Pre-service teachers' beliefs about learning and teaching and about the self-regulation of learning: A conceptual change perspective

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A B S T R A C T

Pre-service teachers' belief systems regarding the self-regulation of learning were investigated from a conceptual change perspective. Four hundred and twenty nine pre-service teachers answered a 6-point Likert scale Beliefs about Learning and Teaching (BALT) questionnaire. The results confirmed that beliefs theoretically consistent with SRL were be positive predictors of beliefs in the importance of teaching students SRL strategies. Beliefs inconsistent with SRL were found to be negative predictors of beliefs in the importance of teaching students SRL strategies. The SEM modeling also revealed that the participants' belief systems contained internally inconsistent beliefs about teaching. The implications for the design of SRL interventions and future research are discussed.

1. Introduction

The research reported in this paper investigated pre-service teachers' beliefs about the self-regulation of learning from a conceptual change point of view. Conceptual change research examines the learning that takes place when individuals are exposed to new information that requires substantial revision of prior knowledge (Chi, 2008; Vosniadou, 2013). Conceptual change has proven to be a fruitful perspective from which to examine the learning of counter-intuitive concepts especially in science and mathematics, though it is by no means restricted to these subject areas. In this paper, we argue that a conceptual change point of view can also be a fruitful perspective from which to examine pre-service teachers' understandings of self-regulation theory and its application in the classroom.

Self-regulation approaches to learning characterise students as active agents, capable of setting goals and modifying their behaviours to achieve these goals. From this point of view, student learning and achievement is determined to a substantial extent by the actions that students take to regulate their learning (Pintrich, 2000; Zimmerman, 2001). There are a number of different theoretical accounts of self-regulated learning (SRL) but all agree that learning can be improved and that it is more effective when students employ appropriate strategies to monitor and control their learning processes and outcomes (Boekaerts, 1997; Pintrich, 2000; Winne, 2011; Zimmerman, 2008). A major stream of educational research including major reviews and meta-analyses has documented the beneficial impact of teaching self-regulated strategies on student motivation and achievement (Dignath & Büttner, 2008; Dignath, Büttner, & Langfeldt, 2008; Hattie, 2013; Schunk & Greene, 2018). Moreover, given that the need for self-managed learning has become an important 'survival tool' in our complex and rapidly changing world, researchers have emphasized the importance of teaching students learning strategies (Bjork, Dunlosky, & Kornell, 2013;),

Despite the importance of SRL, research shows that many students do not display the knowledge that would support effective regulation of learning (Bjork et al., 2013; Elen & Lowyck, 1999; Lawson & Askell-Williams, 2012; Ohst, Glogger, Nückles, & Renkl,

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2015; Trevors, Feyzi-Behnagh, Azevedo, & Bouchet, 2016). Most importantly, many teachers do not provide, or provide very little, explicit instruction to promote the self-regulation of learning in their students (Bolhuis & Voeten, 2004; Dignath-van Ewijk, 2016; Griffin et al., 2012; Kistner et al., 2010; Spruce & Bol, 2015). In trying to understand the infrequent teaching of SRL strategies in the classroom researchers have investigated teachers' beliefs about SRL. Teachers' beliefs can play an important role in promoting or inhibiting changes in teaching practices and innovation (Fives & Buehl, 2008; Lombaerts, Engels, & van Braak, 2009; Pajares, 1992; Richardson & Placier, 2001; Warfield, Wood, & Lehman, 2005). Prior research has shown that teachers' beliefs about SRL have a direct positive effect on their self-reported SRL teaching practices (Dignath-van Ewijk, 2016; Lombaerts, De Backer, Engels, Van Braak, & Athanasou, 2009; Spruce & Bol, 2015).

Despite its appeal, self-regulation theory carries some assumptions or propositions that are different from other theoretical frameworks in education and which might be inconsistent with teachers' existing beliefs and practices about learning and teaching. As Zimmerman (2001) discussed, self-regulation theory shifts the focus of educational analyses regarding students' achievement from mental-abilities or the social environment as fixed entities to students' personally initiated learning strategies. This shift might not be easy for teachers to accept. There is a prevailing emphasis in educational contexts on innate differences in learning ability, which can easily lead to the creation of beliefs that learning cannot be taught (Bjork et al., 2013). Such beliefs are inconsistent with the proposition of self-regulation theory that 'students' perceptions of themselves as learners and their use of various processes to regulate their learning are critical factors in analyses of academic achievement (Zimmerman, 1986, 2001).

We argue that a conceptual change approach that takes into consideration the possible counter-intuitive nature of some of the propositions of self-regulation theory may provide new theoretical and methodological insights into the study of teachers' beliefs and may explain their reluctance to explicitly promote the self-regulation of learning in their teaching. In the present investigation we focus on pre-service teachers rather than on practicing teachers because research has shown that they are less likely to have adequate knowledge of the strategies that can support learning (Bjork et al., 2013; Glogger-Frey, Ampatziadis, Ohst, & Renkl, 2018) and because SRL interventions are most effective when prospective teachers receive their initial training (McCombs & Marzano, 1990; Moos & Ringdal, 2012; Panadero, 2017).

1.1. Examining pre-service teachers' beliefs from a conceptual change perspective

Many educational researchers have drawn analogies between research investigating the conceptual changes that take place when students learn science, and research on belief change in teachers. Pajares (1992) made explicit reference to the conceptual overlap of research on teachers' beliefs and research on students' conceptions in science by Posner, Strike, Hewson and Gertzog (1982). Fives and Buehl (2008) drew a parallel between teachers' beliefs about teaching and students' naive theories of intelligence as defined by Dweck and Leggett (1988); Dweck, 1999). Recent research by Markauskaite and Goodyear (2014) and by Glogger-Frey, Deutscher and Renkl (2018) used concepts such as fragmentation and coherence drawn from debates in the conceptual change literature to characterize teachers' belief systems.

There are a number of different theoretical perspectives on conceptual change (Chi, 2008; diSessa, 1993; Posner et al., 1982; Vosniadou & Skopeliti, 2014). The present research adopts a theoretical perspective on conceptual change loosely based on the framework theory approach (Vosniadou, 2013; Vosniadou & Skopeliti, 2014; Vosniadou, 2019). The framework theory approach to conceptual change claims that students are not tabula rasa when they start being exposed to scientific concepts and theories through formal instruction. On the contrary, they have formed strong beliefs about the physical world based on their everyday experiences, which are organised in framework theories.

In the present paper we argue that it is productive to examine pre-service teachers' beliefs not as isolated and discrete units but as are connected to other beliefs and possibly to other cognitive and affective structures forming complex and interrelated *belief systems* (Nisbett & Ross, 1980; Pajares, 1992). Fives and Buehl (2012) and Churchland and Churchland (2013) also described teachers' beliefs as being represented in an integrated system, critical for guiding perception, interpretation and prediction. We define belief systems as constantly evolving structures that cover a domain of knowledge. Such belief systems are activated depending on the context and are used to interpret incoming information. Our concern centers on pre-service teachers' *educational belief systems* and more specifically their belief systems about learning and teaching. Educational belief systems, we argue, include individuals' subjective theories of learning and teaching, of intelligence and of the epistemic nature of knowledge and can influence the interpretation of information coming from instruction, as well as motivational orientations, perceptions of self-efficacy and subsequent learning and teaching actions. Of particular relevance here is the point made by Lombaerts, De Backer et al. (2009), that belief systems are not necessarily cohesive and that, within belief systems, individuals "may hold contradictory beliefs making it difficult to determine how particular beliefs influence instruction" (p.89) (see also Bjork et al., 2013; Maggioni & Parkinson, 2008; Ohlsson, 2009; Pajares, 1992; Warfield et al., 2005). Such belief systems can have important effects on pre-service teachers' interpretation of self-regulation theory and the application of this theory to their study and teaching practices.

The framework theory approach to conceptual change proposes that students' initial 'theories' or belief systems are very different from scientific concepts and theories in their structure, in their representations and even in the very concepts that comprise them. Similarly, we argue that it is likely that pre-service teachers have belief systems about learning and teaching substantially different from theoretical approaches to self-regulation. This discrepancy may hinder the understanding of self-regulation theory and its implementation in the classroom. Indeed, prior research has shown, for example, that pre-service teachers can easily place the teacher rather than the student at the center of the learning process in the classroom (Kramarski & Michalsky, 2009; McCombs, Daniels, & Perry, 2008; Moos & Ringdal, 2012; Pajares, 1992). The change from a teacher-centered to a student-centered teaching approach dictated by self-regulation theory is a complex process that requires, among others, changes in epistemic beliefs (knowledge

as transmitted vs knowledge as constructed) and in representations (from teacher-centered, individually-focused learning environments to student-centered, collaborative learning environments). These changes in turn have implications for what is to be taught and how learning is to be evaluated. In the process of such a change, we hypothesise that it might be possible to observe the creation of fragmentation, synthetic conceptions and other types of misconceptions in teachers' interpretation of SRL theory and its application in the classroom, in line with conceptual change approaches to learning in the subject matter areas (2019, Vosniadou, 2013).

Although the present research adopts a conceptual change point of view it is not focused on investigating some such conceptual change per se. Rather, the framework theory approach to conceptual change is used to generate innovations in the way teachers' belief systems are studied. Current educational psychology approaches focus on examining teachers' beliefs that are consistent with the promotion of SRL (Dignath-van Ewijk, 2016; Lombaerts, De Backer et al., 2009, 2009b; Spruce & Bol, 2015). They do not investigate what happens when teachers might have beliefs inconsistent with self-regulation theory. On the contrary, the conceptual change framing of this issue seeks to examine whether students and teachers hold beliefs that are inconsistent with the scientific concepts and theories to which they are exposed in an attempt to understand how these 'alternative' beliefs might interfere with student understanding. According to Shulman (1986), understanding the alternative conceptions of students and addressing them in instruction should be at the heart of our definition of pedagogical knowledge. Similarly, if we are interested in understanding how teachers' beliefs might be related to their teaching practices, it is important to understand what happens to teacher practices when teachers have beliefs that are inconsistent with self-regulation theory. Only when such alternative beliefs are uncovered might appropriate SRL interventions to address them be designed (see also Nespor, 1987; Pajares, 1992).

A second area of difference between current educational psychology approaches to teachers' beliefs and the present conceptual change inspired approach is a shift in emphasis from understanding how unitary beliefs influence teacher practices to understanding the influence of the structure of belief systems. The assumption here is that there is a network of beliefs related to each other in complex belief systems and that uncovering the relationships among beliefs is important in order to understand the influence of beliefs on teachers' practices and to guide interventions.

To summarise, the present research adopts the framework theory approach to conceptual change in order to introduce methodological innovations in the study of pre-service teachers' beliefs about the self-regulation of learning. These methodological innovations consist of the following: (a) investigating beliefs that are consistent with SRL as well as beliefs that are inconsistent with SRL and (b) examining the relationships amongst these beliefs and the coherence of pre-service teachers' belief systems. In the discussion that follows, we will describe the beliefs about learning and teaching that we consider inconsistent and consistent with self-regulation theory and discuss our hypotheses regarding how they might be related to each other.

1.2. Beliefs about learning and teaching that might be inconsistent with beliefs in the importance of teaching students SRL strategies

A common set of beliefs that might be inconsistent with beliefs in the importance of teaching students SRL strategies is that teaching involves primarily the transmission of subject matter knowledge and that the teacher is the dispenser of this knowledge. Pre-service teachers who believe that subject matter knowledge consists of certain facts and that the main task of teachers is the transmission of these facts to students, will find it difficult to simultaneously agree that the most important task for teachers is to influence what students do to learn (Ambrose et al. (2010)). SRL theory places less emphasis on role of the teacher as a simple dispenser of subject matter information and more on the teacher teaching students learning strategies that will help them to construct knowledge effectively (Battista, 1994; Calderhead, 1996; Lane, 2015; Perry, Brenner, & MacPherson, 2015; Torff & Sternberg, 2001). Another set of beliefs that might be inconsistent with SRL theory is that learning is quick, that it is an innate or fixed ability, and therefore that it cannot be taught. If pre-service teachers believe that learning is innate or a fixed ability that cannot be changed, they are not likely to agree with the proposition of SRL theories that students can be taught strategies that will make their learning more efficient and will improve their achievement. Several sections on beliefs follow.

1.2.1. Beliefs that teaching involves mainly the transmission of subject matter knowledge

Many researchers have noted that beliefs that teaching involves the transmission of knowledge and that the teacher is the dispenser of that knowledge to the student are strong particularly in novice teachers (Kramarski & Michalsky, 2009; Zohar, 2004). According to Kramarski and Michalsky (2009), there is a continuum in the development of teachers' perceptions of teaching as they transition from novices to experts. Most novices take a teacher-centered perspective while experts are more student-centered. However, empirical research shows that practicing teachers are also teacher centered. In a recent study of experienced geography teachers, Lane (2015) found that more than half of the 16 teachers in his sample (9/16) held transmissionist beliefs about teaching. These teachers believed that learning involves the accumulation of facts that are transmitted from the teacher or text to the students. Beliefs related to the transmission model of teaching seem to be based on people's every-day experiences and have been reported to appear early on in childhood (Pajares, 1992; Van Fleet, 1979). Early experiences are often represented in concrete visual images (Goodman, 1988) or mental models (Vosniadou & Brewer, 1992) that act as filters to incoming information, often distorting it in implicit ways creating misconceptions in the process of learning.

1.2.2. Beliefs that learning cannot be taught

Another set of beliefs that are inconsistent with beliefs in the importance of teaching students SRL strategies are beliefs that learning is something that happens quickly, that it is an innate or fixed ability and that it cannot be taught. These beliefs have also been identified as epistemic (or epistemological) in research by Schommer (1990) and have been found to have a negative influence on student achievement. Research by Schommer-Aikins, Duell, and Hutter (2005)) showed that beliefs in quick and fixed learning

predicted mathematical problem-solving performance negatively. In another study, Dignath-van Ewijk (2016) found that a factor she named 'changeable learning' ("The ability to learn can hardly be influenced through practice") was a negative predictor of teachers' beliefs on the promotion of SRL.

1.2.3. Beliefs that intelligence is a fixed ability and that effort is not important for learning

Beliefs about the modifiability of intelligence have been investigated in detail by Dweck and her colleagues (e.g., Dweck & Leggett, 1988). Dweck and her colleagues have identified two opposing beliefs, or theories about intelligence: the entity theory, i.e., intelligence as something fixed and unchangeable; and the incremental theory, i.e., intelligence as something malleable and subject to change. Beliefs about intelligence are related to beliefs about effort. Beliefs about effort have also been distinguished into positive and negative. Positive beliefs about effort lead to positive learning outcomes. Negative beliefs about effort (i.e., 'if you are not good at a subject, working hard won't make you good at it') and ability (i.e., 'when I work hard it makes me feel like I'm not very smart'), however, have minimal or negative relation to achievement (Blackwell, Trzesniewski, & Dweck, 2007). The work of Dweck and colleagues indicates that students who hold a non-incremental view of intelligence are likely to give up easily in the face of failure and not to believe in the utility of effort. On the contrary, students who hold an incremental view of intelligence are more likely to believe in the importance of effort and to display mastery-oriented learning strategies, such as effort escalation to overcome difficulty. These students are more likely to engage in actions to improve their learning strategies (Blackwell et al., 2007). Although the relevance of these beliefs to the self-regulation of learning has not been studied directly, it could be argued that teachers who hold non-incremental views about intelligence and do not believe in the importance effort would be less likely to believe in the importance of teaching their students strategies for how to better manage and control their learning.

1.3. Beliefs about learning and teaching that are consistent with beliefs in the importance of teaching students SRL strategies

1.3.1. Beliefs that learning is a constructive activity

Self-regulation theory is embedded within a constructivist epistemology. Learners are considered to be active agents who interpret the information they receive in light of what they already know and create their own meanings. In the process of learning what matters most is the activities that students employ to derive meaning from the information to which they are exposed. Within this perspective teachers are more effective when they teach students strategies that can help them improve their learning actions rather than when they simply deliver or display subject-matter information. Although prospective teachers are likely to be exposed to a constructivist epistemology in their teacher education courses, many teachers, especially novice ones, do not fully understand that it is the students themselves who structure their knowledge through their knowledge building activities (Ambrose et al., 2010; Zohar, 2004). For both novice and experienced teachers characterized by such a view, this lack of understanding stands in the way of developing their own self-regulation abilities as well as the teaching practices that foster the self-regulation of learning in their students (Chatzistamatiou, Dermitzaki, & Bagiatis, 2014; Kramarski & Michalsky, 2009; Perry et al., 2015).

Lonka, Joram, and Bryson (1996) investigated links between formal training in educational psychology and beliefs in a constructivist epistemology. Using an open-ended questionnaire they examined the conceptions of learning of participants who ranged in expertise in educational psychology. The results of their studies showed that only the participants who had formal training in educational psychology were able to provide sophisticated definitions of learning and suggestions about how to enhance it consistent with a constructivist epistemology. The teachers in these studies were not found to give constructivist definitions of learning – their definitions were described as being 'a-theoretical' in nature. This result was confirmed in a second study in the same report which showed significant pre-post differences in student-teachers' definitions of learning before and after they took a course in educational psychology. However, these changes were not reflected in the student-teachers' approaches to a concrete problem in which they were asked to suggest forms of instruction that would enhance students' ability to learn. In fact, the participants gave similar answers in the posttests as in the pretests. The results are a reminder of how difficult it is to translate theoretical knowledge into practice.

Beliefs in a constructivist epistemology have usually been considered to go hand in hand with self-regulation theory (Kramarski & Michalsky, 2009; McCombs et al., 2008; Muis, 2007). There is no conclusive evidence, however, that constructivist beliefs predict beliefs in the promotion of SRL in the classroom (Dignath-van Ewijk, 2016), or translate into teaching practices that provide opportunities for SRL (Dignath-van Ewijk & van der Werf, 2012; Pauli, Reusser, & Grob, 2007; Spruce & Bol, 2015). Recently Dignath-van Ewijk and van der Werf (2012) argued that both constructivist and traditional views of learning are beneficial for SRL when considering specifically how to instruct strategy use. The argument here refers to differences between direct instruction (traditional) and inquiry approaches (constructivist) to teaching SRL. Direct or explicit instruction of SRL strategies has been found to be more effective than implicit instruction (see also Paris & Paris, 2001).

1.3.2. Beliefs that the self-regulation of learning can improve student achievement

Teachers' beliefs that the self-regulation of learning can improve student achievement have not been examined specifically, although there have been several attempts to measure students' and teachers' beliefs about the promotion of SRL in general. The most relevant to the present research is the work of Lombaerts and his colleagues (Lombaerts, De Backer et al., 2009, 2009b) who developed the *Self-Regulated Learning Teacher Belief Scale* (SRLTB). The SRLTB is a 10 item self-report scale that assesses teachers' beliefs about the introduction of SRL in primary education and includes items such as 'self-regulated learning makes pupils evaluate their learning approach better", "… makes it easier to take into account pupils' experiences"' "… is practicable in primary education". Teachers scoring high on this scale can be considered strong proponents of SRL.

The SRLTB has been used in several studies to investigate whether beliefs in the promotion of SRLin primary education predict

teacher practices. Lombaerts, Engels et al. (2009) examined the relations between teachers' beliefs as measured by the SRLTB and their actual promotion of SRL in the classroom as measured by another instrument developed by their team (Lombaerts, Engels, & Athanasou, 2007), the *Self-Regulated Learning Inventory for Teachers* (SRLIT). The SRLIT investigates primary school teachers' self-reported promotion of SRL teaching in primary school classrooms based on Zimmerman's model (2002). The results showed that teachers' beliefs about SRL significantly predicted SRL promotion in the classroom.

Dignath-van Ewijk and van der Werf (2012) also used the SRLTB to investigate whether teachers' beliefs influence teachers' promotion of SRL in the classroom. In this study teachers beliefs on constructivist learning and on student centered learning were also investigated as well as teachers' knowledge on SRL and strategy instruction. Teachers' actual promotion of SRL in the classroom was investigated using interviews. The sample was relatively small comprising of 47 teachers who taught grades 7 and 8 in the Dutch system. Ordered logistic regression was used to investigate the impact of teachers' beliefs and teachers' knowledge on self-reported promotion of SRL in the classroom. The results showed that only teachers' beliefs about SRL predicted teacher SRL practices in the classroom. However, as the authors pointed out, the results from the teacher interviews showed that the teaching of SRL strategies was rare. Only five teachers out of 47 reported teaching students SRL strategies while 26 of the remaining teachers reported that they encouraged student autonomy. It was concluded that many teachers who agree with constructivist learning and have positive SRL beliefs think that they should provide students with autonomy but not that they should necessarily teach them learning strategies.

In a subsequent study Dignath-van Ewijk (2016) used path modeling to further investigate teachers' promotion of SRL in the classroom. In this study the Self-Regulated Learning Inventory for Teachers by Lombaerts et al. (2007) was used to measure teachers self-reported promotion of SRL in the classroom and the Self-Regulated Learning Teachers' Belief Scale (Lombaerts, De Backer et al., 2009, 2009b) to measure teachers' beliefs on SRL. In addition, the authors measured teachers' self-efficacy beliefs with regard to the promotion of SRL and teachers' knowledge about how to teach students learning to learn. The path model with the best goodness of fit indices showed that only teachers' beliefs and self-efficacy towards fostering SRL predicted teachers' beliefs in the promotion of SRL in the classroom directly.

1.4. The present study

As mentioned earlier, the purpose of the present research is to investigate pre-service teachers' beliefs that are consistent with SRL as well as beliefs that are inconsistent with SRL and to examine the relationships amongst these beliefs and the coherence of their belief systems. The general hypothesis framing this research is that pre-service teachers may hold beliefs inconsistent with SRL that may hinder the application of SRL theory in the classroom. Moreover, they may simultaneously hold both consistent and inconsistent beliefs. In order to investigate this general hypothesis, we developed a Beliefs about Learning and Teaching (BALT) questionnaire. The purpose of BALT was to investigate beliefs about learning and teaching that are both consistent and inconsistent with SRL, in view of the fact that none of the existing instruments did so (Hermans, van Braak, & van Keer, 2008; Lombaerts et al., 2007, 2009a, 2009b; Woolley, Benjamin, & Woolley, 2004). We also wanted to use structural equation modeling rather than path models based on means to investigate the structure of the pre-service teachers' belief system. SEM models make it possible to represent unobserved or latent factors and account for the measurement error in the estimation process, while path models contain only observed variables and assume that these variables are measured without error. Based on the arguments advanced earlier as well as on existing research we hypothesised a theoretical model (presented in Fig. 1), which specified the following causal relationships amongst the beliefs under investigation.

1.4.1. Relations amongst beliefs consistent with SRL

We hypothesised positive relations amongst the beliefs consistent with SRL. More specifically, we hypothesised that beliefs in constructive learning (CONL) would be positive predictors of beliefs that the self-regulation of learning improves achievement
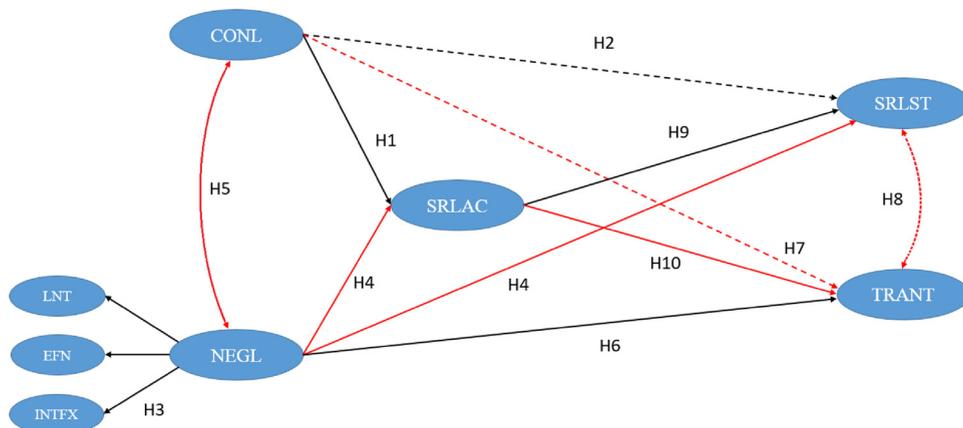

Fig. 1. The hypothesised theoretical model. Red lines indicate negative relations and black lines indicate positive relations. Broken lines indicate uncertainty about the hypothesised relation.

(SRLAC) (H1 in Fig. 1). This hypothesis is supported by existing research linking beliefs in constructivist epistemology with beliefs in the promotion of SRL (Dahl, Bals, & Turi, 2005; Dignath-van Ewijk & van der Werf, 2012; Hofer, 2002; Muis, 2007). However, the same research has shown that beliefs in constructive learning might not necessarily be predictors of beliefs in the teaching of SRL strategies. Therefore, we predicted that beliefs in constructive learning (CONL) would be positive predictors of beliefs in the importance of teaching learning strategies (SRLST) with some reservation (H2 in Fig. 1). Finally, we hypothesised that beliefs that the self-regulation of learning improves achievement (SRLAC) would be positive predictors of beliefs in the promotion of SRL teaching (SRLST) (H9 in Fig. 1).

1.4.2. Relations amongst beliefs inconsistent with SRL

We hypothesized positive relations amongst beliefs inconsistent with SRL. The beliefs that learning cannot be taught (LNT), that intelligence is fixed (INTFIX), and that effort does not make a difference in learning (EFN) are inconsistent with the main principles of self-regulation approaches to learning. In view of the similarities amongst the above mentioned beliefs about learning and the fact that they all promote the idea that learning is an innate ability and cannot be improved, we hypothesized that these three beliefs are likely to form a second order factor, which we called 'negative learning' (NEGL) (H3 in Fig. 1). Further, we hypothesized that both this second order negative learning factor, as well as all three single order factors, would be positive predictors of beliefs in transmissive teaching (TRANT). This is H6 in Fig. 1.

1.4.3. Relations between beliefs consistent and inconsistent with SRL

We hypothesized negative relations amongst beliefs consistent and inconsistent with SRL. Starting with beliefs inconsistent with SRL first, we hypothesized a direct negative effect of the combined negative learning beliefs (NEGL) on beliefs that the self-regulation of learning leads to student achievement (SRLAC), as well as on beliefs that students should be taught self-regulation strategies (SRLST) (H4 in Fig. 1). The beliefs that that intelligence is fixed (INTFX), and that effort does not make a difference in learning (EFN) are less directly associated with SRL, but we hypothesised that they would also have direct negative effects on beliefs that the self-regulation of learning leads to student achievement (SRLAC) and that students should be taught self-regulation strategies (SRLST). Existing research has shown that beliefs that intelligence is not changeable, and that effort is not important, are negative predictors of student achievement (Blackwell et al., 2007; Qian & Alvermann, 1995; Stathopoulou & Vosniadou, 2007).

Regarding beliefs consistent with SRL, we hypothesised that beliefs in constructive learning (CONL) and beliefs that self-regulation is related to student achievement (SRLAC) would be negative predictors of beliefs in transmissive teaching (TRANT) (H7 and H10 respectively, as illustrated in Fig. 1).

We also hypothesised that we will find negative correlations between consistent and inconsistent beliefs. More specifically, we hypothesised negative correlations between constructive learning (CONL) and beliefs in negative learning (NEGL) (H5 in Fig. 1), and between beliefs in the importance of teaching SRL strategies (SRLST) and beliefs that the main purpose of teaching is to transmit subject matter knowledge (TRANT) (H8 in Fig. 1).

Finally, we hypothesised that pre-service teachers are likely to hold both consistent and inconsistent beliefs simultaneously (H11 in Fig. 1). We called this the co-existence hypothesis.

2. Method

2.1. Participants

Four hundred and twenty-nine (429) pre-service teachers (277 female) volunteered to participate in the study. The age ranges of the participants are shown in Table 1. Three hundred and sixty four (84.8 %) were in the second year of study in the Bachelor of Education (BEd) program and 65 (15.2 %) were in the first year of the Master of Teaching (MTeach) program in an Australian university. Both programs prepare pre-service teachers for initial teaching qualifications with common topics on learning and teaching. The research was approved by the university human research ethics committee.

2.2. Materials

Based on a review of the literature, on existing measures as well as on extensive interviews with teachers with various levels of experience, we constructed a pilot version of the Beliefs about Learning and Teaching questionnaire comprised of 30 6-point Likert scale (1 Strongly Agree - 6 Strongly Disagree) items. This questionnaire was administered to 384 pre-service teachers in a pilot study.

Table 1
Age ranges of the participants.

Age	N	%
under 25	349	81.4
25-29	35	8.2
30-39	30	7
40-49	13	3
50-59	2	0.5

Table 2

Sample items and hypothesised constructs included in the BALT questionnaire.

No of items	Hypothesised factor	Beliefs of interest	Example item
17	Constructive Learning (CONL)	Beliefs that learning involves active construction of knowledge	*When students activate their knowledge about a topic they learn more.*
11	SRL teaching strategies (SRLST)	Beliefs that teaching involves facilitating students' learning strategies in a process of knowledge construction	*An important task for teachers is to teach students strategies for learning.*
8	Transmissive Teaching (TRANT)	Beliefs that teaching involves the transmission of information	*The most important task of teachers consists of teaching subject knowledge*
13	Negative Learning (NEGL)	Beliefs that learning cannot be taught (LNT), that intelligence is fixed (INTFX), and that effort does not make a difference (EFN).	*Learning is a natural activity and you cannot teach people how to learn.* *Your intelligence is something that you cannot change very much.* *If you are not good at a subject working hard will not make you good at it*
11	SRL is important for student achievement (SRLAC)	Beliefs that self-regulated learning is positive and improves student achievement	*When students learn how to self-regulate their achievement improves.*

Cognitive interviews were conducted with five pilot participants to investigate what meaning they attached to the items and how they justified their responses. The cognitive interviews revealed that some questions were not interpreted as we had intended, and these were removed or rephrased to make their meaning more transparent. Exploratory Factor Analysis (EFA) using SPSS Version 23.0 (IBM Corp, 2015) was used to investigate the underlying structure of the item pool and to eliminate items with low factor loadings.

We developed a second, more comprehensive Beliefs about Learning and Teaching (BALT) questionnaire, which was used in the present study. The BALT included the following items. (a) 17 items that investigated beliefs that *learning is a constructive activity* (CONL); (b) 11 items that investigated the belief that *SRL improves student achievement* (SRLAC); (c) 11 items that investigated beliefs that *it is important to teach students SRL strategies* (SRLST); (d) eight items that investigated beliefs that *teaching involves mainly the transmission of subject matter knowledge* (TRANT). In addition, 13 items investigated *beliefs about learning* inconsistent with SRL (NEGL). Four items investigated beliefs that *learning is a natural activity that does not need to be taught* (LNT), some of which were taken from the Schommer's epistemological beliefs questionnaire (Schommer, 1990). Five items investigated beliefs that *effort is not important for learning* (EFN), including some from Blackwell et al. (2007). Four items investigated beliefs that *intelligence is a fixed ability* (INTFX), three of which were taken from (Dweck, 1999). The questionnaire also included three demographic and background items asking the participants to provide information about their gender, age and educational level. Table 2 presents the hypothesised constructs and sample items.

2.3. Procedure

A member of the research team informed the students about the purposes of the study and invited them to participate. A week later, the same member of the research team visited the students' different classes and distributed the questionnaires to the students who had indicated their willingness to participate. Completion of the questionnaire took around 30 min. All completed questionnaires were placed in a large envelope and were collected by the research team member. The same script was used for addressing all classes.

2.4. Statistical procedures

The structural equation modeling (SEM) analyses were conducted using the MPLUS Version 6.11 (Muthén & Muthén, 1998-2011Muthén & Muthén, 1998-2011) using the robust categorical data estimator. The guidelines recommended by Hair et al. (2006) were used to distinguish between models. The chi-square index usually indicates a good fit if it is not significant, however this index is sensitive to sample size and, if the data size is large, the chi-square statistic might erroneously imply poor data to model fit. Thus, with large sample sizes, as in the present case, a relative chi-square (χ^2/df) index, which is less dependent on sample size, is often used, with values ranging from 2 to 3 (Carmines & McIver, 1981) and as high as 5 (Marsh & Hocevar, 1985) used to indicate a good fit. In the present study, we used the χ^2/df index with values less than 3.

Values over .92 were used on the Tucker Lewis Index (TLI) and the Comparative Fit Index (CFI) (Hair, Black, Babin, Anderson, & Tatham, 2006). Values smaller than .08 were considered acceptable for the Root Mean Square Error of Approximation (RMSEA) (Browne & Cudeck, 1993), but values smaller than .06 were used to indicate a close fit. Standardised loading estimates for factors in the CFA were regarded as acceptable if 0.4 or higher and variance extracted should be 0.4 or greater to suggest adequate convergent validity (Hair et al., 2006).

The results of SEM analysis include two components: the measurement model and the structural model. The measurement model shows the relationships between each of the latent factors and its observed indicators. The measurement model results can also be used to examine the validity and the reliability of these latent factors. The structural model shows the relationship among the latent factors included in the model and is discussed in the section that follows.

3. Results

3.1. The SEM measurement model

We tested the hypothesised theoretical model shown in Fig. 1. Model 1 treated negative beliefs about learning (NEGL) as a second order factor with fixed intelligence (INTFX), learning cannot be taught (LNT), and effort is not important for learning (EFN) as first order factors. This model was problematic because the latent variable covariance matrix for NEGL was not positive definite. This was due to a negative residual variance for the learning cannot be taught (LNT) factor, producing a standardised coefficient for LNT above one. In order to solve this problem, we tested a second model, which treated negative beliefs about learning (NEGL) as a first order factor. In this second model (Model 2), the factor NEGL included all items previously hypothesised to belong to the individual factors INTFX, LNT and EFN. This model showed a relatively good fit to the data [$\chi^2(1700) = 4128.423$, p < 0.0000, $\chi^2/df = 2.42$, CFI = 0.853, TLI = 0.847, RMSEA = 0.058 with a 90 % interval of 0.055 and 0.060]. However, the CFI and TLI values were low, as were the factor loadings for a few of the items as can be seen in Table 3. We proceeded by removing all items with factor loadings below 0.4. Three additional items were removed because they correlated highly with items from other factors. This improved the goodness of fit indices of the final model, model 3 [$\chi^2(1024) = 2179.623$, p < 0.0000, $\chi^2/df = 2.12$, CFI = 0.919, TLI = 0.915, RMSEA = 0.051 with a 90 % interval of 0.048 and 0.054].

Subsequently, in order to investigate the distinct effects of the three NEGL beliefs, three additional models were tested in which we substituted the NEGL factor with LNT (Model 4), INTFX (Model 5) and EFN (Model 6). These three models will be discussed in greater detail later. The factor loadings for all items in all the models are shown in Table 3.

In addition to the factor loadings and the overall fit indices that can be used as indicators of validity, it is also necessary to confirm that the measurement model has satisfactory levels of reliability. Cronbach's alpha coefficient is a commonly used estimate for reliability. In this paper, a different composite reliability (CR) value was also used. It was computed from the squared sum of factor loadings for each construct divided by the total of the squared sum of factor loading and sum of error variance terms for a construct. The computed reliability values of all the latent factors are shown in Table 4. CR values greater than 0.7 indicate good reliability measures.

Finally, in Table 5 we present the mean agreement and standard deviations of the combined items that were used to measure the various beliefs about learning and teaching and about SRL.

3.2. The SEM structural model

The final structural model with the combined NEGL factor, Model 3, is presented in Fig. 2. This model confirmed the following hypotheses:

3.2.1. Relations amongst beliefs consistent with SRLST

Model 3 confirmed the presence of positive relations amongst beliefs consistent with SRLST. Specifically, the model confirmed H1, showing a strong positive direct effect of beliefs in constructive learning (CONL) on beliefs that SRL leads to student achievement (SRLAC) ($\beta = 0.890$, p < 0.001) and H2, showing a direct positive effect of CONL on beliefs in the importance of teaching SRL strategies (SRLST) ($\beta = 0.226$, p < .0.05). The model also confirmed H9, i.e., the predicted direct positive effect of SRLAC on SRLST ($\beta = 0.715$, p < 0.001).

3.2.2. Relations amongst beliefs inconsistent with SRLST

Regarding the relations between beliefs inconsistent with SRLST, model 3 tested only the hypotheses concerning their combined effects (NEGL). As mentioned earlier the hypothesis that these learning beliefs would form a second order factor was not confirmed, but it was possible to form a first order negative learning (NEGL) factor based on the combined items from fixed intelligence (INTFX), learning cannot be taught (LNT), and effort is not important for learning (EFN). As predicted (H6), the combined negative learning factor (NEGL) had a direct positive effect on beliefs in the importance of transmissive teaching (TRANT).

3.2.3. Relations amongst beliefs consistent and inconsistent with SRLST

The results confirmed the presence of negative relations between beliefs consistent and beliefs inconsistent with SRL only in the case of the combined beliefs in Negative Learning. More precisely, model 3 showed that NEGL had a direct negative effect on beliefs that SRL leads to student achievement (SRLAC) ($\beta = -0.064$, p < 0.05) and on the importance of teaching students SRL strategies (SRLST) ($\beta = -0.098$, p < 0.001) as predicted (H4). The hypotheses concerning the separate effects of the latent factors fixed intelligence (INTFX), learning cannot be taught (LNT), and effort is not important for learning (EFN), were tested in subsequent models, which are presented later. Hypothesis 5 that beliefs in constructive learning (CONL) would correlate negatively with beliefs in negative learning (NEGL) was also confirmed ($\phi = -0.401$, p < 0.001).

H7 and H10 predicting negative relations between beliefs consistent with SRL and transmissive teaching were not confirmed. Neither beliefs in constructive learning (CONL), nor beliefs that SRL leads to student achievement (SRLAC) were negative predictors of beliefs in transmissive teaching (TRANT). On the contrary, CONL and SRLAC showed a positive but not statistically significant path to TRANT. H8, the hypothesis that beliefs in the importance of teaching SRL strategies (SRLST) would correlate negatively with beliefs in transmissive teaching (TRANT) was not confirmed. This last correlation was negative but not statistically significant ($\psi = -0.234$, p > 0.05).

Table 3

Latent factor item loadings for all the SEM models.

Latent Factors	Factor Loadings				
	Model 2	Model 3	Model 4	Model 5	Model 6
Beliefs in the promotion of SRL teaching strategies in the classroom (SRLST)					
An important task for teachers is to teach students strategies for learning	0.666	0.676	0.67	0.667	0.662
The most important task for teachers is to influence what students do to learn	0.291	*	*	*	*
Teachers should teach students ways to integrate new information with their existing knowledge	0.713	0.713	0.714	0.714	0.714
Students will only learn new material if they have opportunities to discuss it	0.284	*	*	*	*
If teachers gave opportunities to students to collaborate with their peers they would learn more effectively	0.391	*	*	*	*
Teachers are most effective when they create an environment that encourages students' inquiry	0.492	0.476	0.468	047	0.474
When teachers create an environment where students can engage in learning, students learn more	0.564	0.545	0.526	0.531	0.537
It is important for teachers to teach students how to monitor their understanding	0.721	0.719	0.718	0.719	0.717
One of the main tasks of teachers is to help students interpret new information using their own words	0.420	0.416	0.421	0.423	0.424
It is important for teachers to teach students ways to remember new information	0.534	0.529	0.533	0.531	0.529
It is important for teachers to teach students ways to organise new information	0.695	0.690	0.703	0.701	0.703
Beliefs that learning is a constructive activity (CONL)					
Students existing knowledge about a topic influences how they understand new information being presented by the teacher	0.467	0.464	0.473	0.468	0.47
Students' learning depends on what they already know about the topic	0.135	*	*	*	*
Learning requires organisation of information in memory	0.728	0.727	0.731	0.73	0.728
Learning is better when students connect new information to what they already know	0.556	0.554	0.56	0.555	0.554
When students activate their existing knowledge about a topic they learn more	0.642	0.651	0.652	0.65	0.653
Learning is more effective when students know a lot about a topic	0.020	*	*	*	*
Students learn better if they organise what they learn in memory	0.629	0.632	0.627	0.634	0.629
When information is well organised in memory it is more likely to be remembered	0.554	0.559	0.562	0.565	0.564
The ability to recall information depends on how well it is organised in memory	0.610	0.617	0.618	0.618	0.617
Learning involves the development of a meaningful knowledge structure	0.665	0.673	0.675	0.675	0.672
Effective learning requires the ability to detect gaps in one's own understanding	0.676	0.684	0.685	0.683	0.685
Learning is better when students can evaluate their level of understanding	0.731	**	**	**	**
Students who can detect gaps in their knowledge learn more effectively	0.671	0.673	0.669	0.667	0.671
If students ask themselves how well they have understood the material their learning improves	0.686	0.687	0.682	0.686	0.686
Learning requires students to be able to reflect on how they learn	0.697	0.695	0.689	0.691	0.692
Learning involves the interpretation of information by the student	0.289	*	*	*	*
Effective learning relies on the student selecting the relevant information	0.223	*	*	*	*
Beliefs in the importance of SRL for student achievement (SRLAC)					
When students self-regulate their learning their achievement can improve	0.601	0.618	0.615	0.615	0.615
When students can learn to self-regulate their learning their achievement improves	0.713	0.723	0.728	0.724	0.725
When student learn how to learn their performance improves	0.707	0.716	0.717	0.715	0.711
Students perform better when they can check on their understanding	0.706	0.658	0.651	0.657	0.652
When students have detailed strategies for how to remember key ideas they develop better understanding	0.695	0.706	0.706	0.705	0.709
The ability to learn is a skill that can be developed	0.635	**	**	**	**
When students learn to regulate their learning in a lesson their understanding improves	0.701	0.715	0.715	0.715	0.717
Students need to have strategies for learning to enable them to develop a good understanding	0.557	0.563	0.563	0.56	0.56
When students learn detailed strategies for learning they develop better understanding	0.645	0.661	0.655	0.658	0.658
To develop a good understanding students need to use both their knowledge about learning and their knowledge about subject matter	0.628	0.645	0.651	0.65	0.654
Students need to continuously use their knowledge about learning during a lesson to develop a good understanding	0.551	0.566	0.571	0.575	0.572
Beliefs that the main goal of teaching is to transmit subject matter knowledge (TRANT)					
The most important task of teachers consists of teaching subject knowledge	0.677	0.713	0.68	0.713	0.696
Students will only learn the material and get good marks if the teacher explicitly teaches them	0.446	0.463	0.43	0.439	0.458
If teachers would stick more to the facts and talk less about ideas, students could get more out of class	0.696	**	**	**	**
The more information is repeated during teaching the better the students will learn that information	0.240	*	*	*	*
The main task of the teacher is to dispense information	0.679	0.727	0.69	0.694	0.691
Teaching mostly involves the provision of information	0.612	0.638	0.667	0.648	0.644
The main goal of teaching is to increase the amount of knowledge in the students' memory	0.516	0.581	0.654	0.627	0.645
Teachers are most effective when they explicitly tell students what they need to know about the material	0.322	*	*	*	*
Negative learning beliefs (NEGL)					
Beliefs that learning cannot be taught (LNT)					
If students are going to be able to learn something it will make sense to them the first time they hear it	0.480	0.467	0.506		
Learning is a natural activity and students don't need to be taught how to learn	0.534	0.526	0.555		
Some people just have a knack for learning and others don't	0.519	0.522	0.426		
Some people are good learners and you can't teach people how to learn	0.640	0.631	0.655		
Beliefs that effort is not important for learning (EFN)					
If you're not doing well at a subject, it's better to try something easier	0.524	0.516			0.551
To tell the truth, when I work at my university study, it makes me feel like I'm not very smart	0.342	*			*
If a subject is hard for someone, it means that he or she probably won't be able to do really well at it	0.603	0.584			0.674
If you're not good at a subject, working hard won't make you good at it	0.626	0.630			0.709

Table 3 (*continued*)

Latent Factors	Factor Loadings				
	Model 2	Model 3	Model 4	Model 5	Model 6
It doesn't matter how hard you work, if you're not smart in a subject, you won't do well in it	0.714	0.713			0.754
Beliefs that intelligence cannot be changed (INTFX)					
You can learn new things but you cannot really change your basic intelligence.	0.754	0.764		0.792	
Your intelligence is something that you can't change very much	0.798	0.808		0.84	
You have a certain amount of intelligence and you can't really do much to change it	0.870	0.871		0.9	
You can't really change your intelligence even if you work very hard	0.788	0.788		0.831	

Note. * indicates items deleted from the model due to standardized path below 0.4. ** indicates items deleted from the model due to information from modification indices.

Table 4
Reliability values for the latent factors in Models 3–6 (Cronbach's α and Composite Reliability).

Latent factors	Model 3		Model 4		Model 5		Model 6	
	A	CR	A	CR	α	CR	α	CR
Beliefs in the promotion of SRL teaching strategies in the classroom (SRLST)	0.748	0.818	0.748	0.817	0.748	0. 817	0.748	0. 817
Beliefs that learning is a constructive activity (CONL)	0.848	0.891	0.848	0.891	0.848	0.891	0.848	0.891
Beliefs in the importance of SRL for student achievement (SRLAC)	0.834	0.884	0.834	0.884	0.834	0.884	0.834	0.884
Beliefs that the main goal of teaching is to transmit subject matter knowledge (TRANT)	0.729	0.764	0.729	0.764	0.729	0.764	0.729	0.766
Negative Learning Beliefs (NEGL)	0.858	0.901						
Beliefs that learning cannot be taught (LNT)			0.527	0.619				
Beliefs that effort is not important for learning (EFN)							0.690	0.698
Beliefs that intelligence cannot be changed (INTFX)					0.865	0.906		

Table 5
Means and standard deviations for the combined items in all belief categories.

Belief categories	Mean	SD
Beliefs in the promotion of SRL teaching strategies in the classroom (SRLST)	4.911	0.433
Beliefs that learning is a constructive activity (CONL)	4.688	0.453
Beliefs in the importance of SRL for student achievement (SRLAC)	4.732	0.462
Beliefs that the main goal of teaching is to transmit subject matter knowledge (TRANT)	3.369	0.699
Negative Learning Beliefs (NEGL)	2.187	0.608
Beliefs that learning cannot be taught (LNT)	2.334	0.664
Beliefs that effort is not important for learning (EFN)	2.143	0.666
Beliefs that intelligence cannot be changed (INTFX)	2.082	0.812

Note. Means and standard deviations are calculated using composite scores in SPSS.

As was mentioned earlier, Model 3 included all the items expressing negative beliefs in learning in one factor – negative learning (NEGL). This model did not provide information about the distinct effects of the separate beliefs about learning, namely fixed intelligence (INTFX), learning cannot be taught (LNT), and effort is not important for learning (EFN), with the other factors and particularly with beliefs that SRL leads to student achievement (SRLAC) and the importance of teaching SRL strategies (SRLST). In order to investigate the separate effects of these factors, we tested three additional models. Model 4 substituted the negative learning (NEGL) factor with learning cannot be taught (LNT) [χ^2(692) = 1669.302, p < 0.0000, χ^2/df = 2.41, CFI = 0.920, TLI = 0.914, RMSEA = 0.057 with a 90 % interval of 0.054 and 0.061]. Model 5 substituted the NEGL factor with fixed intelligence (INTFX) [χ^2(692) = 1669.529, p < 0.0000, χ^2/df = 2.41, CFI = 0.925, TLI = 0.920, RMSEA = 0.057 with a 90 % interval of 0.054 and 0.061]. Model 6 substituted the NEGL factor with effort is not important for learning (EFN) [χ^2(692) = 1659.732, p < 0.0000, χ^2/df = 2.39, CFI = 0.920, TLI = 0.914, RMSEA = 0.057 with a 90 % interval of 0.054 and 0.061].

The results showed that Model 4 with learning cannot be taught (LNT) replicated the pattern of relationships in Model 3 that included the combined negative learning factor (NEGL). The analysis for Model 5 with fixed intelligence indicated that the direct negative effects on beliefs that SRL leads to student achievement (SRLAC) and the importance of teaching SRL strategies (SRLST) were both non-significant. Similarly, in Model 6 with effort is not important for learning (EFN) the direct negative effect to beliefs that SRL leads to student achievement (SRLAC) was non-significant.

3.3. Examining the co-existence hypothesis

In order to examine the coexistence of consistent and inconsistent beliefs, composite scores were calculated by averaging the scores of all items reflecting a particular scale. Responses received the scores of 1, 2, 3, 4, 5 and 6 respectively for Strongly Disagree,
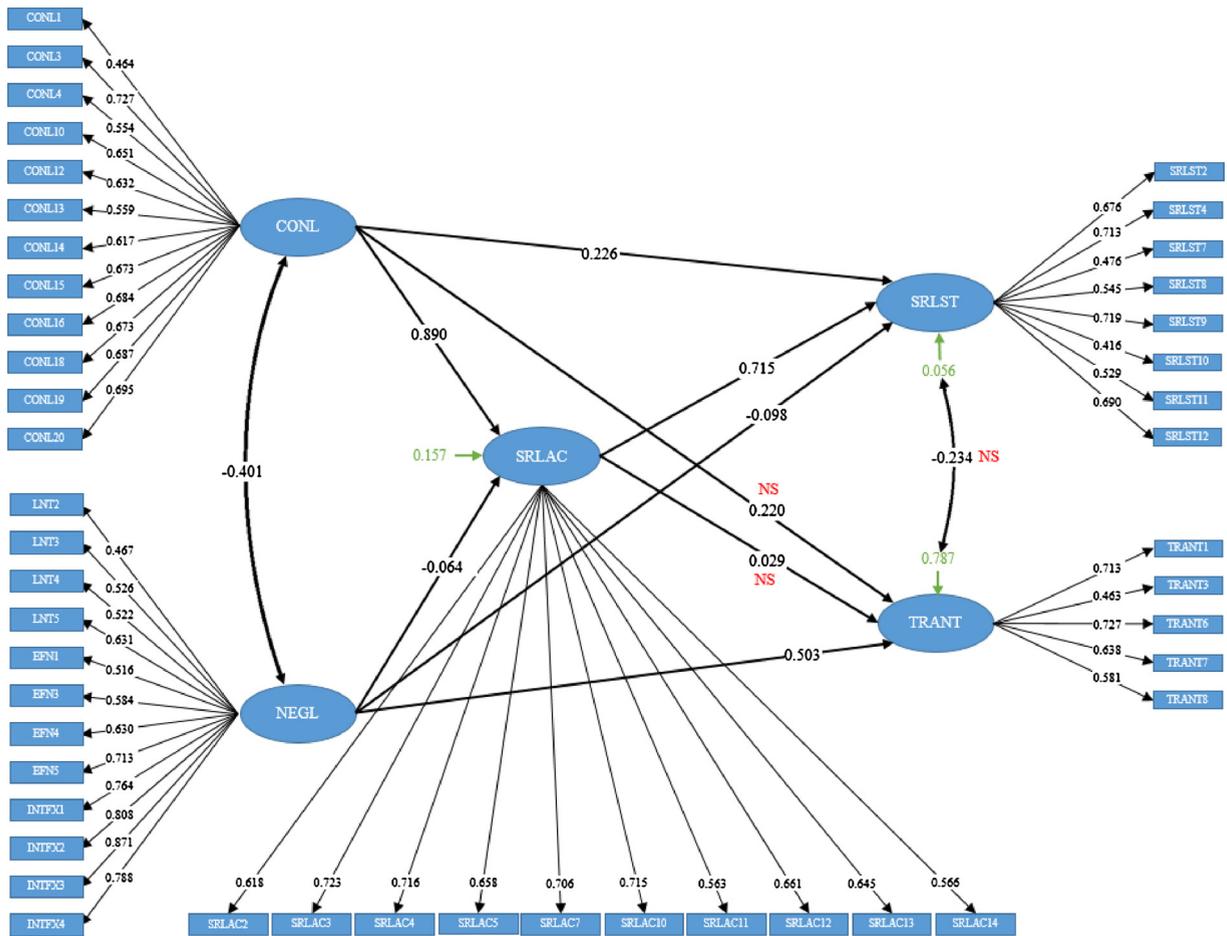
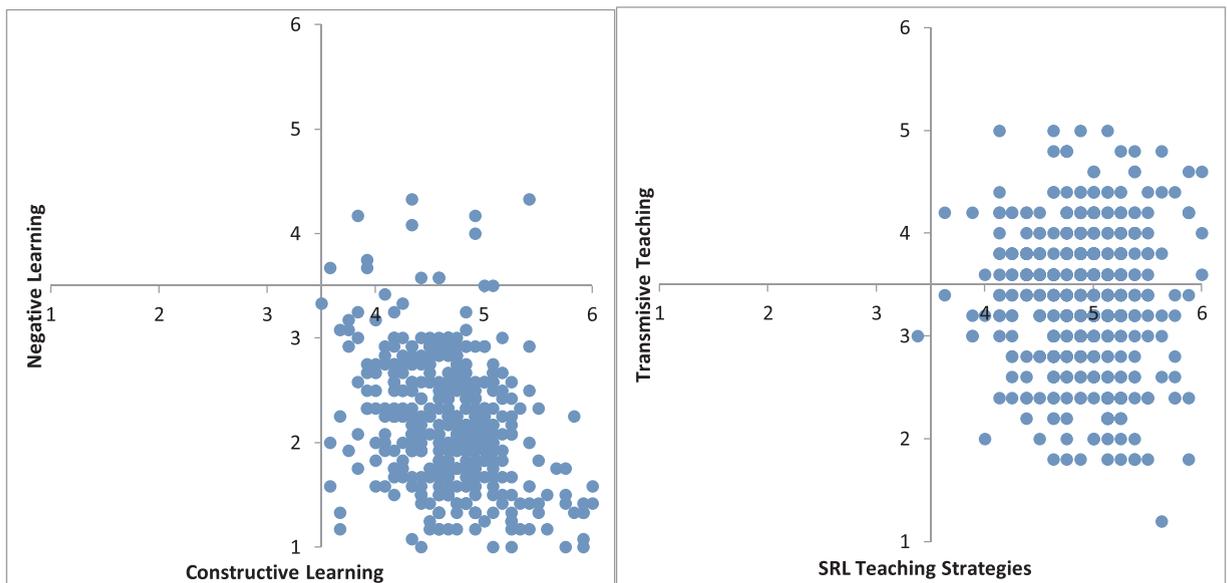**Fig. 2.** The final SEM model (Model 3).

Fig. 3. Scatter plots showing degree of agreement with composite scores for opposing beliefs about learning and teaching.
(a) Constructive Learning vs Negative Learning; (b) SRL Teaching Strategies vs Transmissive Teaching.

Table 6

Frequency and percent agreement with composite scores for opposing beliefs about learning and teaching.

		NEGL		Total				TRANT		Total
		Disagree	Agree					Disagree	Agree	
CONL	Disagree	1 (0.2%)	0 (0.0%)	1 (0.02%)		SLRST	Disagree	1 (0.2%)	0 (0.0%)	1 (0.02%)
	Agree	414 (96.5%)	14 (3.3%)	428 (99.8%)			Agree	213 (52.8%)	197 (45.9%)	428 (99.8%)
	Total	415 (96.7%)	14 (3.3%)	429 (100.0%)			Total	232 (54.1%)	197 (45.9%)	429 (100.0%)

Disagree, Somewhat Disagree, Somewhat Agree, Agree, and Strongly Agree. The composite scores for opposing beliefs were then plotted as shown in Fig. 3. Two scatter plots were produced. The first plot (a) shows the response pattern for Constructive Learning and Negative Learning and the second plot (b) shows the response patterns for SRL Teaching Strategies and Transmissive Teaching

As can be seen in Fig. 3(a) as well as in Table 6, the majority of the pre-service teachers (96.5 %) held high level of beliefs regarding Constructive Learning and low level of beliefs in Negative Learning and were located in the second quadrant. Only a small number of pre-service teachers (3.3 %) exhibited the coexistence of these two opposing beliefs.

The second plot can also be described in the same manner. For the two beliefs in teaching, SRL Teaching Strategies and Transmissive Teaching, almost all of the respondents (99.8 %) agreed with beliefs in the importance of Teaching SRL Strategies. However, almost half of them (45.9 %) also agreed with Transmissive Teaching. In other words, the two teaching beliefs coexisted in almost half of the pre-service teachers.

Some examples of the co-existence of opposing beliefs are shown in Table 7. Table 7 shows the pre-service teachers' percent agreement with select items from the Transmissive Teaching factor and the SRL Teaching Strategies factor. The last column of Table 7 shows the percent of pre-service teachers who agreed with both items.

4. Discussion

The present research is based on the application of the framework theory approach to conceptual change on research regarding pre-service teachers' beliefs about learning and teaching, with a focus on the self-regulation of learning. It presents a methodological innovation over existing approaches by drawing attention to the study of beliefs that are not only consistent but also inconsistent with self-regulation theory. Moreover, we argued that it is more fruitful to study beliefs not as isolated and discrete units, but as forming a belief system, and that it is important to study the structure of this belief system and its coherence. The results confirmed both the presence of beliefs inconsistent with SRL and the co-existence of opposing beliefs in pre-service teachers. In what follows, we discuss these results in detail and then develop their implications for further research and for SRL interventions.

4.1. The measurement model

The analysis of the BALT questionnaire produced a SEM measurement model, which confirmed that the items used were valid and reliable measures of five latent factors. These five factors included three beliefs consistent with SRL: Beliefs in constructive learning (CONL), beliefs that SRL can improve student achievement (SRLAC) and beliefs in the importance of teaching SRL strategies (SRLST). They also included four beliefs inconsistent with SRL: Beliefs that teaching involves mainly the transmission of subject matter knowledge (TRANT), beliefs that learning cannot be taught (LNT), beliefs that intelligence is a fixed ability (INTFX) and beliefs that effort is not important for learning (EFN). The pre-service teachers exhibited high levels of agreement with beliefs consistent with SRL and low levels of agreement of beliefs inconsistent with SRL. This agrees with the expectation that pre-service teachers' formal education would have exposed them to current theories of learning and teaching. Further analysis of the BALT questionnaire revealed six SEM structural models, which examined the hypothesised relations of the above-mentioned latent factors with each other, allowing us to test our specific hypotheses.

4.2. Hypotheses regarding the relations amongst beliefs consistent with SRL

The SEM models confirmed the presence of positive relations amongst beliefs consistent with SRL. However, beliefs in constructive learning were found to be only a weak predictor of beliefs in the importance of teaching SRL strategies. This result is consistent with previous findings in the literature showing that beliefs in constructive learning often translate into beliefs that teachers should give students greater autonomy, but not that they should explicitly teach SRL strategies (Dignath-van Ewijk & van der Werf, 2012). It is also consistent with observations of teaching showing that beliefs in a constructivist epistemology do not necessarily predict the teaching of SRL strategies in the classroom (Spruce & Bol, 2015).

Another interesting finding was that beliefs that SRL improves student achievement acted as mediators between beliefs in constructive learning and beliefs in the importance of teaching SRL strategies. This is a new finding, which makes theoretical sense and has practical implications. It suggests that if teachers are going to invest in teaching students SRL, they are more likely do so if they

Table 7

Percent agreement with specific items testing opposing beliefs about teaching and percept of overlap of agreement.

Teaching as transmission of subject knowledge (TRANT)	% Agreement with TRANT	Teaching as influencing student strategies (SRLST)	% Agreement with SRLST	% Overlap between TRANT and SRLST
The main task of the teacher consists of teaching subject knowledge	57.1	The most important task for teachers is to influence what students do to learn	84.4	49.9
The more information is repeated during teaching the better the students will learn that information	84.8	It is important for teachers to teach students ways to remember new information	96.5	82.3
The main goal of teaching is to increase the amount of knowledge in the students' memory	65.5	It is important for teachers to teach students how to monitor their understanding	96.0	63.6
Teaching mostly involves the provision of information	52.7	An important task for teachers is to teach students strategies for learning	97.9	51.3

are persuaded that this investment is going to be fruitful and that it will result in improvements in student achievement. This is not a path commonly followed by SRL interventions, which tend to focus more on providing teachers with information about the self-regulation of learning rather than persuading them about its efficacy. While providing information about SRL is of course necessary, it might not be utilised if the teachers do not believe that developing self-regulation skills can result in improvements in students' academic performance. Lack of strong beliefs in the importance of SRL for student achievement may be one of the reasons why SRL interventions do not often translate into changes in teacher practices (see also Lawson, Vosniadou, Van Deur, Wyra, & Jeffries, 2018).

4.3. Hypotheses regarding the relations amongst beliefs inconsistent with SRL

Prior research has shown that beliefs that learning cannot be taught, that intelligence is not malleable, and the effort is not important for learning can have negative effects on student achievement (Blackwell et al., 2007; Schommer-Aikins et al., 2005). In the present study we examined the relations between these negative beliefs about learning and beliefs about transmissive teaching. All the SEM models investigated showed that these beliefs, both when they were combined and separately, were positive predictors of beliefs in transmissive teaching. The link between negative learning beliefs and transmissive teaching is a new finding, confirming the hypothesis that beliefs about learning inconsistent with SRL would be related to beliefs about teaching that are inconsistent with promotion of SRL. Although the participants in the present research showed low levels of agreement with negative learning beliefs, these types of beliefs are met with much higher level of agreement in other populations and particularly with secondary school students and need to be addressed (Vosniadou, Pobke, Heath, Van Deur, & Jeffries, 2017).

4.4. Hypotheses regarding the relations amongst beliefs consistent and inconsistent with SRL

The results confirmed the hypothesis of negative relations amongst beliefs consistent and inconsistent with SRL only partially. More specifically, the results confirmed the hypothesis that the combined beliefs in negative learning will be negative predictors of beliefs consistent with SRL. The SEM models that tested the separate effects of each of these negative learning beliefs showed, however, that this was only the case with the beliefs that learning is quick and natural and cannot be taught. On the contrary, beliefs that intelligence is not malleable were not negative predictors neither of beliefs in the importance of SRL for student achievement and/or the importance of teaching SRL strategies. It appears that it is possible to think that intelligence is a fixed ability but still believe that learning strategies are important for student achievement and can be improved through instruction. Beliefs that effort is not important for learning were found to be negative predictors only of beliefs in the importance of teaching SRL strategies, but not of beliefs that improved learning strategies can lead to better student achievement.

Most importantly, the results did not confirm the hypotheses that beliefs consistent with SRL would be negative predictors of beliefs inconsistent with SRL. On the contrary, there was a borderline significant positive effect both of constructive learning on transmissive teaching, and of beliefs that SRL is important for student achievement on transmissive teaching. Transmissive teaching had a negative but not statistically significant correlation with beliefs in the importance of teaching students SRL strategies. The unraveling of these relations between beliefs consistent and inconsistent with the self-regulation of learning is interesting and demonstrates that it is possible to exhibit high agreement with beliefs in a constructivist epistemology and even beliefs in the importance of SRL and also agree that the teaching of subject knowledge is the most important task for teachers.

The results of the SEM modeling were consistent with the results of the analysis that examined the co-existence of beliefs consistent and inconsistent with SRL using scatter plots. The scatter plots based on the pre-service teachers' composite scores on the items that investigated the various beliefs showed that while almost all of them agreed with the importance of teaching students SRL strategies, about 50 % of them also simultaneously agreed that 'the main goal of teaching is to increase the amount of information in students' memory'.

It could be argued here that beliefs that learning is a constructive activity and in the importance of teaching SRL strategies are neutral as to how exactly SRL should be taught (see for example, Dignath-van Ewijk and van der Werf, 2012). In most of these arguments, however, the debate has to do with direct vs indirect instruction. We agree that SRL is not inconsistent with direct instruction, indeed we believe that it is possible to design direct instruction where the students are active and constructive and where meaningful learning takes place (Gijbels & Loyens, 2009; Renkl, 2009). However, in the present research we did not ask the pre-service teachers questions about direct instruction. We only asked them if they agreed that 'the main goal of teaching is to increase the amount of information in students' memory'.

To sum up, the results confirmed the presence of beliefs both consistent and inconsistent with SRL in the pre-service teachers' belief systems. Most importantly the research also showed that the belief systems of many of these teachers were not coherent, confirming the hypothesized co-existence of opposing beliefs. The co-existence of opposing beliefs is not a surprising phenomenon when examined through the lenses of conceptual change theory. Conceptual change research provides countless examples of cases where scientific information has been added on to existing belief systems resulting in fragmentation and inconsistency, or in misconceptions that distort scientific information (Vosniadou & Brewer, 1992; Vosniadou & Skopeliti, 2018; Vosniadou, 2019; Wiser & Smith, 2008).

The present results justify the analogy between pre-service teachers learning about self-regulation theory and students learning science. It appears that considerable conceptual changes might need to take place in pre-service teachers' existing belief systems when exposed to SRL theory during their formal education. While they start forming positive beliefs about constructivist epistemology and the importance of self-regulation, existing beliefs, inconsistent with SRL continue to be present diminishing the coherence of their belief systems and most likely inhibiting their translation in the adoption of SRL practices.

4.5. Limitations and future directions

A limitation of the research is that it is confined to pre-service teachers from mainly middle-class backgrounds. More research is needed to further validate the findings with a larger number of pre-service teachers from different ethnic and cultural backgrounds. Most importantly, future research needs to investigate the belief systems of practicing teachers. The present research focused on pre-service teachers and though it seems likely that similar patterns of findings might emerge in research with practicing teachers, this remains an area to be investigated in future research.

Another limitation is the use of a self-report questionnaire. Future research needs to investigate in greater detail and through in-depth-interviews and observations whether and how pre-service and practicing teachers reconcile their opposing beliefs about the self-regulation of learning, what misconceptions they might form, and how they influence their practices. For example, it is possible that teachers create an interpretation of SRL according to which the teaching of learning strategies is a secondary teaching goal, to be achieved only if the provision of subject matter knowledge, which is the major goal of teaching, has been achieved. These teachers fail to appreciate that teaching their students effective strategies is key to the acquisition of effective and transferable subject matter knowledge. This interpretation is consistent with the findings of research by Harding, Nibali, Griffin, Graham, and English (2017)) on the SRL beliefs and practices of a group of 112 practicing teachers. This research showed that 89 percent of the teachers agreed that students' SRL ability impacts their academic progress. However, only 39 percent reported including elements of SRL when planning their lessons, and only 19 percent said that they focus on SRL in order to support high capacity students. The most common reason stated to explain the observed disparity between teachers' valuing of SRL activity and their facilitation of this activity in their lessons was that there was not enough time to teach both the content of the curriculum and learning skills. It appears that for these teachers teaching the content of the curriculum is the most important activity and they need not teach students strategies for learning until this is accomplished.

5. Implications for SRL interventions

Effective intervention programs need to be developed to both test the predictions of the present SEM models and to find effective ways to promote SRL practices that can increase pre-service and practicing teachers' confidence in the effectiveness of their teaching. Conceptual change research can provide important information about the kinds of instructional interventions that can be used to promote change (Amin & Levrini, 2018; Vosniadou, 2013). The first step towards producing some conceptual change is to make teachers aware of their beliefs and make them the point of explicit discussion and reflection in teacher education and professional development programs so that teachers will become aware of the influence they exert on their practices. A combination of dissonance producing instructional strategies, such as cognitive conflict, with positive approaches, such as using instructional and explanatory analogies can be used to produce dissatisfaction with existing beliefs and motivation for change (Clement, 2013). Although some researchers have been critical of the use of cognitive conflict (Smith, diSessa, & Roschelle, 1994), it has been shown that moderate uses of dissonance can be helpful to increase metacognitive awareness and facilitate discussions that can lead to deeper understanding. However, cognitive conflict alone cannot produce conceptual change. Positive approaches to conceptual change, such as instructional and explanatory analogies and models (Clement, 2013; Vosniadou & Skopeliti, 2018) are also necessary. Such positive approaches can be helpful if they target specifically teachers' alternative beliefs and misconceptions. The findings of the present research have relevance here. For example, the finding that beliefs that SRL is important for student achievement act as a mediator between beliefs in constructivist epistemology and beliefs in the promotion of learning strategies in the classroom, indicates that SRL interventions can become more effective if they provide convincing information to teachers and pre-service teachers about the links between student self-regulation and academic achievement. The efficient integration of the teaching of subject content with teaching students SRL strategies is also another area that the present research has revealed as an important focus in programs for the education of pre-service teachers and for the professional development of practicing teachers.

Although teacher educators have been aware of the importance of pre-service teachers' beliefs on the explicit promotion of self-regulation in the classroom, little has been done so far to identify possible conflicting beliefs, to examine the structure of their belief systems and to use the information from the research to inform program direction and educational practice. Taking a conceptual change perspective can provide new methodological insights about how to study teachers belief systems and about how to find effective ways to induce belief change.

Funding

Declaration of Competing Interest

None.

References

Ambrose, S. A., Bridges, M. W., Dipietro, M., Lovett, M. C., Norman, M. K., & Mayer, R. E. (2010). *How learning works: Seven research-based principles for smart teaching, Vol. 32.* Hoboken: Hoboken: John Wiley & Sons, Incorporated.

Amin, T. G., & Levrini, O. (2018). *Converging perspectives on conceptual change: Mapping an emerging paradigm in the learning sciences.* New York: Routledge/Taylor & Francis Group.

Battista, M. T. (1994). Teacher beliefs and the reform movement in mathematics education. *Phi Delta Kappan, 75*, 462–470.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual Review of Psychology, 64*, 417–444. https://doi.org/10.1146/annurev-psych-113011-143823.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*, 246–263. https://doi.org/10.1111/j.1467-8624.2007.00995.x.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and Instruction, 7*, 161–186. https://doi.org/10.1016/S0959-4752(96)00015-1.

Bolhuis, S., & Voeten, M. J. M. (2004). Teachers' conceptions of student learning and own learning. *Teachers and Teaching: Theory and Practice, 10*, 77–98. https://doi.org/10.1080/13540600320000170936.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen, & J. S. Long (Eds.). *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner, & R. C. Calfee (Eds.). *Handbook of educational psychology* (pp. 709–725). New York: Macmillan.

Carmines, E. G., & McIver, J. P. (1981). Analyzing models with unobserved variables. In G. W. Bohrnstedt, & E. F. Borgatta (Eds.). *Social measurement: Current issues.* Beverly Hills: Sage.

Chatzistamatiou, M., Dermitzaki, I., & Bagiatis, V. (2014). Self-regulatory teaching in mathematics: Relations to teachers' motivation, affect and professional commitment. *European Journal of Psychology of Education, 29*, 295–310. https://doi.org/10.1007/s10212-013-0199-9.

Chi, M. T. H. (2008). Three types of conceptual change: Belief revision, mental model transformation, and categorical shift. In S. Vosniadou (Ed.). *Handbook of research on conceptual change* (pp. 61–82). Hillsdale, NJ: Erlbaum.

Churchland, P. S., & Churchland, P. M. (2013). What are beliefs? In F. Krueger, & J. Grafman (Eds.). *The neural basis of human belief systems* (pp. 1–18). New York: Psychology Press.

Clement, J. J. (2013). The role of explanatory models and analogies in conceptual change. In S. Vosniadou (Ed.). *International handbook of research on conceptual change* (pp. 412–446). (2nd ed.). New York: Routledge.

Dahl, T. I., Bals, M., & Turi, A. L. (2005). Are students' beliefs about knowledge and learning associated with their reported use of learning strategies? *The British Journal of Educational Psychology, 75*(2), 257–273. https://doi.org/10.1348/000709905X25049.

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning, 3*, 231–264. https://doi.org/10.1007/s11409-008-9029-x.

Dignath, C., Büttner, G., & Langfeldt, H. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review, 3*, 101–129. https://doi.org/10.1016/j.edurev.2008.02.003.

Dignath-van Ewijk, C. (2016). Which components of teacher competence determine whether teachers enhance self-regulated learning? Predicting teachers' self-reported promotion of self-regulated learning by means of teacher beliefs, knowledge, and self-efficacy. *Frontline Learning Research, 4*(5), 83–105. https://doi.org/10.14786/flr.v4i5.247.

Dignath-van Ewijk, C., & van der Werf, G. (2012). What teachers think about self-regulated learning: Investigating teacher beliefs and teacher behavior of enhancing students' self-regulation. *Education Research International, 2012.* https://doi.org/10.1155/2012/741713 Article ID 741713, 10 pages.

diSessa, A. A. (1993). Toward an epistemology of physics. *Cognition and Instruction, 10*(2/3), 105–225. https://doi.org/10.1080/07370008.1985.9649008.

Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality, and development.* New York: Psychology Press.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256–273. https://doi.org/10.1037/0033-295X.95.2.256.

Elen, J., & Lowyck, J. (1999). Metacognitive instructional knowledge: Cognitive mediation and instructional design. *Journal of Structural Learning and Intelligent Systems, 13*, 145–169.

Fives, H., & Buehl, M. (2008). What do teachers believe? Developing a framework for examining beliefs about teachers' knowledge and ability. *Contemporary Educational Psychology, 33*, 134–176. https://doi.org/10.1016/j.cedpsych.2008.01.001.

Gijbels, D., & Loyens, S. M. M. (2009). Constructivist learning (environments) and how to avoid another tower of Babel: Reply to Renkl. *Instructional Science, 37*(5), 499–502. https://doi.org/10.1007/s11251-009-9100-2.

Glogger-Frey, I., Ampatziadis, Y., Ohst, A., & Renkl, A. (2018). Future teachers' knowledge about learning strategies: Misconcepts and knowledge-in-pieces. *Thinking Skills and Creativity, 28*, 41–45. https://doi.org/10.1016/j.tsc.2018.02.001.

Glogger-Frey, I., Deutscher, M., & Renkl, A. (2018). Student teachers' prior knowledge as a prerequisite to learn how to assess pupils' learning strategies. *Teaching and Teacher Education,* s1. https://doi.org/10.1016/j.tate.2018.01.012.

Goodman, J. (1988). Constructing a practical philosophy of teaching. A study of preservice teachers' professional perspectives. *Teacher & Teaching Education, 4*, 121–137. https://doi.org/10.1016/0742-051X(88)90013-3.

Griffin, P., Care, E., Crigan, J., Robertson, P., Zhang, Z. H., & Arratia-Martinez, A. (2012). The influence of evidence-based decisions by collaborative teacher teams on student achievement. In S. Billett, C. Harteis, & H. Gruber (Eds.). *International handbook of research in professional and practice-based learning. Springer International handbooks of education.* Dordrecht: Springer.

Hair, J. J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis* (6th ed.). Upper Saddle River, NJ: Pearson-Prentice Hall.

Harding, S. M., Nibali, N., Griffin, P., Graham, L., & English, N. (2017). Teaching self-regulated learning in Victorian classrooms. *Paper Presented at the Australian Association for Research in Education (AARE) as Part of a Symposium: Beliefs and Knowledge About Learning and Teaching in Teachers and Students.*

Hattie, J. (2013). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* London: Routledge.

Hermans, R., van Braak, J., & van Keer, H. (2008). Development of the beliefs about primary education scale: Distinguishing a developmental and transmissive dimension. *Teaching and Teacher Education, 24*(1), 127–139. https://doi.org/10.1016/j.tate.2006.11.007.

Hofer, B. K. (2002). Epistemological world views of teachers: From beliefs to practice. *Issues in Education: Contributions from Educational Psychology, 8*, 166–173.

IBM Corp (2015). *IBM SPSS statistics for windows (Version 23.0)* (Released 2015)Armonk, NY: IBM Corp.

Kistner, S., Rakoczy, K., Otto, B., Dignath-van Ewijk, C., Büttner, G., & Klieme, E. (2010). Promotion of self-regulated learning in classrooms: Investigating frequency, quality, and consequences for student performance. *Metacognition and Learning, 5*, 157–171. https://doi.org/10.1007/s11409-010-9055-3.

Kramarski, & Michalsky, T. (2009). Investigating preservice teachers' professional growth in self-regulated learning environments. *Journal of Educational Psychology, 101*(1), 161–175.

Lane, R. (2015). Experienced geography teachers' PCK of students' ideas and beliefs about learning and teaching. *International Research in Geographical and Environmental Education, 24*(1), 43–57. https://doi.org/10.1080/10382046.2014.967113.

Lawson, M. J., & Askell-Williams, H. (2012). Framing the features of good quality knowledge for teachers and students. In J. R. Kirby, & M. J. Lawson (Eds.). *Enhancing the quality of learning* (pp. 137–159). New York: Cambridge University Press.

Lawson, M. J., Vosniadou, S., Van Deur, P., Wyra, M., & Jeffries, D. (2018). Teachers' and students' belief systems about the self-regulation of learning. *Educational Psychology Review.* https://doi.org/10.1007/s10648-018-9453-7 Advance online publication.

Lombaerts, K., De Backer, F., Engels, N., Van Braak, J., & Athanasou, J. A. (2009). Development of the self-regulated learning teacher belief scale. *European Journal of Psychology of Education, 24*(1), 79–96. https://doi.org/10.1007/BF03173476.

Lombaerts, K., Engels, N., & Athanasou, J. A. (2007). Development and validation of the self-regulated learning inventory for teachers. *Perspectives in Education, 25*, 29–47.

Lombaerts, K., Engels, N., & van Braak, J. (2009). Determinants of teachers' recognitions of self-regulated learning practices in elementary education. *The Journal of Educational Research, 102*(3), 163–174. https://doi.org/10.3200/JOER.102.3.163-174.

Lonka, K., Joram, E., & Bryson, M. (1996). Conceptions of learning and knowledge: Does training make a difference? *Contemporary Educational Psychology, 21*, 240–260. https://doi.org/10.1006/ceps.1996.0021.

Maggioni, L., & Parkinson, M. M. (2008). The role of teacher epistemic cognition, epistemic beliefs, and calibration in instruction. *Educational Psychology Review, 20*, 445–461. https://doi.org/10.1007/s10648-008-9081-8.

Markauskaite, L., & Goodyear, P. (2014). Tapping into the mental resources of teachers' working knowledge: insights into the generative power of intuitive pedagogy. *Learning Culture and Social Interaction, 3*, 237–251. https://doi.org/10.1016/j.lcsi.2014.01.001.

Marsh, H. W., & Hocevar, D. (1985). Application of confirmatory factor analysis to the study of self-concept: First- and higher-order factor models and their invariance across groups. *Psychological Bulletin, 97*, 562–582. https://doi.org/10.1037/0033-2909.97.3.562.

McCombs, B. L., & Marzano, R. J. (1990). Putting the self in self-regulated learning: The self as agent in integrating will and skill. *Educational Psychologist, 25*(1), 51–69.

McCombs, B. L., Daniels, D. H., & Perry, K. E. (2008). Children's and teachers' perceptions of learner-centered practices and student motivation: Implications for early schooling. *The Elementary School Journal, 109*(1), 16–35. https://doi.org/10.1086/592365.

Moos, D. C., & Ringdal, A. (2012). Self-regulated learning in the classroom: A literature review on the teachers' role. *Education Research International, 2012*. https://doi.org/10.1155/2012/423284 Article ID 423284.

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist, 42*, 173–190. https://doi.org/10.1080/00461520701416306.

Muthén, & Muthén (2011). *MPLUS (Version 6.11). [Computer Software].* Los Angeles: CA.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*, 317–328. https://doi.org/10.1080/0022027870190403.

Nisbett, R., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment.* NJ: Prentice-Hall: Englewood Cliffs.

Ohlsson, S. (2009). Resubsumption: A possible mechanism for conceptual change and belief revision. *Educational Psychologist, 44*, 20–40. https://doi.org/10.1080/00461520802616267.

Ohst, A., Glogger, I., Nückles, M., & Renkl, A. (2015). Helping preservice teachers with inaccurate and fragmentary prior knowledge to acquire conceptual understanding of psychological principles. *Psychology Learning & Teaching, 14*, 5–25. https://doi.org/10.1177/1475725714564925.

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology, 8*(422), 1–28. https://doi.org/10.3389/fpsyg.2017.00422.

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

Paris, S., & Paris, A. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist, 36*(2), 89–101. https://doi.org/10.1207/S15326985EP3602_4.

Pauli, C., Reusser, K., & Grob, U. (2007). Teaching for understanding and/or self-regulated learning? A video-based analysis of reform-oriented mathematics instruction in Switzerland. *International Journal of Educational Research, 46*(5), 294–305. https://doi.org/10.1016/j.ijer.2007.10.004.

Perry, N. E., Brenner, C. A., & MacPherson, N. (2015). Using teacher learning teams as a framework for bridging theory and practice in self-regulated learning. In T. J. Cleary (Ed.). *Self-regulated learning interventions with at-risk youth* (pp. 229–250). Washington, DC: American Psychological Association.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.). *Handbook of self-regulation* (pp. 451–502). San Diego, CA: Academic. https://doi.org/10.1016/B978-012109890-2/50043-3.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*, 211–227. https://doi.org/10.1002/sce.3730660207.

Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology, 87*, 282–292. https://doi.org/10.1037/0022-0663.87.2.282.

Renkl, A. (2009). Why constructivists should not talk about constructivist learning environments: A commentary on Loyens and Gijbels (2008). *Instructional Science, 37*, 495–498. https://doi.org/10.1007/s11251-009-9098-5.

Richardson, V., & Placier, P. (2001). Teacher change. In V. Richardson (Ed.). *Handbook of research on teaching* (pp. 905–947). (4th ed.). Washington, DC: American Educational Research Association.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology Review, 82*, 498–504. https://doi.org/10.1037/0022-0663.82.3.498.

Schommer-Aikins, M., Duell, O. K., & Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving, and academic performance of middle school students. *The Elementary School Journal, 105*, 289–304. https://doi.org/10.1086/428745.

Schunk, D. H., & Greene, J. A. (2018). *(Eds.). The handbook of self-regulation of learning and performance.* New York: Routledge.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Smith, J. P., diSessa, A. A., & Roschelle, J. (1994). Misconceptions Reconceived: A Constructivist Analysis of Knowledge in Transition. *Journal of the Learning Sciences, 3*(2), 115–163.

Spruce, R., & Bol, L. (2015). Teacher beliefs, knowledge, and practice of self-regulated learning. *Metacognition and Learning, 10*, 245–277. https://doi.org/10.1007/s11409-014-9124-0.

Stathopoulou, C., & Vosniadou, S. (2007). Exploring the relationship between physics related epistemological beliefs and physics understanding. *Contemporary Educational Psychology, 32*, 255–281. https://doi.org/10.1016/j.cedpsych.2005.12.002.

Torff, B., & Sternberg, R. J. (2001). Intuitive conceptions among learners and teachers. In B. Torff, & R. J. Sternberg (Eds.). *Understanding and teaching the intuitive mind: Student and teacher learning.* Mahwah, NJ: Erlbaum.

Trevors, G., Feyzi-Behnagh, R., Azevedo, R., & Bouchet, F. (2016). Self-regulated learning processes vary as a function of epistemic beliefs and contexts: Mixed method evidence from eye tracking and concurrent and retrospective reports. *Learning and Instruction, 42*, 31–46. https://doi.org/10.1016/j.learninstruc.2015.11.003.

Van Fleet, A. (1979). Learning to teach: The cultural transmission analogy. *Journal of Thought, 14*, 281–290.

Vosniadou, S. (2013). *International handbook of research on conceptual change* (2nd ed.). New York: Routledge.

Vosniadou, S. (2019). The development of students' understanding of science. *Frontiers in Education, 4*(32), https://doi.org/10.3389/Feduc.2019.00032.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24*, 535–585. https://doi.org/10.1016/0010-0285(92)90018-W.

Vosniadou, S., & Skopeliti, I. (2014). Conceptual change from the framework theory side of the fence. *Science & Education, 23*(7), 1427–1445.

Vosniadou, S., & Skopeliti, E. (2018). Evaluating the effects of analogy enriched text on the learning of science: The importance of learning indexes. *Journal of Research in Science Teaching.* https://doi.org/10.1002/tea.21523.

Vosniadou, S., Pobke, K., Heath, J., Van Deur, P., & Jeffries, D. (2017). Fostering the development of self-directed learners. *Paper Presented at the Annual Conference of the Australian Association for Research in Education.*

Warfield, J., Wood, T., & Lehman, J. D. (2005). Autonomy, beliefs and the learning of elementary mathematics teachers. *Teaching and Teacher Education, 21*(4), 439–456. https://doi.org/10.1016/j.tate.2005.01.011.

Winne, P. H. (2011). A cognitive and metacognitive analysis of self-regulated learning. In B. J. Zimmerman, & D. H. Schunk (Eds.). *Handbook of self-regulation of learning and performance* (pp. 15–32). New York: Routledge.

Wiser, M., & Smith, C. L. (2008). Learning and teaching about matter in grades K-8: When should the atomic-molecular theory be introduced? In S. Vosniadou (Ed.). *The international handbook of research on conceptual change* (pp. 205–239). New York: Routledge.

Woolley, S. L., Benjamin, W. J. J., & Woolley, A. W. (2004). Construct validity of a self-report measure of teacher beliefs related to constructivist and traditional approaches to teaching and learning. *Educational and Psychological Measurement, 64*, 319–331. https://doi.org/10.1177/0013164403261189.

Zimmerman, B. J. (1986). Development of self-regulated learning: Which are the key subprocesses? *Contemporary Educational Psychology, 16*, 307–313.

Zimmerman, B. J. (2001). Models of self-regulated learning and academic achievement. In B. J. Zimmerman, & D. H. Schunk (Eds.). *Self-regulated learning and academic achievement: Theoretical perspectives* (pp. 1–25). (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*, 64–70. https://doi.org/10.1207/s15430421tip4102_2.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166–183. https://doi.org/10.3102/0002831207312909.

Zohar, A. (2004). Elements of teachers' pedagogical knowledge regarding the instruction of higher order thinking. *Journal of Science Teacher Education, 15*(4), 293–312. https://doi.org/10.1023/B:JSTE.0000048332.39591.e3.