights into the relevance of deep cognitive learning processes for acquiring complex teacher knowledge. Based on the current findings that pre-service teachers showed topic-specific elaboration processes, also domain-specific capacities can be expected. However, then also the kind of video material used has to be reconsidered as well as the analysis instruments need to be adjusted for measuring cognitive learning activities in these contexts.

Last but not least, the theoretical outlines at the beginning of this thesis have shown that pre-service teachers' learning defined as knowledge acquisition in the context of information-processing also includes metacognitive and motivational aspects (Klauer & Leutner, 2007; Oosterheert & Vermunt, 2001). Therefore, the issue of how pre-service teachers' metacognition (e.g. regulation strategies, learning orientations) and their motivation and interest towards the learning content influence their cognitive processing should be another future research aim in order to achieve an integrated view about pre-service teachers' way of becoming professionals.

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