



Student teachers' knowledge integration across conceptual borders: the role of study approaches, learning strategies, beliefs, and motivation

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Abstract

There is widespread agreement that student teachers need to construct an integrated knowledge base across multiple domains. This study examined the contributions of intraindividual factors of self-regulated learning to explaining student teachers' (a) integration of knowledge across topics and domains (i.e., integrative learning) and (b) disjointed processing of potentially domain-specific learning content (i.e., separative learning). The factors considered were study approaches; cognitive, metacognitive, and resource-related learning strategy use; epistemological and pedagogical beliefs; and career choice motivation. The study applied a cross-sectional survey design and examined separative and integrative learning in $N=103$ student teachers by way of multiple regression analyses with backward eliminations. A key finding is that deep and strategic study approaches and certain cognitive learning strategies contributed significantly to explaining integrative learning in student teachers. Epistemological and pedagogical beliefs were not able to predict integrative learning. Regarding separative learning, the study identified the surface study approach, specific epistemological and pedagogical beliefs, and the “usefulness” motive for career choice as positive predictors and critical thinking as a negative predictor. The study demonstrates differences in how integrative and separative learning are shaped by distinct intraindividual factors. Implications are discussed with regard to student teachers' self-regulated learning and pre-service teacher education.

Keywords Knowledge integration · Self-regulated learning (SRL) · Learning strategies · Study approaches · Epistemological beliefs · Pre-service teacher education

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Introduction

Research following the classical expert-novice paradigm (e.g., Chi et al., 1981) and models of teacher competence (e.g., Baumert & Kunter, 2006) suggests that teachers' proficient action is determined not only by the availability but by the degree to which their professional knowledge is integrated (e.g., Reynolds, 1992; Weinert et al., 1990). Expert teachers possess a knowledge base which is well connected across the conceptual borders of different knowledge domains: (a) content knowledge (CK), (b) general pedagogical knowledge (PK), and (c) pedagogical content knowledge (PCK) (Baumert & Kunter, 2006; Shulman, 1986). They possess numerous cross-references that bridge the gaps between CK, PK, and PCK (e.g., Berliner, 2001; Livingston & Borke, 1990). In contrast, pre-service and inexperienced in-service teachers lack such connections (Darling-Hammond, 2006). This limits their ability to apply multiple knowledge domains simultaneously, for example, in planning lessons (Janssen & Lazonder, 2016), modifying existing learning material from textbooks (Hashweh, 1987), or designing learning tasks (Wäschle et al., 2015). Acknowledging that pre-service teacher education is in many countries often not systematically linked across the different knowledge domains (Darling-Hammond, 2006; Hudson & Zgaga, 2017), student teachers need to apply *integrative learning* (IL) processes. These processes—together also referred to as *knowledge integration*—interrelate the conceptually distinct knowledge domains CK, PK, and PCK and corresponding topics to build a well-connected, more coherent knowledge base in a self-regulated manner. Yet, student teachers often fail to engage in knowledge integration and lapse into *separative learning* (SL). SL is defined by a rather narrowly focused mental processing, acquisition, and organization of what needs to be learned without making connections to other disciplines, knowledge domains, and topics (Lehmann, 2020).

While the argument for the importance of student teachers' knowledge integration seems compelling in regard to professional development, the literature lacks empirical findings on intraindividual factors that explain why student teachers are successful with IL. Also, it remains open why they tend to a separative processing of information from different knowledge domains without increasing coherence among their domain-specific knowledge structures. Most of the studies primarily focused on curricular models (e.g., "Adaptive Cycles of Teaching" [ACT]; Salmon et al., 2020) and instructional strategies (e.g., Lehmann et al., 2019) to foster knowledge integration. Other studies (e.g., Hashweh, 2005; Winsor et al., 2020) examined "real life" classroom experiences as a means of overcoming separative modes of processing and promoting the integration of different types of teacher knowledge. Recognizing this gap in the literature, the present study examines the role of intraindividual factors that characterize self-regulated learning (SRL) for knowledge integration across domains. The factors considered are study approaches, learning strategies, epistemological and pedagogical beliefs, and motivation. As these factors are all multidimensionally conceptualized in the literature, the study clarifies which subordinate facets are predictive for IL and SL, respectively.

In the following, I first introduce the concepts of knowledge integration and SRL, including their various factors and subordinate facets. Next, I propose the research question and hypothesized links between SRL and integrative/separative learning in student teachers. Then, I present the methodology applied in this study and the results, followed by a discussion of findings and limitations.

Theoretical background

Knowledge integration in pre-service teacher education

Knowledge integration has evolved within constructivist approaches to learning. It is perceived as a dynamic process of interrelating originally unconnected pieces and structures of knowledge to promote a coherent understanding within a person's memory (Clark & Linn, 2013; Schneider, 2012). Lee and Turner (2017) argue that knowledge integration involves “the construction of new knowledge, connection of new information to existing knowledge, and the integration of knowledge across topics and domains” (Shell et al., 2005, p. 329). The last factor is particularly important in initial teacher education, where courses on CK, PK, and PCK are rarely linked (Darling-Hammond, 2006). Yet students tend to SL. That is, they often focus on information or bits and structures of knowledge as presented in the learning sources without making novel connections (Bråten & Strømsø, 2009; Lehmann et al., 2019). This leads to fragmentary, incoherent, and isolated elements of cognition, that is, *knowledge in pieces* (diSessa, 1993; Wagner, 2006), which is more likely to be inert, and hence inapplicable (Renkl et al., 1996). Due to the common practice in pre-service teacher education of holding courses on CK, PK, and PCK without systematic reference to each other, student teachers need to integrate their domain-specific knowledge mainly in a self-regulated manner.

Self-regulated learning (SRL)

The concept of SRL describes an individual's complex arrangement and control of multiple information and affective processing dimensions that facilitate his/her deep understanding of the learning content(s) and the accomplishment of goals and tasks (Pintrich, 2000). According to Entwistle (2012), students' SRL is influenced by their general approach to studying. Moreover, SRL involves the application of cognitive, metacognitive, and resource strategies (Weinstein & Mayer, 1986). Besides, the SRL of student teachers is characterized by their epistemological and pedagogical beliefs (Cheng et al., 2009) and their motivation (Künsting & Lipowsky, 2011; Lehmann et al., 2014). Figure 1 displays this multifaceted conceptualization of SRL. The respective intraindividual factors are described more thoroughly and linked to the concepts of IL and SL below.

Study approaches

To examine student learning on a more holistic level (compared to specific learning strategies), research has previously focused on different *study approaches* (Teixeira et al., 2013). The distinction between deep and surface “levels of processing” (Marton & Säljö, 1976) led to the development of *deep* and *surface approaches* to studying, later supplemented by the *strategic approach* (Entwistle & Waterston, 1988). In addition to the focus on the cognitive processing of content, study approaches refer to the intentions and motives students possess (Entwistle, 2012). A *deep approach* involves a strong content-related interest as a major motive. It gears learning activities towards understanding in terms of seeking meaning, interpenetrating the subject matter, using evidence, and relating different ideas to each other. This understanding tends to show that the deep approach and IL are two conceptually overlapping constructs. From a

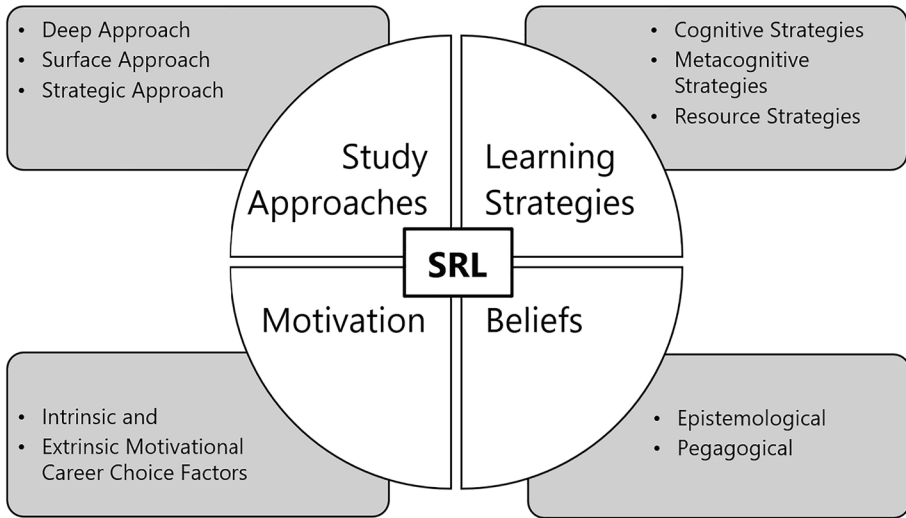


Fig. 1 Intraindividual factors characterizing student teachers' SRL

theoretical perspective, this notion finds support in the attempt by Nelson Laird and colleagues (Nelson Laird et al., 2008) to measure students' deep study activities in a variety of domains using three subscales: higher-order learning, reflective learning, and integrative learning. The last-named subscale contains items that focus on the extent to which students engage in integrating ideas from different sources, incorporating different perspectives into their academic work, and discussing ideas of class. However, although a relation between deep studying and IL was identified (supporting the notion of a conceptual overlap of the constructs), the size of the correlations indicates that considerable proportions of the deep study approach remain unexplained by IL. Hence, the constructs can be considered distinct from an empirical standpoint despite their relatedness (see also Lehmann et al., 2020; Nelson Laird et al., 2006). In conclusion, it appears reasonable that a deep approach to studying is conducive to IL. In contrast, a *surface approach* is a short-term approach aimed at passing exams or fulfilling course requirements. It is primarily driven by a fear of failure. This results in a narrowly defined, less transferable learning process. Often the content(s) of the learning material are perceived as incoherent due to a lack of understanding, which leads to a concentration on content reproduction. Learners with a surface approach appear to be more likely to perform knowledge-telling as opposed to knowledge-transforming activities (Lehmann et al., 2019), thus engaging in SL. Finally, the *strategic approach* is concerned with students' focus on achievement and performance (in terms of achieving high grades). This involves a strong orientation towards standards and requirements of the learning environment and assessment demands. Diseth and Martinsen (2003) assume that the strategic approach is not correlated with specific learning strategies because students' achievement motivation will co-determine the use of whatever strategy they perceive to serve the overriding achievement motive best. Chiou and colleagues (Chiou et al., 2012) elaborate this percept by assuming that the surface and deep approaches involve both a strategy and a motive component: "While the strategy component represents the actual process engaged in a learning task, the motive

component denotes the orientation, or motivation, to perform a specific learning task. Moreover, this dual component may result in multiple motive-strategy combinations of approaches to learning.” (p. 171). Hence, a strategic approach might be related to learning processes that relate to both deep and surface approaches (see also Godor, 2016). It is therefore difficult to formulate a hypothesis on the relationship between the strategic approach and integrative or separative learning.

Cognitive strategies

Cognitive strategies involve the application of basic strategies (for simple memory tasks) and complex strategies (for tasks that demand a deeper understanding). They are “directly related to understanding subject matter, a thinking activity, and initiated by the learner” (Glogger-Frey et al., 2018, p. 43). This suggests that there is a conceptual overlap between cognitive strategies and study approaches. However, there are differences that emerge both from theoretical backgrounds and from methodologies: Models of study approaches are usually bottom-up models that are mainly derived from phenomenographical (qualitative) research approaches. In contrast, cognitive strategies have usually been studied using an information processing approach (“described as being derived in a top-down manner from theoretical constructs and theories in cognitive and educational psychology”; Heikkilä & Lonka, 2006, p. 103) and quantitative research designs/methods. Typically, three types of cognitive strategies are distinguished: rehearsal, organization, and elaboration strategies (Weinstein & Mayer, 1986). Rehearsal strategies are concerned with different techniques that foster the memorization of facts and rules by continuous repetition. This includes reviewing or re-reading summaries, records, and/or notes, or simply memorizing key words. Conceptually, they show no overlap with IL but aid in the separative processing (and retention) of information. Organization strategies refer to learners’ strategic attempts to organize content in a way that is conducive to learning. This involves structuring, summarizing, concept mapping, and highlighting text passages. Thus, organization strategies can be associated with both IL and SL. Elaboration strategies deal with learning activities that aim at deep comprehension by connecting the content with prior knowledge and personal experiences, establishing relationships, and generating examples. Critical thinking is another form of higher-order cognitive engagement. According to Halpern (1998), critical thinking might refer to a skill, an attitude, or a disposition. Ennis (1993) also discusses various conceptions of critical thinking. He concludes that it “is reasonable reflective thinking focused on deciding what to believe or do” (p. 180). However, this definition still asks for further explanation as it remains open what a person typically does when thinking critically (ibid.). Ennis’s further elaborations are largely in line with the operationalization of critical thinking as a specific learning strategy proposed by Pintrich et al. (1993) and Wild and Schiefele (1994). Accordingly, critical thinking involves scrutinizing statements, conclusions, and contexts of justification, for example, by judging the credibility of sources, generating and identifying different argument components, comparing different concepts, and evaluating the conclusiveness of arguments. Together, these mental operations and procedures enhance the comprehension of the content. Although these higher-order processing activities can refer to both knowledge integration and elaboration within a single knowledge domain (Lehmann et al., 2019), both elaboration and critical thinking appear to be crucial for IL.

Metacognitive strategies

Metacognition plays a superior role in planning, monitoring, and controlling one's learning activities and may be differentiated into (a) knowledge and (b) strategies (Veenman et al., 2006). Metacognitive knowledge includes declarative knowledge about the self as a learner and about various strategies, procedural knowledge about how to apply the strategies, and conditional knowledge about when and why to use them (Brown, 1978; Flavell, 1979). Metacognitive strategies involve goal-setting, planning of learning steps, self-monitoring, and adaptation according to the perceived difficulty and success in comprehending the content and reaching the objectives (Weinstein & Mayer, 1986). In principle, it is conceivable that metacognitive strategies benefit both IL and SL. However, since successful self-regulated learners and experts are both characterized by a high degree of metacognitive thinking (Veenman et al., 2006), a relation to the rather complex *integrative* form of learning can be assumed.

Resource-related strategies

Finally, SRL involves the use of resource-related strategies (Glogger-Frey et al., 2018). They aim at managing internal and external learning resources, for example, time, attention/effort, the study environment, fellow students, and literature (Pintrich et al., 1993). Although these actions are generally not directly related to a learner's *cognitive* processing of content, they can stimulate and enhance elaborative procedures, which subsequently improve understanding and academic achievement (Blickle, 1996). In the present paper, I focus on two resource-related strategies: (a) learning with fellow students and (b) using additional literature. I consider these types of resource strategies to be particularly important for knowledge integration because cooperative learning (i.e., group work and help-seeking with/from fellow students) and consultation of additional textual sources (e.g., textbooks, journals, own records) were found to support learners in taking multiple (potentially domain-specific) perspectives, making (intertextual) links between the perspectives of learning resources, and eliciting argumentative elaborations (Bråten & Strømsø, 2009; Lenski, 1998; Weinberger et al., 2010).

Epistemological beliefs

Beliefs about the nature of knowledge and knowing (i.e., epistemological beliefs) play an important role in SRL as well (Hofer & Pintrich, 1997; Limón, 2006; Muis, 2007). Schommer (1993) originally considered five more or less independent dimensions that shape a person's epistemological belief system. However, her questionnaire for assessing students' epistemological beliefs yielded only four factors: innate ability (i.e., "the ability to learn is rather innate than acquired"), simple knowledge (i.e., "knowledge is simple rather than complex"), quick learning (i.e., "learning is quick or not at all"), and certainty of knowledge (i.e., "knowledge is certain rather than tentative"). Similarly, Hofer and Pintrich (1997) introduced four epistemic belief dimensions: certainty of knowledge ("ranging from knowledge is unchanging to knowledge is evolving"), source of knowledge ("ranging from knowledge is handed down by authority to knowledge is acquired through reasoning and logic"), simplicity of knowledge ("ranging from knowledge is organised as isolated bits and pieces to knowledge is organised as highly interrelated concepts"), and justification

of knowledge (“which refers to how individuals consider how a proposition or belief becomes justified knowledge”; Muis, 2007, p. 176). Both frameworks led researchers to distinguish between naïve and sophisticated epistemological stances, the former being hindering and the latter beneficial for learning (Bråten & Strømsø, 2006; Hofer & Pintrich, 1997; Kizilgunes et al., 2009; Schommer, 1993). More recently, Haehnlein and Mägdefrau (2017) adopted these conceptualizations for education students’ and pre-service teachers’ academic learning with texts. Their research suggests a four-dimensional understanding incorporating beliefs about (1) the absoluteness of knowledge, (2) the simplicity of knowledge, (3) the multimodality of knowledge acquisition, and (4) the development of knowledge. The “naïve” absoluteness and simplicity beliefs presumably relate to SL because they imply that study text information need not be questioned, and they are founded on reliable, discrete facts to be known. On the contrary, “sophisticated” multimodality beliefs appear to relate to IL because they imply that knowledge acquisition in educational science requires a multifaceted, elaborate examination of information, thus involving consideration of different sources, research opinions, and points of view.

Pedagogical beliefs

Pedagogical beliefs (i.e., beliefs about the nature of learning and teaching) are commonly accepted as an important construct for teacher educators to consider (Seifried, 2012). Two major conceptions of pedagogical beliefs are typically contrasted: a traditional (teacher-centered) *transmissive* view, which derived from behaviorism, and a *constructivist* (student-centered) view (Dubberke et al., 2008). Teachers that hold strong transmissive beliefs are more likely to take on an authoritative role and organize teacher-centered activities, which aim at transmitting knowledge. Moreover, such teachers regard lesson control and extensive instruction as crucial for successful learning. In contrast, teachers with strong constructivist beliefs think that effective learning involves discovering ways to solve problems, discussing one’s own ideas, and developing extra activities on one’s own. Constructivist teachers also prefer student-centered teaching methods and tend to view themselves more as facilitators who encourage students to actively learn and construct meaning (Liu et al., 2017; Seifried, 2012). Although it might seem reasonable to consider transmissive and constructivist beliefs to be at opposite ends of a single continuum, there is evidence that teachers hold these pedagogical beliefs simultaneously and switch between teacher- and student-centered practices (Crespo, 2016). In regard to the present study, it is important that pedagogical beliefs are not only relevant for in-service teachers’ decisions, which are made for teaching and classroom management, but also for student teachers’ learning and professional development (Sheridan, 2016; Tang et al., 2012). Against this background, it is reasonable to assume that student teachers’ pedagogical belief system affects their ability to recognize potential relations to be made between CK-, PK-, and PCK-specific pieces of knowledge.

Motivation for choosing teacher education

Motivational orientations are another dimension of teachers’ professional competencies which play a role in successful teaching (Baumert & Kunter, 2006) and in student teacher learning (Künsting & Lipowsky, 2011). Examining the motivation to choose teaching as a career, Watt and Richardson (2007) introduced the FIT (Factors Influencing Teaching) choice model. This model is based on the expectancy-value theory of motivation (Eccles

et al., 1983), which is well suited for explaining students' achievement-related choices (cf. Watt & Richardson, 2007). Künsting and Lipowsky (2011) found that student teachers' intrinsic motivation for choosing teaching as a career is positively related to their learning strategy use and study satisfaction, whereas their extrinsic career choice motivation is not related to these learning-relevant variables. Ability beliefs as an intrinsic facet might play a major role in that relation (Pohlmann & Möller, 2010). That is, high teaching-related self-efficacy (e.g., having confidence in general explaining, teaching specific subject-matter content, being patient, having deep subject-matter knowledge) refers to the different professional knowledge domains CK, PK, and PCK and hence likely relates to IL. In contrast, low difficulty (as an extrinsic facet) might be related to SL because it involves the expectation to accomplish the study program without much effort, thus leading to less challenging, rather simple cognitive processing modes.

The present study: research question and hypotheses

In sum, the literature on the significance of study approaches and learning strategies indicates positive relations to students' effective SRL and their academic achievement (e.g., Entwistle, 2012; Muwonge et al., 2018). Moreover, student teachers' epistemological and pedagogical beliefs (Cheng et al., 2009; Schommer, 1993) and their career choice motivation (Künsting & Lipowsky, 2011) influence specific facets of SRL, including the approach to learning (Chan, 2003; Kizilgunes et al., 2009) and strategy use (Bråten & Strømsø, 2006; Cano, 2005), as well as learning outcomes and professional development (König & Rothland, 2012; Sheridan, 2016; Tang et al., 2012). However, what needs to be explored, especially regarding the fragmented teaching of CK, PK, and PCK in initial teacher education, is which of these factors influence student teachers' IL and SL. Accordingly, the present study investigates the role these factors and their subordinate facets play for student teachers' (a) knowledge integration across the conceptually distinct core domains of their professional knowledge (*integrative learning*) and (b) knowledge fragmentation in terms of processing domain-specific learning content without making novel connections to increase coherence (*separative learning*). The particular hypotheses to be tested are displayed in Table 1. For an estimation of the relative predictive value, it appears important to additionally test the hypothesized relations by way of a regression analysis. This makes it possible to account for potentially confounding effects in the bivariate analyses and to compare the degree to which the predictors explain IL and SL.

Method

Sample and design

$N = 103$ pre-service primary school teachers from a German university participated in this study, which had a cross-sectional survey design. Most participants were female (79%), which is typical of primary school teachers in Germany (Federal Statistical Office, 2018). The participants had a mean age of $M = 25.35$ years ($SD = 4.43$). They had been enrolled in initial teacher education for $M = 6.62$ semesters ($SD = 1.57$) with a variety of CK and corresponding PCK domains as a subject-related professional orientation. Examples included

Table 1 Hypotheses of the study

SRL factor	Hypothesis
Study approaches	H1a The deep approach to studying is related positively to integrative learning and negatively to separative learning
Learning strategies	H1b The surface approach is related positively to separative learning and negatively to integrative learning
	H2a Learning strategies geared towards deep comprehension (i.e., elaboration, critical thinking) are related positively to integrative learning
Epistemological beliefs	H2b Learning strategies that are rather superficial and aid in performance goal orientation (i.e., rehearsal strategies) are related positively to separative learning
	H3 Metacognitive strategies are related positively to integrative learning
Pedagogical beliefs	H4 The resource-related strategies "learning with fellow students" and "learning with literature" are related positively to integrative learning
	H5 "Naive" epistemological beliefs (i.e., absoluteness and simplicity of knowledge beliefs) are related negatively to integrative learning (H5a) and positively to separative learning (H5b)
Motivation for choosing teacher education	H6 "Sophisticated" beliefs (i.e., beliefs about the multimodality of knowledge acquisition) are related positively to integrative learning (H6a) and negatively to separative learning (H6b)
	H7 Pedagogical beliefs are associated with knowledge integration and fragmentation in that constructivist beliefs are related positively to integrative learning (H7a) and instructional beliefs to separative learning (H7b)
	H8 Study choice motivation is associated with knowledge integration and fragmentation in that self-efficacy is related positively to integrative learning (H8a) and low difficulty motives to separative learning (H8b)

German language, mathematics, social studies, art, and English language. All participants were recruited in obligatory seminars on learning analysis and evaluation.

Instruments

Twenty-four subscales from six instruments, all embedded in an online survey system, were used to assess the variables. The participants rated all items on a Likert-type response scale. Further details on each scale are reported below.

Separative and integrative learning in pre-service teacher education

Student teachers' SL and IL were measured by way of the Separative and Integrative Learning in Teacher Education (SILTE) questionnaire (Lehmann et al., 2020). This self-report instrument includes two short scales with twelve items in total. The *separation* scale comprised five items (e.g., "I rarely put learning content from the different fields of my teacher education studies into an overall context."), and the *integration* scale seven items (e.g., "When I get to know an educational concept or model, I try to imagine how this can help me later on teaching my subjects."). Items used a 5-point Likert scale ranging from 1 (not true at all) to 5 (completely true). As regards validity, Lehmann and colleagues (Lehmann et al., 2020) report a two-factorial structure with good model fit indices in which all seven items of the integration scale loaded on a first factor (Cronbach's alpha: $\alpha=0.77$) and the five items of the separation scale on a second factor ($\alpha=0.75$) with satisfying to good factor loadings and reliability coefficients.

Study approaches

Participants' approaches to studying were measured using a German version (Stadler & Broemel, 2014) of the Approaches and Study Skills Inventory for Students (ASSIST) (Entwistle, 1997), which includes three subscales: (1) the *deep approach* subscale (6 items, e.g., "Ideas in course books or articles often set me off on long chains of thought of my own"), (2) the *strategic approach* subscale (6 items, e.g., "I put a lot of effort into studying because I'm determined to do well"), and (3) the *surface approach* subscale (6 items, e.g., "I concentrate on learning just the bits of information I have to know to pass"). The participants were asked to respond to each item on the basis of how they currently approach their studies in their pre-service teacher education program. Items had a 5-point rating scale ranging from 1 (strongly disagree) to 5 (strongly agree). The construct validity of the ASSIST questionnaire is well studied and appears satisfying (e.g., Teixeira et al., 2013). The reliability of the German version is reported to be acceptable (Cronbach's alphas for deep approach: $\alpha=0.72$; surface approach: $\alpha=0.70$; strategic approach: $\alpha=0.74$; Stadler & Broemel, 2014).

Cognitive strategies

To measure the use of cognitive learning strategies, I used four subscales of the LIST ("questionnaire for measuring learning strategies of university students"; Wild & Schiefele, 1994), which is a slightly modified German adaption of the MSLQ ("motivated strategies for learning questionnaire"; Pintrich et al., 1993): the *organization* subscale (8 items, e.g., "I prepare an outline of the main points of the study material"), the *elaboration*

subscale (8 items, e.g., “In my mind, I try to combine newly learned content with what I already know”), the *critical evaluation* subscale (8 items, e.g., “I think about alternatives to the assertions or conclusions presented in teaching texts”), and the *rehearsal* subscale (7 items, e.g., “I memorize key words to better remember important content areas”). All items had a 5-point rating scale ranging from 1 (very seldom) to 5 (very often). Various studies (Blickle, 1996; Boerner et al., 2005; Wild & Schiefele, 1994) suggest satisfying to good reliabilities of the scales (Cronbach's alphas for organization: $\alpha \geq 0.81$; elaboration: $\alpha \geq 0.72$; critical evaluation: $\alpha \geq 0.77$; rehearsal: $\alpha \geq 0.73$).

Metacognitive strategies

To assess student teachers' use of metacognitive learning strategies, I used the *metacognition* subscale from the LIST (Wild & Schiefele, 1994). It consisted of 11 items in total. The scale dealt with planning (e.g., “Before learning a certain topic, I think about how to be most effective”), monitoring (e.g., “I ask myself questions about the learning content to make sure that I have understood everything”), and regulation/control (e.g., “If I find a certain text passage to be confusing and unclear, I go through it again slowly”) of ongoing learning processes. Items had a 5-point rating scale ranging from 1 (very seldom) to 5 (very often). The scale combined the three metacognitive components due to unexpected discrepancies in a 3-factorial and a good-fitting 1-factorial solution. In terms of reliability, Cronbach's alphas reported for the metacognition scale vary from 0.64 (Wild & Schiefele, 1994) to 0.72 (Blickle, 1996). In this study, the metacognition scale demonstrated an alpha of 0.64. Hence, when interpreting the results, it is important to consider that the internal consistency of this scale is below the benchmark typically demanded for standardized tests.

Resource strategies

Two subscales from the LIST (Wild & Schiefele, 1994) were used as a means of assessing the use of resource-related strategies. The *learning with fellow students* subscale assessed the extent of different forms of group work and help-seeking to overcome understanding difficulties (7 items, e.g., “I take the time to discuss the learning content with fellow students”). The *learning with literature* subscale assessed the degree to which participants consult additional sources, such as textbooks, journals, and their own records, when they encounter comprehension problems (4 items, e.g., “I look for further literature if certain content is not yet clear to me”). The items had a 5-point rating scale ranging from 1 (very seldom) to 5 (very often) and acceptable to excellent reliabilities (Cronbach's alphas for learning with fellow students: $\alpha = 0.82$ to 0.90; learning with literature: $\alpha = 0.71$ to 0.87; Blickle, 1996; Boerner et al., 2005; Wild & Schiefele, 1994).

Epistemological beliefs

To assess student teachers' epistemological beliefs concerning their learning with texts in educational sciences, I used four subscales (all with satisfying to good Cronbach's alphas in the present study; see below) of the Students' Epistemological Beliefs (StEB) inventory (Haehnlein, 2018; Haehnlein & Mägdefrau, 2017). The *absoluteness* subscale measured epistemological beliefs about the absoluteness of knowledge (8 items, e.g., “I do not doubt what is written in teacher education study texts”; $\alpha = 0.83$). The *simplicity* subscale was concerned with assessing epistemological beliefs about the simplicity of knowledge (6

items, e.g., “In teacher education study texts, things are often unnecessarily complicated”; $\alpha=0.78$). The *multimodality* subscale referred to epistemological beliefs about the multimodality of knowledge acquisition (7 items, e.g., “It is important that study texts in education to not only include derivations and statements but also inform about how exactly something was investigated”; $\alpha=0.76$). The *development* subscale measured epistemological beliefs about the development of knowledge (5 items, e.g., “Many views in contemporary educational study texts no longer correspond to what was once considered correct”; $\alpha=0.74$). Participants rated their agreement with each item in regard to their education studies on a 5-point Likert-type scale ranging from 1 (not true at all) to 5 (completely true). An expert panel rating ($n=10$) ensured the content validity of the instrument.

Pedagogical beliefs

To assess pedagogical beliefs, I used two subscales of the German adaption (Seifried, 2012) of the Teacher Belief Scale (Fennema et al., 1990). In contrast to the questionnaire of Seifried (2012), who implemented an accounting-specific wording in several items, I modified the formulation of the items to make them into subject-matter unspecific statements. I used the *constructivist pedagogical beliefs* subscale to measure pedagogical beliefs that consider teaching to support learners’ knowledge construction (9 items, e.g., “In the classroom, students should discuss their own ideas of problem solving” and “In class, students learn best by discovering ways to solve problems themselves”) and the *instructional pedagogical beliefs* subscale to assess student teachers’ transmissive view of teaching and learning (9 items, e.g., “One should practice problem-solving routines with the students” and “In class, the teacher should demonstrate how to solve a particular task”). Items were rated on a 6-point Likert-type response scale ranging from 1 (not true at all) to 6 (completely true). The *constructivist pedagogical beliefs* subscale demonstrated Cronbach’s alpha of 0.76 and the *instructional pedagogical beliefs* subscale an alpha of 0.77, indicating satisfying reliabilities. Results of an exploratory factor analysis supported the construct validity of the original questionnaire (Seifried, 2012).

Motivation for choosing teacher education

To assess student teacher motivation for choosing teacher education, I used the FEMOLA questionnaire (Pohlmann & Möller, 2010). The questionnaire is based on the expectancy-value theory and consists of six subscales with satisfying to excellent reliability coefficients (see below). The item stem was “I chose teacher education because...”. The *low difficulty* subscale dealt with the expected difficulty and challenge of the course of study (4 items, e.g., “...it is easier than other studies”; $\alpha=0.86$ to 0.88), whereas the *self-efficacy* subscale dealt with ability beliefs in relation to expected professional requirements (5 items, e.g., “...I am good at explaining things”; $\alpha=0.74$ to 0.75), both being parts of the expectation component. As parts of the value-related component of the questionnaire, the *pedagogical interest* subscale referred to generic pedagogical and educational interests of student teachers (6 items, e.g., “...it is important to me to make a contribution to the education of children and adolescents”; $\alpha=0.83$ to 0.84), the *subject-related interest* subscale to specific interest towards the subject domains they will teach later on as teachers (5 items, e.g., “...I want to learn a lot in my subjects”; $\alpha=0.82$ to 0.84), and the *usefulness* subscale to values that lie outside of the teacher profession, such as financial security and work-life balance (8 items, e.g., “...I also want to have time for family, friends, and hobbies alongside my job”;

$\alpha=0.86$ to 0.90). The *social influence* subscale (5 items, e.g., "...I was advised to choose teacher education by friends and family"; $\alpha=0.77$ to 0.84) represented another motivation complex which is assigned to neither of the expectation-value components (Pohlmann & Möller, 2010). All items were scored on a 4-point Likert-type scale from 1 (not true at all) to 4 (completely true). The factorial structure of the questionnaire was investigated in several studies which support its construct validity (Künsting & Lipowsky, 2011; Pohlmann & Möller, 2010).

Data collection

The participants were recruited in compulsory teacher education courses by way of a message posted on the university's learning management system. The message provided information about the study and its overall aim (i.e., to gain insight into the interrelatedness of learning processes in initial teacher education). It then asked the students to participate in the study by filling out an online questionnaire. Participation was voluntary. They could access the questionnaire by clicking on a hyperlink. Then, they completed personal questions about their age, sex, study program, semester, and subject-related fields of study. Next, the instruments were presented consecutively with all corresponding subscales on a single screen. Items on each screen were in a random order. Once they started, participants were given as much time as they needed to complete the survey in a single session ($M=24$ min, $SD=5.46$). The data was collected during weeks 6, 7, and 8 of the lecture period. This enabled the participants to optimally assess their learning behavior.

Results

As an initial data analysis, I calculated descriptive statistical values (see Table 2) and zero-order correlations (see Table 3) for all measures.

As can be seen in Table 3, many of the variables were significantly correlated (i.e., 120 out of 276 correlations). IL was positively related to twelve of the 22 SRL variables: (a) deep study approach, $r=0.600$; (b) strategic study approach, $r=0.258$, (c) elaboration strategies, $r=0.563$, (d) critical evaluation strategies, $r=0.602$, (e) metacognitive strategies, $r=0.297$, (f) use of literature strategies, $r=0.519$, (g) epistemological beliefs about the multimodality of knowledge, $r=0.420$, (h) self-efficacy motive, $r=0.280$, and (i) subject-related interest, $r=0.259$. It was negatively related to (j) student teachers' surface study approach, $r=-0.324$, and their epistemological beliefs about (k) the absoluteness, $r=-0.194$, and (l) the simplicity of knowledge, $r=-0.245$.

SL was correlated with nine of the 22 SRL variables, that is, there were positive correlations with participants' (a) surface learning approach, $r=0.522$, their epistemological beliefs about (b) the absoluteness, $r=0.369$, and (c) the simplicity of knowledge, $r=0.485$, and (d) instructional pedagogical beliefs, $r=0.329$. Furthermore, SL was negatively related to (e) deep study approach, $r=-0.260$, (f) elaboration strategies, $r=-0.264$, (g) critical evaluation strategies, $r=-0.376$, (h) strategic literature use, $r=-0.245$, and (i) subject-related interest, $r=-0.228$.

The results indicate a considerable overlap of seven variables which contribute to both IL and SL with a consistently reversed direction. Taking the amount of intercorrelations among the SRL variables into account, I conducted multiple regression analyses with

Table 2 Means and standard deviations for all subscales

Measures	Subscales	<i>M</i>	<i>SD</i>
Integrative and separative learning in pre-service teacher education ¹	Integration	3.31	.51
	Separation	2.80	.58
Study approaches ¹	Deep approach	3.22	.69
	Strategic approach	3.45	.65
	Surface approach	3.23	.61
Learning strategies ¹	Organization	3.50	.55
	Elaboration	3.45	.56
	Critical evaluation	3.03	.68
	Rehearsal	3.21	.68
	Metacognition	3.44	.44
	Learning with fellow students	3.26	.67
	Learning with literature	3.20	.79
Epistemological beliefs ¹	Absoluteness of knowledge beliefs	2.81	.59
	Simplicity of knowledge beliefs	3.04	.66
	Multimodality of knowledge acquisition beliefs	3.70	.52
	Development of knowledge beliefs	3.64	.56
Pedagogical beliefs ²	Constructivist pedagogical beliefs	4.88	.47
	Instructional pedagogical beliefs	2.78	.60
Motivation for choosing teacher education ³	Usefulness	2.49	.69
	Pedagogical interest	3.70	.38
	Self-efficacy	3.12	.53
	Social influence	1.98	.65
	Low difficulty	1.45	.53
	Subject-related interest	3.03	.55

Note. ¹=rated on a 5-point Likert scale, ²=rated on a 6-point Likert scale, ³=rated on a 4-point Likert scale

backward eliminations to determine which of these variables could predict (1) IL and (2) SL after adjusting for potentially confounding effects in the bivariate analyses.

Table 4 shows the results of the regression analysis for students' IL. The first model entered all predictor variables. According to the *F*-test results, the regression of the first model was significant (see Table 4, model 1) and provided a sufficient goodness of fit, adjusted $R^2=0.418$. Although the overall regression of the initial model with all candidate predictor variables seemed to provide considerable explanatory power with satisfying accuracy, single candidates were not statistically significant. With the backward eliminations method, the regression analysis identified model 18 as the best-fitting significant model with the fewest possible remaining predictors (see Table 4, model 18). That is, five predictor candidates were eligible to explain participants' IL. Model 18 yielded an adjusted R^2 of 0.46, which indicated an increased explanatory power (compared to model 1).

Regarding the question of which of the candidate predictor variables was significant for explaining students' IL, the results showed that students' deep study approach ($\beta=0.27$) and their self-estimated use of three specific cognitive learning strategies, that is, elaboration ($\beta=0.23$), critical evaluation ($\beta=0.29$), and rehearsal ($\beta=0.15$), were significant positive predictors.

Table 3 Zero-order correlations (Pearson's *r*) for all measures

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1	-.45***																							
2		.60***																						
3			.26**																					
4				.15																				
5					-.12																			
6						.51***																		
7							.29***																	
8								.04																
9									.49***															
10										.23*														
11											.24*													
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Note. 1 = Integration, 2 = Separation, 3 = Deep approach, 4 = Strategic approach, 5 = Surface approach, 6 = Organization, 7 = Elaboration, 8 = Critical evaluation, 9 = Rehearsal, 10 = Metacognition, 11 = Learning with fellow students, 12 = Learning with literature, 13 = Absoluteness of knowledge beliefs, 14 = Simplicity of knowledge beliefs, 15 = Multimodality of knowledge acquisition beliefs, 16 = Development of knowledge beliefs, 17 = Constructivist pedagogical beliefs, 18 = Instructional pedagogical beliefs, 19 = Usefulness, 20 = Pedagogical interest, 21 = Self-efficacy, 22 = Social influence, 23 = Low difficulty, 24 = Subject-related interest

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 4 Results of the multiple regression analysis with backward eliminations for student teachers' integrative learning

Model and criterion variable	β	F	df	R^2	adj. R^2	ΔR^2
Model fit		4.326***	22,80	.543	.418	.543
Deep approach	.253					
Strategic approach	-.025					
Surface approach	-.111					
Organization	.044					
Elaboration	.188					
Critical evaluation	.238					
Rehearsal	.139					
Metacognition	.009					
Learning with fellow students	.019					
Learning with literature	.107					
Absoluteness of knowledge beliefs	-.079					
Simplicity of knowledge beliefs	-.086					
Multimodality of knowledge acquisition beliefs	-.055					
Development of knowledge beliefs	-.021					
Constructivist pedagogical beliefs	.024					
Instructional pedagogical beliefs	.081					
Usefulness motive	.106					
Pedagogical interest	-.051					
Self-efficacy	.081					
Social influence	.122					
Low difficulty	-.181					
Subject-related interest	-.117					

Table 4 (continued)

Model and criterion variable	β	F	df	R^2	adj. R^2	ΔR^2
Model 18. Integrative learning		18.388***	5.97	.487	.460	-.012
Model fit						
Deep approach	.266*					
Elaboration	.232*					
Critical evaluation	.286*					
Rehearsal	.152*					
Social influence	.132					

Note. * $p < .05$; ** $p < .01$; *** $p < .001$

Table 5 Results of the multiple regression analysis with backward eliminations for student teachers' separative learning

Model and criterion variable	β	F	df	R ²	adj. R ²	ΔR^2
Model fit		3.446***	22.80	.487	.345	.487
Deep approach	.100					
Strategic approach	.093					
Surface approach	.398***					
Organization	-.160					
Elaboration	-.020					
Critical evaluation	-.282					
Rehearsal	-.071					
Metacognition	.037					
Learning with fellow students	-.139					
Learning with literature	.053					
Absoluteness of knowledge beliefs	.098					
Simplicity of knowledge beliefs	.299**					
Multimodality of knowledge acquisition beliefs	.060					
Development of knowledge beliefs	.103					
Constructivist pedagogical beliefs	-.014					
Instructional pedagogical beliefs	.137					
Usefulness	-.247*					
Pedagogical interest	-.024					
Self-efficacy	.023					
Social influence	-.032					
Low difficulty	.060					
Subject-related interest	.066					

Table 5 (continued)

Model and criterion variable	β	F	df	R^2	adj. R^2	ΔR^2
Model 16. Separative learning		11.219***	7.95	.453	.412	-.006
Model fit						
Deep approach	.222					
Surface approach	.366***					
Organization	-.135					
Critical evaluation	-.317*					
Simplicity of knowledge beliefs	.280**					
Instructional pedagogical beliefs	.165*					
Usefulness	-.187*					

Note. * $p < .05$; ** $p < .01$; *** $p < .001$

I conducted another multiple regression analysis with backward eliminations to determine which candidate predictors could explain student teachers' SL. The results showed that the initial model including all candidate predictors was significant (see Table 5, model 1). It provided a sufficient goodness of fit, adjusted $R^2=0.345$. After deleting candidate predictors whose loss did not lead to a statistically significant deterioration of the model fit, model 16 was identified as the final model with seven remaining predictors, five of which were statistically significant (see Table 5, model 16). The corresponding regression yielded an adjusted R^2 of 0.412, hence suggesting an increase in prediction power compared to the original model with all candidate predictors.

The results showed that students' surface study approach ($\beta=0.37$), their epistemological beliefs about the simplicity of knowledge ($\beta=0.28$), and their instructional pedagogical beliefs ($\beta=0.17$) were significant positive predictors, whereas their critical evaluation ($\beta=-0.32$) and their perceived usefulness of being a teacher as a motivation for choosing teacher education ($\beta=-0.19$) were significant negative predictors for SL.

Discussion

The goal of the present study was to examine different aspects of students' SRL with regard to their role for knowledge integration across the core domains of teachers' professional knowledge (i.e., CK, PK, PCK). The literature review revealed that students' study approaches, their use of cognitive, metacognitive, and resource-related learning strategies, their epistemological and pedagogical belief dimensions, and their career choice motivation might be predictive for (a) IL processes (which interrelate CK, PK, and PCK to build a more coherent, integrated knowledge base) and (b) SL processes (which handle pieces of knowledge within their original domain without making connections to the others). Against this background, the study assessed twenty-two variables that characterize SRL and empirically tested them to clarify which of them are significantly related and actually contribute to explaining (a) IL and (b) SL in pre-service teacher education. Taken together, the different statistical analyses (bivariate and multivariate) revealed a pattern which does not allow a clear acceptance or rejection of the hypotheses. Instead, the results require a more nuanced interpretation.

Considering zero-order correlations, the study found empirical support for most of the proposed hypotheses. With regard to more holistic conceptualizations of academic learning, the study found evidence that IL is related positively to the deep study approach and negatively to the surface approach (thus supporting H1a). Conversely, SL was related positively to the surface approach and negatively to the deep approach (thus supporting H1b). Another result is that IL was also related to the strategic approach. This is unexpected because the strategic approach can be associated with both deep and superficial cognitive learning processes depending on the learners' motivation (Diseth & Martinsen, 2003). In this study, the strategic approach was related positively to both critical evaluation and rehearsal strategies to a comparable degree (thus supporting Diseth and Martinsen's percept). An explanation could lie in the amount of integrative course work and exams the participants experienced. Further research needs to more closely examine the links between these variables and potential moderators. The work of Chiou et al. (2012) and Godor (2016), which suggest considering the effect of various combinations of study approaches, motivation, and strategy, provides a theoretical starting point.

Regarding more specific learning strategies, IL was related positively to elaboration and critical evaluation (thus supporting H2a), metacognitive strategies (i.e., planning, monitoring, and regulation/control; thus supporting H3), and the consultation of diverse literature sources as a resource-related strategy (partially supporting H4). SL did not correlate with the rather superficial rehearsal strategies (thus contradicting H2b). This is surprising because previous studies showed that student teachers who process information and ideas from domain-specific learning material in a more separative way focus on restating knowledge entities without changing or expanding the meaning (Wäschle et al., 2015, Lehmann et al., 2019). Future studies should tap into this discrepancy between the findings.

Regarding pre-service teachers' beliefs, "naïve" epistemological beliefs (i.e., absoluteness and simplicity of knowledge beliefs) were related negatively to IL (thus supporting H5a) and positively to SL (thus supporting H5b). "Sophisticated" beliefs (i.e., beliefs about the multimodality of knowledge acquisition) were related positively to IL (thus supporting H6a) but not correlated with SL (thus contradicting H6b). Moreover, constructivist pedagogical beliefs were not correlated with IL (thus contradicting H7). However, there was evidence that instructional pedagogical beliefs were related positively to SL (thus supporting H7b).

Finally, the study found empirical evidence for positive correlations between study choice motivation in terms of perceived self-efficacy in teaching (thus supporting H8a) and subject-related interest on the one hand and IL on the other. Considering the theoretical foundation of the motivation questionnaire, this result suggests that both expectation and value motives are relevant for student teacher knowledge integration. No significant correlation was found between motivational factors and SL (thus contradicting H8b). Interestingly, many of the variables that are conceptualized to foster deep comprehension were either not (i.e., the use of metacognitive strategies, strategic study approach, multimodality of knowledge acquisition beliefs, and the self-efficacy motive) or negatively (i.e., using elaboration and critical evaluation strategies, learning with literature, the deep study approach, and subject-related interest) correlated with student teacher SL. Taken together, these results indicate that student teachers need to be able to make use of more complex learning strategies and study approaches and to possess more sophisticated personal beliefs on knowledge and knowledge acquisition.

In an attempt to account for potentially confounding effects in bivariate analyses, I conducted two regression analyses with backward eliminations. These analyses incorporated twenty-two candidate predictor variables. Compared to the correlational results, the regressions considerably reduced the number of explanatory variables from twelve to four for IL and from nine to five for SL. As will be discussed more specifically in the following, IL appears to be mainly driven by a deep study approach and corresponding cognitive strategies (i.e., elaboration, critical evaluation) (thus supporting H1a and H2a), whereas SL appears to be driven by the surface approach and different beliefs (thus supporting H1b, H7b, and partially H5b). Surprisingly, except for critical evaluation there was no overlap between the significant predictors of the two regressions.

Regarding IL, the results suggested that student teachers' use of elaboration and critical evaluation and their deep study approach were the most important contributors to explaining the application of IL processes. This is in line with prior findings in that successful SRL (with regard to learning outcomes and academic achievements) demands deep processing strategies and a corresponding study approach (Entwistle, 2012; Muwonge et al., 2018). Likewise, this supports the interpretation that deep learning strategies are (a) needed to process complex tasks such as integrating information and pieces of knowledge to construct a coherent understanding of the content of multiple sources (Bråten & Strømsø,

2009) and are (b) involved in extensive knowledge integration in teacher education (Lee & Turner, 2017). An unanticipated result was that the use of rehearsal strategies remained significant in the final regression model. This is surprising for two reasons: first, because rehearsal is not deep comprehension-oriented but targeted towards the memorizing of facts and rules by continuous repetition, and second, because there was no zero-order correlation between IL and the use of rehearsal strategies. A possible explanation for this result might lie in student goal orientations (Künsting & Lipowsky, 2011). Future research needs to address this issue.

Another interesting finding is that metacognitive strategies (i.e., planning, monitoring, and control/regulation) did not remain in the regression model despite a significant correlation and their general importance for SRL (Veenman et al., 2006). Similarly, epistemological beliefs concerning the nature of both knowledge/knowing and teaching/learning were not statistically relevant to the regression. Regarding the former, this is unexpected since significant correlations were identified for absoluteness beliefs, simplicity beliefs, and multimodality beliefs. To gain more insight into the role of different beliefs in pre-service teachers' SRL and knowledge integration, I suggest complementing self-report data with actual learning performance measures in future studies.

Contrary to the regression model identified for explaining integration across CK, PK, and PCK, the model for SL involved the surface approach, "naïve" epistemological beliefs, pedagogical beliefs, and students' career choice motivation as positive predictors. Hence, it seems reasonable to not only design challenging learning environments that ask for a deep study approach and corresponding processing strategies but also to develop learning environments and study conditions for student teachers that discourage a surface approach and more naïve epistemological beliefs. Moreover, the regression analysis suggested that critical evaluation plays an important role. This deep comprehension-oriented strategy proved to be a negative predictor which is in conformity with theory. This indicates that students who avoid engaging in more complex, sophisticated cognitive strategies such as critical evaluation are likely to process information within a single, conceptually distinct knowledge domain. This interpretation finds additional support in the result that a surface approach to studying is the comparatively strongest predictor for student teachers' SL.

The present study of course has certain limitations. First, the findings are based on a sample of $N=103$ student teachers. In terms of both more conservative and liberal rules of thumb for sample size selection (e.g., Green, 1991; Harris, 1985), the number of participants in the present study may be considered both satisfactory and unsatisfactory. On the one hand, the sample size could have decreased the statistical power of the regression analyses, resulting in insufficient sensitivity for potentially important predictors. On the other hand, the significant effects indicated by the results should prove significant a fortiori in larger samples. The fact that the sample consisted of pre-service elementary teachers restricts generalizability and calls for further studies that take pre-service secondary teachers into account. Also, it should be mentioned that the majority of the sample was female. Although this might limit the generalizability of the findings, the proportion of females in the sample was representative of primary school teachers in Germany (Federal Statistical Office, 2018). Moreover, conducting another cross-sectional survey with a larger sample would allow testing of a path model that affords more insight into the interrelatedness of the variables affecting knowledge integration. Second, the findings are based on data obtained via self-estimation scales. This is an issue, because students' self-reported use of learning strategies might be limited by biases, such as socially desirable answers. This also applies to their self-reported study approach, epistemological and pedagogical beliefs, and their motivation to choose teacher education. Another limitation pertains to

students' epistemological beliefs. This study adopted the common differentiation between naïve and sophisticated epistemological stances. Considering the effect of naïve beliefs on SL, future research should consider the role of different epistemological conceptualizations (see Limón (2006) for a comparison of the three major conceptualizations of epistemological beliefs).

Overall, I consider this study an exploratory step to gaining a deeper understanding of students' self-regulated knowledge integration across domains in pre-service teacher education. I also suggest conducting further experimental studies examining whether there are discrepancies between students' self-reported IL and their actual learning behavior when dealing with multiple CK-, PK-, and PCK-specific sources. In addition, I see merit in investigating the relation between IL and SL (as measured by the SILTE) and learning performance. Last, it would be interesting to find out whether, and if so to what degree, the participants had already been exposed to integrative course work and examples of CK, PK, and PCK integration. I expect this to be another predictor for their self-regulated knowledge integration across domains. Hence, it would be interesting to examine how the findings relate to curricular variables and curricular changes.

Conclusion

The most prominent result of this study lies in the discrepancies between the predictors of integrative and separative learning among students in teacher education. The study indicates that student teachers' IL is shaped by a deep approach to studying, that is, by motivational orientations that allow them to recognize the need for knowledge integration across domains and foster strategic engagement in IL, mainly by way of elaboration and critical thinking processes. Hence, teacher training and assessment methods should foster a deep approach to learning. In addition, student teachers might benefit from learning environments that integrate strategy training and prompts to enable higher-order information processing activities. In contrast, student teachers' SL is explained not only by a surface approach to studying, that is, by their tendency to focus on simply memorizing parts of the learning content, accepting ideas and information without questioning them and without distinguishing underlying principles. Rather, SL is also related to epistemological and pedagogical beliefs. This finding points out that beliefs are not only to be viewed as an important outcome variable of teacher training. In addition, beliefs need to be regarded as a crucial influencing factor in how student teachers construct their professional knowledge in pre-service teacher education.

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Declarations

Conflict of interest The author declares no competing interests.

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Current themes of research:

Knowledge integration, mental models, self-regulated learning, technology-enhanced teaching, and instructional design.

Most relevant publications in the field of Psychology of Education:

Lehmann, T., Pirnay-Dummer, P., & Schmidt-Borcherding, F. (2020). Fostering integrated mental models of different professional knowledge domains: Instructional approaches and model-based analyses. *Educational Technology Research and Development*, 68(3), 905–927. <https://doi.org/10.1007/s11423-019-09704-0>.

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