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Chapter 3

Beyond the dichotomy of teacher- versus student-focused education: A survey study on physics teachers' beliefs about the goals and pedagogy of physics education[2]

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ABSTRACT

This chapter aims to explore the content and structure of physics teachers' beliefs on teaching and learning in general in relation to their domain-specific beliefs, which has hardly been explored. A questionnaire was administered to a sample of 126 Dutch secondary school teachers in physics and measured beliefs about teaching and learning physics in secondary education (students aged 12-18) in the Netherlands. The questionnaire measured beliefs about teaching and learning in general (i.e., orientation towards instruction and beliefs about learning and the regulation of students' learning processes) and domain-specific beliefs (i.e., curriculum emphases in teaching physics). The results of this study showed that physics teachers' beliefs about the goals of education in general (i.e., orientation towards instruction) and beliefs about the goals of physics education (i.e., curriculum emphases) formed an interrelated belief system consisting of both content-oriented and student-oriented beliefs. Moreover, teachers agreed with the importance of both teacher-regulated and student-regulated learning. As a result, we argue that labels such as 'teacher-focused' and 'student-focused', which are often used in the educational literature, might be inappropriate for describing differences in teachers' belief systems and instructional practices.

3.1 INTRODUCTION

In the daily practice of teaching, beliefs play a significant role in shaping teachers' instructions. Beliefs about teaching and learning in general, as well as domain-specific beliefs, are deemed especially important in this respect (e.g., Richardson, 1996; Stipek, et al., 2001; Thompson, 1992). According to Jones and Carter (2007), teachers hold a complex web of attitudes and beliefs that influence more or less every aspect of teaching, "including knowledge acquisition and interpretation, defining and selecting instructional tasks, interpreting course content, and choices of assessment" (p. 1067). For this reason, teacher beliefs are examined with regard to a wide array of topics, such as teaching and learning (Meirink, et al., 2009), classroom management (Weinstein, 1998), the nature of knowledge and knowing (Hofer & Pintrich, 1997), and educational reforms (Luttenberg, Van Veen, & Imants, 2011).

According to Pajares (1992), beliefs are organized into a system: "beliefs are prioritized according to their connections or relationship to other beliefs" and "the filtering effect of belief structures ultimately screens, redefines, distorts, or reshapes subsequent thinking and information processing" (p. 325). Thus, in order to understand the specific role of beliefs in shaping teachers' instructional practices, we need to acquire insight into both content and structure of teachers' belief systems. Until now, empirical studies of teacher beliefs have mainly focused on one specific type of belief, for example about teaching, learning and instruction in general (e.g., Boulton-Lewis, 2001); epistemological beliefs (e.g., Duell & Schommer-Aikins, 2001); or domain-specific beliefs, such as (in the domain of science education) teachers' curriculum emphases (e.g., Van Driel, et al., 2008).

Some studies focused on belief structures by investigating relationships between different types of beliefs. However, the literature reports on findings that are not always in line with each other: Some studies found consistencies in teachers' belief systems whereas other studies showed that individual teachers held mixed and divergent beliefs. For example, Tsai (2002) studied science teachers' beliefs about teaching, learning, and science (N=37). He found that the majority of teachers held not only 'traditional' beliefs about teaching (e.g., "science is best taught by transferring knowledge from teacher to students") but also 'traditional' beliefs about learning (e.g., "learning science is reproducing knowledge from credible sources"). In addition, other teachers held 'constructivist' beliefs about both teaching and learning (e.g., "science is best taught by helping students construct knowledge" and "learning science is constructing personal understanding", respectively). Because many teachers were consistent in their beliefs, Tsai concluded that teachers' belief systems could be seen as *nested epistemologies*. In another study, Van Driel, Bulte, and Verloop (2007) explored the relationships between chemistry teachers' general beliefs about teaching and learning on the one hand and their domain-specific curricular beliefs (i.e., curriculum emphases) on the other. They identified two different belief structures, namely a combination of 1) subject-matter oriented educational beliefs and a 'fundamental chemistry' curriculum emphasis (i.e., the opinion that theoretical chemistry concepts should be taught first in order to provide a basis for understanding the natural world and students' future education) and 2) learner-centred educational beliefs and a 'chemistry, technology, and society' curriculum emphasis (i.e., the idea that technological and societal issues should play an explicit role within the chemistry curriculum). A large-scale study by Seung and colleagues (2011) on elementary pre-service teachers' beliefs about teaching and learning science (N=106) showed that many of the participants had both traditional and constructivist views. Furthermore, two teachers in the study of Tsai (2002) held 'divergent' beliefs (i.e., 'process' beliefs about teaching and 'constructivist' beliefs about learning science and vice versa). Finally, Bryan's (2003) study on one pre-service elementary teacher's belief system revealed that this system included 'foundational' beliefs (i.e., more central beliefs) and 'dualistic' beliefs. The foundational beliefs referred to the value of science and science teaching, the goals of science instruction and nature of scientific concepts, and control in the science classroom. The dualistic beliefs were about how children learn science, the students' role in science instruction, and the teacher's role in science instruction. According to Bryan, these dualistic beliefs formed two sets of compatible and intricately related beliefs.

Until now, however, little is known about the relations between different types of beliefs within a teacher's belief system. Therefore, the aim of this study is to explore the content and structure of teachers' beliefs about teaching and learning in general and their domain-specific beliefs. The present study was conducted in the context of Dutch secondary physics education (students aged 12-18).

3.2 THEORETICAL FRAMEWORK

3.2.1 Research on teacher beliefs

Research on teacher beliefs is complicated due to a lack of consensus about appropriate definitions of the construct of 'beliefs' as well as different perspectives on the relationship between knowledge and beliefs (Jones & Carter, 2007; Pajares, 1992). In general, scholars agree that teacher beliefs are organized into larger belief systems. In these systems, beliefs are related not only to other beliefs but also to cognitive and affective constructs such as self-efficacy, epistemologies, attitudes, and expectations (Jones & Carter, 2007; Lombaerts, et al., 2009; Pajares, 1992). Furthermore, some beliefs function as priorities or core beliefs, whereas others are more peripheral (Brownlee, et al., 2002; Hofer & Pintrich, 1997; Keys, 2003). In the literature teacher beliefs are sometimes distinguished from teacher knowledge (e.g., Den Brok, 2001), but this distinction remains somewhat arbitrary since in the mind of a teacher knowledge and beliefs are intertwined (Keys, 2003; Lombaerts, et al., 2009; Meijer & Van Driel, 1999; Pajares, 1992; Verloop, et al., 2001).

Another factor that enhances the complexity of research on teacher beliefs is the 'fact' that beliefs are often tacit (Pajares, 1992; Thompson, 1992). This means that teacher beliefs must be inferred, for example, by taking into account the congruence of teachers' belief statements, the intentionality to behave in a predisposed manner, and the actual behavior related to the belief in question (Kagan, 1990; Lombaerts, et al., 2009).

3.2.2 Assumptions about teacher beliefs

In the present study on teachers' beliefs about teaching and learning physics, we use the reviews of Pajares (1992) and Jones and Carter (2007) together with the work of Richardson (1996) and Calderhead (1996) to formulate some fundamental assumptions about teacher beliefs. These assumptions refer to the *stability*, *organization*, and *functionality* of teacher beliefs:

- Beliefs about teaching and learning (in general) are well established by the time (pre-service) teachers enter teacher education and start their educational careers. As a consequence, teacher beliefs tend to be relatively stable and resistant to change. This is particularly true for teachers with many years of teaching experience. In contrast, pre-service and novice teachers' beliefs seem less resistant to change. Moreover, limited pedagogical and content knowledge may hinder a change of teachers' beliefs (*stability*).
- Teacher beliefs are part of larger belief systems. These systems contain *beliefs about teaching and learning in general* (e.g., conceptions of learning and beliefs about a range of topics such as the regulation of students' learning processes, goals of education, the nature of knowing and knowledge development, assessment, and so on) and *domain-specific beliefs* (e.g., beliefs about the nature of the subject, curricular goals, instructional strategies for teaching particular content, and so on) (*organization*).
- Teacher beliefs play a key role in knowledge interpretation and cognitive monitoring. The processing of new information is mediated by these beliefs because they function as perceptual filters. Moreover, beliefs serve as mental exemplars for constructing and evaluating teachers' own teaching practices (*functionality*).

3.3 LITERATURE REVIEW

3.3.1 Research on science teachers' beliefs about teaching and learning science

Metaphors to describe teachers' beliefs about teaching and learning in general

In the domain of science education, research on teachers' beliefs about teaching and learning science reveals that these beliefs comprise a wide array of topics. For instance, Simmons and colleagues (1999) found that beginning science (and mathematics) teachers hold a range of beliefs about how to interact with subject content and processes, what activities to employ in the classroom, what teaching is all about, and how they perceived themselves as classroom teachers.

In order to explore these beliefs and the assumptions that teachers apply to their teaching practices, *metaphors* have proved to be useful (Jones & Carter, 2007). For example, Buaraphan (2011) investigated beginning teachers' beliefs about teaching and learning science in Thailand (N=110). He found that the participants mostly used the following four metaphors to express their *beliefs about teaching and learning in general*, namely the teacher as a 'nurturer/cultivator', 'knowledge provider', 'superior authoritative figure', and 'cooperative, democratic figure'. The metaphor of 'nurturer/cultivator' represents the belief that a teacher should nourish students' potential capabilities within a caring environment because the student is a developing organism and learning occurs when students develop at their own pace. The 'knowledge provider' metaphor refers to the opinion that a teacher should transmit knowledge to students because learning occurs when students, as passive recipients of knowledge, accumulate this knowledge. The metaphor of the teacher as a 'superior, authoritative figure' reflects that idea that a teacher should control the learning process because learning occurs when students follow instruction and obey the teacher. Finally, the 'cooperative, democratic figure' metaphor represents the belief that a teacher should coordinate the learning activities in the classroom in such a way that students, as active participants in the community of practice, could learn in a process of collaborative knowledge construction (together with the teacher).

Science teachers' beliefs about teaching and learning science

The four metaphors seem to reflect the findings of other studies on teacher beliefs about teaching and learning science. For instance, Yerrick & Hoving (2003) conducted a study among 32 pre-service earth science teachers and found that they viewed teaching primarily as 'disseminating facts'. In addition, Markic and Eilks (2012), following the quantitative and qualitative data of 36 physics pre-service teachers, concluded that the majority of the participants held 'traditional' beliefs. These teachers expressed the opinion that they should control classroom activities and that learning is passive and controlled by a dissemination of knowledge. In this respect, a teaching style in which the teacher lectures and the students watch and listen was preferred. Furthermore, Tsai (2002) interviewed 37 science teachers who worked in secondary education. The majority of the interviewees expressed 'traditional' beliefs about teaching and learning science: they thought that the best way to teach science is to transfer knowledge from teacher to students and that science is learned by acquiring and reproducing knowledge from credible sources. However, some teachers held 'constructivist' beliefs, namely indicating that teachers should teach science by helping students construct knowledge because learning science was seen as constructing personal understanding. Moreover, Simmons et al. (1999) investigated the beliefs of 116 science and mathematics teachers and found that the majority of teachers "wobbled" in their beliefs about teaching and learning: they possessed both 'teacher-centered' and 'student-centered' beliefs. The 'teacher-centered' beliefs reflected the idea that the teacher is responsible for organizing, delivering, and transmitting content knowledge to students by employing primarily teacher-directed instructional methods with minimal student input. The 'student-centered' beliefs referred to the idea that students are primarily responsible for acquiring and processing their own knowledge and that they gain (content) knowledge through active participation in group work, hands-on activities, laboratory investigations, and project work. In this learning process, the teacher acts as a guide and facilitator. To summarize, the beliefs expressed in the study of Yerrick and Hoving (2003) together with the traditional and teacher-centered beliefs identified in the other three studies (mentioned above) seem to be captured best by the metaphors of the teacher as 'knowledge provider' and 'superior, authoritative figure'. With respect to the latter two studies, it seems that the constructivist and student-centered beliefs are reflected in the metaphors of the teacher as 'nurturer/cultivator' and 'cooperative, democratic figure'.

Besides these beliefs about teaching and learning in general, some teachers participating in the studies of Tsai (2002) and Simmons et al. (1999) expressed *domain-specific* beliefs. For example, Tsai found that four teachers held 'process' beliefs about teaching and learning science, namely that science education should focus on the processes of science and problem-solving procedures. Likewise, Simmons and colleagues found that some teachers expressed beliefs related to a 'conceptual teaching style'. These teachers held the idea that science education should focus primarily on (students' understanding of) the key concepts of content and the processes of science, for instance by emphasizing the explanatory nature of science, focusing lab sessions and demonstrations on concepts, attempting to change students' unscientific ideas, focusing on the connections within the conceptual framework of scientific knowledge, encouraging students to ask procedural and conceptual questions, and so on.

3.3.2 Teacher beliefs about teaching and learning in general

The four metaphors mentioned above reflect teachers' beliefs about teaching and learning in general, particularly their beliefs about 1) the *goals of education in general* (e.g., to provide, transmit and disseminate knowledge to students or to nourish students' capabilities and to stimulate their personal development), 2) *learning* (e.g., passively receiving and accumulating knowledge or actively constructing knowledge), and 3) the *regulation of students' learning processes* (e.g., the teacher should control the learning process and the students should obediently follow the instruction or teacher and students collaborate while the teacher coordinates the learning activities in the classroom).

First, teachers' beliefs about the goals of education in general refer to the goals that are considered important in terms of general development and schooling (cf. Van Veen, et al., 2001). The literature reveals that these beliefs can usually be divided into two 'orientations', namely an orientation towards 1) *qualification and schooling* (i.e., a focus on students' qualifying for further education and jobs in terms of the necessary knowledge and skills) and 2) *personal and moral development of students in general* (i.e., a focus on guiding students to adulthood and preparing them for functioning in a democratic society) (Denessen, 1999; Van Veen, et al., 2001). These orientations are often reflected in the way that teachers prepare, practice, and evaluate instruction. In other words, a specific 'orientation towards the goals of education' is often reflected in a particular 'orientation towards instruction'. According to Van Veen and colleagues (2001), there are generally two prototypical ideologies that underlie these 'orientations towards instruction'. In the first place, some teachers hold *content-oriented* beliefs, which place a strong emphasis on imparting subject matter and on knowledge reproduction by students. In the second place, other teachers hold *learning-oriented* beliefs, which focus on supporting student learning (cf. Meirink, 2007).

Second, with regard to teachers' beliefs about learning, the literature shows two fundamentally different conceptions of learning (Meirink, et al., 2009; Scott, et al., 2007). The first conception perceives learning as *acquisition*: it involves the mastery of new knowledge and skills, for instance by knowledge reproduction, in order to fill 'knowledge-gaps'. The second conception regards learning as *construction/participation*. In this respect, learners are seen as active constructors of their own knowledge; they make sense of the world and learn by participating in authentic and meaningful learning activities. The latter conception is related to a paradigm shift from cognitive to social-constructivist accounts of learning in the past three decades (Palincsar, 1998). Social-constructivist theories view learning and understanding as inherently social. As a consequence, cultural activities and tools such as artefacts, symbol systems, and language are seen as conditions for conceptual development. According to Palincsar, this paradigm shift led to an increased focus on the process of personal construction of meaning and the active construction of knowledge by students (cf. Hermans, Van Braak, & Van Keer, 2008; Kember, 1997; Trigwell & Prosser, 2004).

Third, beliefs about the regulation of students' learning processes are often divided into beliefs favoring either *teacher-regulated learning* or *student-regulated learning* (Meirink, et al., 2009; Pintrich, 2004). Teacher-regulated learning refers to a situation whereby the teacher actively regulates and evaluates students' learning processes, for instance by determining learning goals and the sequence of learning activities or providing structure in lesson content. In addition, teachers who favour teacher-regulated learning might also prefer instructional strategies that promote the transmission of knowledge, such as lecturing and reproducing knowledge. In contrast, student-regulated learning refers to the situation whereby learners, to a greater or lesser extent, control, monitor, and regulate certain aspects of their own learning process (e.g., students are formulating their own learning goals) (Azevedo, 2009; Lombaerts, et al., 2009; Patrick & Middleton, 2002; Winne, 2010). Due to the paradigm shift mentioned before, notions of 'learning to learn', students' active participation in learning activities, shared responsibilities in both setting and achieving learning goals, and 'lifelong learning' gained prominence and led to the promotion of self-regulated learning (e.g., Del Río & Álvarez, 2002; Wells & Claxton, 2002). In this respect, the teacher primarily acts as a guide and facilitator (Meirink, et al., 2009).

3.3.3 Domain-specific teacher beliefs

Apart from beliefs about teaching and learning in general, teachers also possess domain-specific beliefs. The findings of the studies of Tsai (2002) and Simmons (1999) suggest that these beliefs (i.e., 'process' beliefs and beliefs related to a 'conceptual teaching style) are related to the domain-specific goals of the science curriculum. The review of Bybee and DeBoer (1994) showed that three major goals have shaped the content of science curricula and instructional practices in the past four decades, namely 1) understanding scientific knowledge, 2) understanding and using scientific methods, and 3) promoting students' personal-social development. It is possible that these major goals are reflected (to some extent) in teachers' domain-specific beliefs about teaching and learning science.

According to Van Driel and colleagues (2008), teachers often have a particular intent or purpose in teaching subject matter; they "not only want their students to learn specific subject matter, but also aim at more general science learning goals that lie beyond the subject itself" (p. 108). These more general objectives are termed *curriculum emphases* (Roberts, 1982) and "provide an answer to the student question: 'Why am I learning this?" (Roberts, 1982, p. 245 cited in Van Driel et al., 2008). Van Driel and colleagues combined and clustered the seven curriculum emphases distinguished by Roberts, and investigated chemistry teachers' curriculum emphases by means of the following scales: 1) *fundamental chemistry* (i.e., the idea that theoretical notions should be taught first because these are needed for students' future schooling and can provide a basis for understanding the natural world), 2) *chemistry, technology and society* (focusing on relations between applications of chemical and technological knowledge and students' personal lives or the decisions they make), and 3) *knowledge development in chemistry* (i.e., the development of scientific skills and of an understanding of the nature of chemical knowledge and its developmental process). In line with this, De Putter-Smits and colleagues (2011) rephrased the domain-specific items of this questionnaire in order to measure, among other things, teachers' curriculum emphases in teaching the subject *science*. They found that on average Dutch physics teachers (N=95) agreed to a larger extent with the *fundamental science* curriculum emphasis than with *science, technology and society*.

3.4 RESEARCH QUESTIONS

In this study we explored the content and structure of physics teachers' belief systems by focusing on 1) their beliefs about teaching and learning in general and 2) their domain-specific beliefs. We narrowed the focus by formulating the following two research questions:

1. What is the content of physics teachers' 1) *beliefs about teaching and learning in general* (i.e., orientation towards instruction as well as the goals of education, and beliefs about learn-

ing and the regulation of students' learning processes) and 2) *domain-specific beliefs* (i.e., curriculum emphases in teaching physics)?
2. What relations and/or patterns can be identified between the beliefs mentioned in 1?

3.5 METHOD

In order to explore the content of physics teachers' beliefs we conducted a survey study among physics teachers teaching in secondary education (students aged 12-18) in the Netherlands.

3.5.1 Data collection

Sample and procedure

Data were gathered by means of a sample from another study conducted in spring 2010, in which we used the directory of the Dutch *Digischool* online educational community network as a starting point for sampling (see Chapter 4). Of this sample 223 physics teachers did previously indicate that they were willing to participate in a follow-up study. In March 2011 we sent them an invitation letter with a personal identification number and a link to the online version of a questionnaire measuring 1) beliefs about teaching and learning in general (i.e., orientation towards instruction as well as the goals of education) and 2) domain-specific beliefs (i.e., curriculum emphases). The identification number made it possible to relate teachers' responses in the present study to data gathered in the previous study, in which we measured, among other aspects, beliefs about learning (i.e., knowledge construction versus knowledge reproduction) and the regulation of students' learning processes. A total of 158 teachers (70.9%) responded to our invitation; the useful response was 126 (56.5%). General characteristics of the respondents are summarized in Table 3.1.

Instruments

Teachers' beliefs about teaching and learning in general and their domain-specific beliefs were investigated by using shortened and/or adapted versions of three existing Dutch instruments.

First, we measured teachers' orientation towards instruction and the goals of education by using a shortened version (15 items) of a questionnaire developed by Van Veen and colleagues (2001). The questionnaire contained *learning-oriented*, *moral-oriented,* and *transmission/ qualification-oriented* items. The *learning-oriented* items represented a focus on the learner's construction of knowledge and on teaching methods that emphasize both the students' responsibility for their own learning processes and cooperation with peers; the *moral-oriented* items represented a focus on students' general and moral development (i.e., the teacher attempts to guide students into adulthood by moral education and stimulating a critical attitude); and the *transmission/qualification-oriented* items referred to a focus on the transmission

Table 3.1. *General characteristics of the physics teachers in the survey study (N=126)*

Variable	Categories	Frequency	Percentage
Gender	Male	109	86.5
	Female	17	13.5
Age	19-25 years	1	0.8
	26-35 years	26	20.6
	36-50 years	46	36.5
	51-65 years	51	40.5
	> 65 years	2	1.6
Years of teaching experience	0-2 years	9	7.1
	3-5 years	16	12.7
	6-10 years	35	27.8
	11-20 years	22	17.5
	> 20 years	44	34.9
Previous education of teacher	Category 1: Teacher education physics - *Higher vocational education*	45	35.7
	Category 2: Teacher education physics - *University Master's degree*	43	34.1
	Category 3: No teacher education physics – *Physics University Master's degree and/or other previous education*	36	28.6
	Category 4: Unknown	2	1.6

of core-subject knowledge and teaching methods that emphasize qualification, attainment, and schooling functions.

Second, teachers' beliefs about learning and the regulation of students' learning processes were measured by using a shortened version (28 items) of an instrument developed by Meirink and colleagues (2009). This instrument contained items representing beliefs about both *knowledge construction* and *knowledge reproduction* in order to investigate teachers' beliefs about learning. In addition, teachers' beliefs about the regulation of students' learning processes were measured by statements representing beliefs about either *teacher-* or *student-regulation* of learning processes.

Third, teachers' curriculum emphases were investigated by using a shortened and adapted version (i.e., items were adapted to physics content (cf. De Putter-Smits, et al., 2011)) of the questionnaire developed by Van Driel and colleagues (2008). The questionnaire (13 items) contained items representing the *fundamental physics* (FP), *physics, technology and society* (PTS), and *knowledge development in physics* (KDP) emphases. *Fundamental physics* refers to the idea that theoretical notions, in particular those about the corpuscular nature of physics subject matter, are taught first, because such notions can provide a basis for understanding the natural world and are also needed for students' future education. The emphasis *physics, technology, and society* represents the idea that practical applications of physics as well as technological knowledge are often related to students' personal lives, in the sense that it is assumed that these applications are interrelated with students' decisions. *Knowledge development in physics* refers to the idea that students are expected to develop scientific skills, for instance by reflection activities that promote their understanding of the nature of physics knowledge and how it is developed (cf. De Putter-Smits, et al., 2011; Van Driel, et al., 2008).

All items of the questionnaires had to be scored on a five-point Likert scale, ranging from 1 'totally disagree', through 3 'neither agree, nor disagree', to 5 'totally agree'. Some examples of the questionnaire items, translated from the Dutch, are presented in Appendix 2.

3.5.2 Data analysis

Because we used adapted versions of existing questionnaires, (i.e., we selected those items that were relevant for secondary physics education, and questionnaire items were sometimes adapted to physics content), we were interested to see if our data revealed the same factor structure as found by Van Veen et al. (2001), Meirink et al. (2009), and Van Driel et al. (2008). For this reason, we analyzed our data by conducting Principal Axis Factoring on the answers to the items from the different parts of the questionnaire. In order to determine the factor structure at item level we used Varimax with Kaiser Normalization as rotation method. Since oblique rotation resulted in the same factor structure at item level, further analyses were conducted on the basis of an orthogonal factor structure. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) showed satisfactory results. Items that did not fit (i.e., items with factor loadings of less than .30) or ambiguous items (i.e., items with factor loadings on multiple scales and differences between these factor loadings are ≤ .05) were excluded from further analysis. In addition, we created scales based on the factor structure and conducted a reliability analysis on each of the scales by computing Cronbach's alpha coefficient scores; items that threatened reliability were eventually removed. After computing the mean scores for each of the scales identified, we conducted a two-way ANOVA, in order to compare means among different groups of respondents; here we used background variables such as *gender*, *age*, *years of teaching experience*, and *previous education* as grouping factor.

To investigate patterns within physics teachers' belief systems we conducted the following analyses: 1) computation of bivariate Pearson correlations between mean scale scores to investigate the relationships between physics teachers' beliefs about teaching and learning in general and their domain-specific beliefs, 2) hierarchical cluster analysis to investigate distinctive patterns in teacher beliefs, and 3) the creation of a difference variable, indicating the extent to which a teacher has relatively higher mean scores on one of the scales measuring orientation towards instruction and the goals of education than on the other. This difference variable functioned as a grouping factor for comparing the mean scale scores of the other scales.

3.6 RESULTS

3.6.1 The underlying factor structure of teachers' beliefs

With reference to teachers' *orientation towards instruction and the goals of education*, two different factors were extracted, explaining 37.40% of the total variance; two items were excluded from further analysis. The first factor was called 'learning-/moral-oriented' (LMO, 9 items, α=.81, N=126), and the second was labeled 'transmission-/qualification-oriented' (TQO, 4 items, α=.79, N=126).

Furthermore, with regard to teachers' *beliefs about learning and the regulation of students' learning processes*, three different factors were extracted, explaining 29.80% of the total variance; three items were excluded from further analysis. The first factor referred to 'student-regulated learning and knowledge construction' (SRLCON, 14 items, α=.80, N=126), the second was called 'knowledge reproduction' (REP, 4 items, α=.78, N=126), and the third factor indicated 'teacher-regulated learning' (TRL, 7 items, α=.70, N=126).

With respect to teachers' *curriculum emphases in teaching physics*, three factors were extracted, explaining 38.50% of the total variance; two items were excluded from further analysis. These three factors corresponded to the three original scales used in the existing instruments of Van Driel and colleagues (2008) and De Putter-Smits and colleagues (2011). The first factor referred to the curriculum emphasis of 'physics, technology, and society' (PTS, 4 items, α=.73, N=126), the second factor was labeled 'fundamental physics' (FP, 3 items, α=.73, N=126), and the third factor was associated with the 'knowledge development in physics' emphasis (KDP, 4 items, α=.62, N=126). Tables 3.2a, 3.2b, and 3.2c show the accompanying rotated factor matrices. The first column contains the scale items we eventually used in further analyses, the other columns show the factor loadings of each item per factor.

Table 3.2a. *Rotated factor matrix (rotation converged in three iterations): Orientation towards instruction and the goals of education (N=126)*

Scale	***Factor***	
Item	*1*	*2*
LMO 1	.679	
LMO 2	.605	
LMO 3	.605	
LMO 4	.596	
LMO 5	.584	.371
LMO 6	.574	
LMO 7	.542	
LMO 8	.451	
LMO 9	.433	
-	.368	.327
-		
TQO 1		.771
TQO 2		.762
TQO 3		.660
TQO 4		.558

Table 3.2b. *Rotated factor matrix (rotation converged in five iterations): Beliefs about learning and the regulation of students' learning processes (N=126)*

Scale		***Factor***	
Items	*1*	*2*	*3*
SRLCON 1	.699		
SRLCON 2	.546		
SRLCON 3	.499		
SRLCON 4	.494		
SRLCON 5	.492		
SRLCON 6	.491		-.347
SRLCON 7	.490		
SRLCON 8	.467		
SRLCON 9	.450	-.359	
SRLCON 10	.438		
SRLCON 11	.438		
SRLCON 12	.407		
SRLCON 13	.361		
SRLCON 14	.339		

Table 3.2b. *Rotated factor matrix (rotation converged in five iterations): Beliefs about learning and the regulation of students' learning processes (N=126)* (continued)

Scale		***Factor***	
Items	*1*	*2*	*3*
REP 1		.690	
REP 2		.668	
REP 3		.633	
REP 4		.584	
-			
TRL 1			.560
TRL 2			.555
TRL 3			.529
TRL 4		.389	.513
TRL 5			.489
TRL 6			.466
TRL 7			.378
-		.328	.369

Table 3.2c. *Rotated factor matrix (rotation converged in five iterations): Curriculum emphases in teaching physics (N=126)*

Scale		***Factor***	
Items	*1*	*2*	*3*
PTS 1	.836		
PTS 2	.798		
PTS 3	.499		
PTS 4	.428		
FP 1		.755	
FP 2		.693	.302
FP 3		.568	
KDP 1			.617
KDP 2			.585
KDP 3			.563
-	.340		.366
KDP 4			.332
-			

3.6.2 Means and standard deviations of questionnaire scales

An overview of the descriptive statistics of the various questionnaire scales is presented in Table 3.3. Questionnaire items were scored on a five-point Likert scale, namely: 1=totally disagree, 2=disagree, 3=neither agree, nor disagree, 4=agree, and 5=totally agree.

Table 3.3 reveals that on average our respondents agreed not only with the statement that instruction and education should be focused on students' construction of knowledge and their moral development in general (M_{LMO}=4.04, *SD*=.45), but also that education is about the transmission of core subject knowledge and students' qualifying for higher education (M_{TQO}=4.09, *SD*=.53). Furthermore, physics teachers' beliefs about learning and the regulation of students' learning processes were on average characterized by an agreement with not only the importance of student-regulated learning and knowledge construction (M_{SRLCON}=3.83, *SD*=.40), but also the importance of teacher-regulated learning, for instance by giving clear explanations, showing the causes of mistakes, and helping students to prepare for assessments (M_{TRL}=3.44, *SD*=.51). In addition, the teachers in this sample on average thought that knowledge reproduction, such as memorizing, was not important for learning physics content (M_{REP}=2.30). However, we found a larger deviation on this scale (*SD*=.69) than on the other questionnaire scales. With regard to our respondents' curriculum emphases, no explicit preference was found. The teachers in this study thought on average that all three curriculum emphases were important (M_{PTS}=3.87, *SD*=.60; M_{FP}=3.99, *SD*=.62; M_{KDP}=3.77, *SD*=.59).

We investigated mean differences between scale scores by conducting a series of two-way ANOVAs. Here, background variables such as age, years of teaching experience, and teachers' previous education were used as grouping factors. For the variable gender we conducted a *t*-test to investigate mean differences. We found a significant main effect of previous education

Table 3.3. *Descriptive statistics of questionnaire scales (N=126)*

Beliefs	Scale description	n items	Cronbach's alpha	N	M	SD
Orientation towards Instruction and the goals of Education (OIE)	Learning-/Moral-oriented (LMO)	9	.81	126	4.04	.45
	Transmission-/Qualification-oriented (TQO)	4	.79	126	4.09	.53
Learning and the Regulation of students' learning processes (L&RL)	Student-regulated learning and knowledge construction (SRLCON)	14	.80	126	3.83	.40
	Knowledge reproduction (REP)	4	.78	126	2.30	.69
	Teacher-regulated learning (TRL)	7	.70	126	3.44	.51
Curriculum Emphases in teaching Physics (CurEm)	Physics, Technology and Society (PTS)	4	.73	126	3.87	.60
	Fundamental Physics (FP)	3	.73	126	3.99	.62
	Knowledge Development in Physics (KDP)	4	.62	126	3.77	.59

on the TQO-scale (F(2,110)=6.881, p=.002, partial η^2=.111). Post hoc comparisons were conducted by using Tukey HSD, since Levene's test of equality of error variances was not significant (F(11, 110)=1.285, p=.243). We found that those teachers who had done their (physics) teacher training at an institute of higher vocational education (N=45) on average scored lower on the TQO-scale (M_{TQO}=3.82, SE=.08) than the teachers who had done their training at university level (M_{TQO}=4.22, SE=.08; N=43), and the teachers either without teacher training or with another type of schooling (M_{TQO}=4.17, SE=.10;) N=36), see Table 3.1. No other significant main effects and interaction effects were found.

3.6.3 Bivariate Pearson correlations between the mean scale scores

In order to investigate relations between physics teachers' beliefs about teaching and learning in general and their domain-specific beliefs, we computed bivariate Pearson correlations between teachers' mean scale scores. Significant correlations are shown in Table 3.4.

We used the following rule of thumb to determine the strength of a relationship: < .30 were 'weak' correlations, correlations ≥ .30 and < .50 were called 'moderate', and correlations ≥ .50 were seen as a 'strong' relationship (Weinberg & Knapp Abramowitz, 2002). With regard to *beliefs about teaching and learning in general*, we found a moderate positive relation (.304) between the two scales measuring orientation towards instruction and the goals of education. This means that teachers who agreed with learning-/moral-oriented (LMO) items, on average, also tended to agree with transmission-/qualification-oriented (TQO) items. Other significant correlations were weak and in most cases positive.

With regard to *domain-specific beliefs*, a moderate positive correlation (.331) was found between the 'fundamental physics' (FP) and 'knowledge development of physics' (KDP) curriculum emphases. In other words, teachers who thought that it is important to teach theoretical notions first in order to provide a basis for understanding the world, also tended on average to hold the belief that it is important for students to develop scientific skills, as well as to construct knowledge in order to understand the nature of knowledge development in physics.

With respect to *relations between beliefs about teaching and learning in general and curriculum emphases in teaching physics*, we found a strong positive correlation (.528) between transmission-/qualification-oriented beliefs (TQO) and the 'fundamental physics' (FP) curriculum emphasis, and a moderate positive correlation (.346) between learning-/moral-oriented beliefs (LMO) and the 'physics, technology, and society' (PTS) emphasis. In addition, moderate positive correlations were found between the 'knowledge development in physics' (KDP) curriculum emphasis on the one hand, and the orientation towards instruction and the goals of education on the other (i.e., KDP and LMO =.304; KDP and TQO =.398). The other significant correlations found were weak.

Table 3.4. *Bivariate Pearson correlation matrix of mean scale scores (N=126)*

		LMO	TQO	SRLCON	REP	TRL	PTS	FP	KDP
Orientation towards instruction and the goals of education (OIE)	Learning & Moral-oriented (LMO)	1							
	Transmission / Qualification-oriented (TQO)	.304**	1						
Beliefs about Learning and Regulation of students' learning processes (L&RL)	Student-regulated learning and knowledge construction (SRLCON)	.239**	-.182*	1					
	Knowledge reproduction (REP)		.181*	-.195*	1				
	Teacher-regulated learning (TRL)		.196*		.225*	1			
Curriculum Emphases in teaching Physics (CurEm)	Physics, Technology and Society (PTS)	.346**					1		
	Fundamental Physics (FP)	.185*	.528**	-.288**	.194*		.192*	1	
	Knowledge Development in Physics (KDP)	.304**	.398**				.183*	.331**	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

3.6.4 Identifying patterns in teachers' beliefs

We conducted a hierarchical cluster analysis on teachers' scale scores representing beliefs about teaching and learning in general (i.e., LMO, TQO, SRLCON, REP, and TRL) and domain-specific beliefs (i.e., curriculum emphases PTS, FP, and KDP) by means of Ward's cluster method; we chose this particular method because descriptive statistics of the questionnaire scales showed relatively small standard deviations (Norusis, 2010). However, it was difficult to interpret the characteristics and mean differences of the clusters that were found.

Since the literature suggests that there is a relation between content-oriented beliefs and teacher-regulated learning on the one hand, and learning-oriented beliefs and student-regulated learning on the other (see section 3.3.2), we were interested in finding patterns in the way teachers scored the items on specific scales. In particular, we wondered if teachers with a higher mean score on the TQO scale than the LMO scale 1) considered teacher regulation (TRL) to be more important than student-regulated learning and construction of knowledge (SRLCON), and 2) regarded the 'fundamental physics' (FP) curriculum emphasis to be more important than 'physics, technology and society' (PTS), and vice versa. Thus, we created a new variable by computing the difference between a teacher's mean scores on the two scales measuring orientation towards instruction and the goals of education (LMO and TQO). With regard to the newly created variable, the absolute difference score indicated the extent to which a teacher valued one scale over the other. We decided that difference scores ranging from |0 through .50| indicated that neither scale was considered more important, whereas difference scores of more than |.50| indicated that one scale was valued over the other.

Inspection of the difference scores for the LMO and TQO scales resulted in the identification of three groups of teachers. Teachers belonging to group A (N=29) had higher mean scores on the TQO-scale than on the LMO scale, group B teachers (N=79) had relatively equal scores on both scales, and teachers in group C (N=16) had higher mean scores on the LMO scale than on the TQO scale. Mean scale scores for each group are presented in Table 3.5 and Figure 3.1 is a graphical representation of these means on each of the questionnaire scales.

The majority of teachers belonged to group B (N=79). Although on average these teachers had equal mean scores for the scales representing learning-/moral-oriented and transmission-/qualification-oriented beliefs (M_{LMO}=M_{TQO}=4.07), they showed a stronger agreement with statements about the importance of student-regulated learning and knowledge construction (M_{SRLCON}=3.82) than with statements about the importance of teacher-regulated learning (M_{TRL}=3.43). In addition, for statements about 'knowledge reproduction' they mostly chose the 'disagree' option (M_{REP}=2.34).

Table 3.5. *Group means on questionnaire scales (N=124)*

Beliefs	**Questionnaire scales**	*Group A (N=29)*	*Group B (N=79)*	*Group C (N=16)*
OIE	Learning-/moral-oriented (LMO)	3.70	4.07	4.51
	Transmission-/qualification-oriented (TQO)	4.45	4.07	3.50
L&RL	Student-regulated learning and knowledge construction (SRLCON)	3.68	3.82	4.18
	Knowledge reproduction (REP)	2.32	2.34	2.05
	Teacher-regulated learning (TRL)	3.48	3.43	3.36
CurEm	Physics, technology and society (PTS)	3.58	3.93	4.11
	Fundamental physics (FP)	4.11	4.05	3.44
	Knowledge development in physics (KDP)	3.79	3.80	3.58

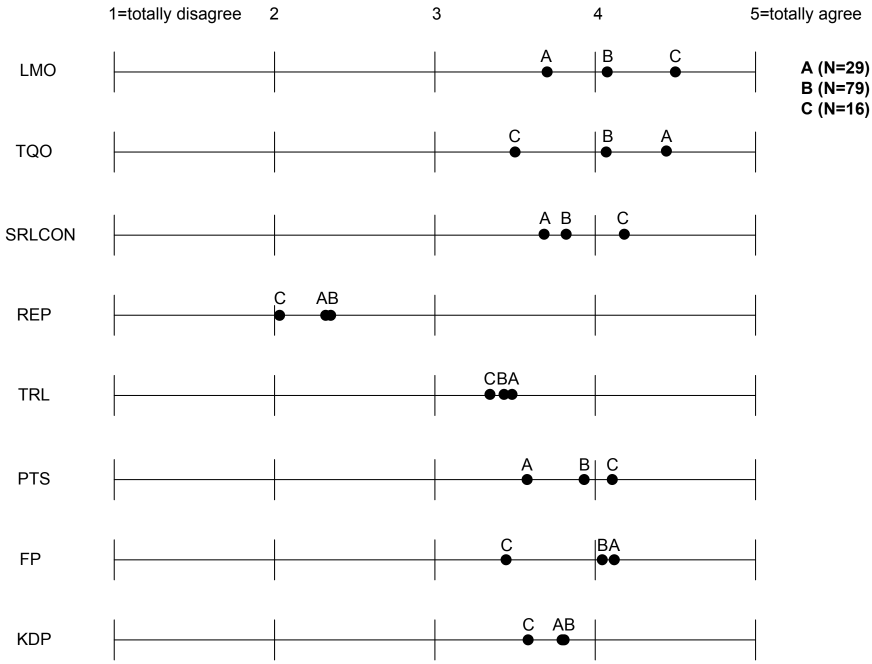

Figure 3.1. Group means on the various questionnaire scales (N=124)

Teachers in group A (N=29) differed from those in groups B and C in their strong orientation on transmission/qualification (M_{TQO}=4.45). This orientation was reflected in a stronger preference for the 'fundamental physics' curriculum emphasis (M_{FP}=4.11) compared to the other two emphases. Remarkably, despite the fact that teachers in group A were strongly transmission-/qualification-oriented, they still had higher scores on the scale representing beliefs about student-regulated learning and knowledge construction (M_{SRLCON}=3.68) than on the scale associated with beliefs about teacher-regulated learning (M_{TRL}=3.48). However, group means on the SRLCON scale were the lowest for group A as compared to the other two groups.

With regard to group C (N=16), these teachers differed from those in groups A and B in their stronger agreement with learning-/moral-oriented statements (M_{LMO}=4.51). This preference was strengthened by a stronger agreement with items reflecting beliefs in favor of student-regulated learning and knowledge construction (M_{SRLCON}=4.18) as well as a stronger disagreement with statements reflecting beliefs in favor of knowledge reproduction (M_{REP}=2.05) compared to groups A and B. Despite their strong agreement with learning-/moral-oriented items, on average, teachers in group C still agreed with items reflecting the importance of teacher-regulated learning (M_{TRL}=3.36).

3.7 CONCLUSIONS AND DISCUSSION

3.7.1 Conclusions

One of the main conclusions of this study, which provided an answer to the first research question, is that on average physics teachers held both learning-/moral-oriented (LMO) and transmission-/qualification-oriented (TQO) beliefs. They also agreed on the importance of student-regulated learning and knowledge construction (SRLCON), as well as the importance of teacher-regulated learning (TRL). Moreover, the teachers in this sample had no explicit preference for one of the curriculum emphases (FP, PTS, KDP); they thought that all three curriculum emphases were important. It was difficult to make a meaningful interpretation of the differences in beliefs that were found based on either the mean scores of the belief scales or by taking background variables such as gender, age, and years of teaching experience into account. On average, the physics teachers held similar beliefs concerning what goals of education, both in general and domain-specific, and what types of regulation were important in the context of physics education.

Another main conclusion, which provided an answer to the second research question, is that teachers' orientations towards instruction and the goals of education (TQO and LMO) were significantly related to the three curriculum emphases in teaching physics. We found a strong positive correlation between the scale measuring transmission-/qualification-oriented (TQO) beliefs and the 'fundamental physics' (FP) curriculum emphasis. The other significant correlations were moderate and positive. Thus, this study showed that the beliefs of physics teachers about the goals of education in general and their domain-specific beliefs about the goals of physics education (i.e., curriculum emphases) formed an interrelated belief system. However, the relations between these beliefs and beliefs about the regulation of students' learning processes were less clear-cut: these correlations were only weak or non-significant (see Figure 3.2).

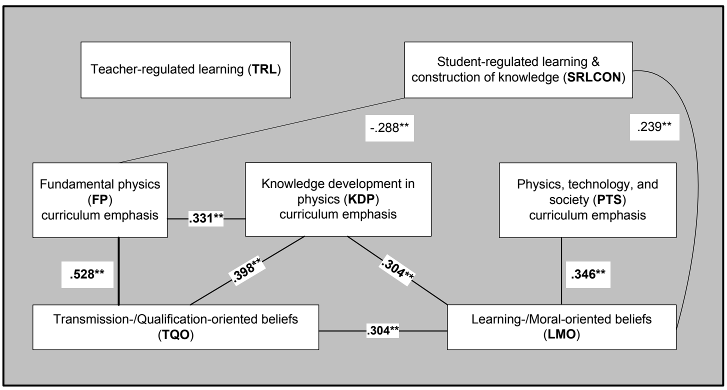

Figure 3.2. Graphic representation of bivariate Pearson correlations (that are significant at the .01 level, marked with **) between teachers' beliefs about the goals of physics education and the regulation of students' learning processes (N=126)

3.7.2 Discussion

When exploring the patterns in teachers' beliefs about teaching and learning in general we noticed some differences in the way teachers scored on specific scales. We found that the majority of teachers (group B, N=79) had roughly equal mean scores on the TQO and LMO scales (cf. Geelan, Wildy, Louden, & Wallace, 2004). In addition, even if teachers showed stronger agreement with one of the two scales (groups A and C), they had, on average, 1) higher individual mean scale scores on the scale measuring beliefs about student-regulated learning and knowledge construction (SRLCON) than on the scale representing beliefs about teacher-regulated learning (TRL), and 2) roughly equal group means on the TRL scale (see Table 3.5). Thus, our findings suggest that the orientation towards instruction and the goals of education, as well as beliefs about learning and the regulation of students' learning processes consist of at least two dimensions (cf. Denessen, 1999).

A possible explanation for the finding that teachers in this study valued not only student-regulated learning and knowledge construction (SRLCON), but also teacher-regulated learning (TRL) is related to the complicated process of learning formalized physics concepts. This is often accompanied by a comparison of different ideas, consistent and logical reasoning, deciding what theories are 'best' for explaining natural phenomena, and sometimes even conceptual conflicts. According to Mulhall and Gunstone (2008), many physics teachers agree that it is their role and responsibility to actively guide students in their search for a clear understanding of the conceptual framework of physics knowledge. For instance, they think it is important to ask the 'right' questions, to encourage students to make their reasoning explicit or to reason through conceptual conflicts, and to provide a clear structure for modeling and problem-solving (e.g., establishing explicit connections with prior knowledge or showing a sequence of steps in finding solutions). Another explanation refers to the nature of the domain. Physics content includes both procedural and conceptual knowledge (i.e., 'knowing how' and 'knowing why'). In this respect, transmission-/qualification-oriented instruction might be associated with the acquisition of procedural knowledge, whereas learning-/moral-oriented instruction possibly aims at students' learning of conceptual knowledge (cf. Hodson, 1992; Wong, 2009). This might explain why the teachers in our sample held beliefs about both student-regulated learning and knowledge construction and teacher-regulated learning.

With respect to beliefs about learning and the regulation of students' learning processes, we found only weak correlations between these beliefs on the one hand, and the three curriculum emphases plus the orientation towards instruction and the goals of education on the other. This result might be explained by the conceptual distance between beliefs about learning and the regulation of students' learning processes and the other beliefs mentioned. For instance, the former beliefs concern aspects of learning in general, whereas curriculum emphases and the orientation towards instruction and the goals of education are related to aspects of the instructional context of secondary physics education. Another explanation might be that beliefs about learning and the regulation of students' learning processes are less explicit than the other beliefs (cf. Mathijsen, 2006).

Limitations of the present study

In this study it was difficult to interpret the clusters or patterns in physics teachers' belief systems in a meaningful way. This might be explained by the types of beliefs we investigated and the instrument used. The relatively small variances in the questionnaire scale scores indicate that the teachers in our sample, on average, held similar beliefs about teaching and learning in general and the goals of the physics curriculum. Furthermore, research on teacher beliefs is complicated because these beliefs are often tacit (Pajares, 1992), with the added problem that the questionnaires we used might offer only limited possibilities to measure these beliefs. In addition, the questionnaire measured only teachers' beliefs about teaching and learning physics in general, not those about specific teaching situations or contexts. More research is needed if we are to gain knowledge about the relations between these variables, the direction and/or causality of these relations, and how teacher beliefs are manifested in both the planning of specific lessons and the way teachers actually deal with the complexity of the daily school context.

Implications

In the educational literature there is a tendency to characterize teachers' instructional practices as either 'teacher-focused' or 'student-focused' (Struyven, Dochy, & Janssens, 2010). In this respect, the former approach to teaching is associated with a focus on information transmission and the latter with a focus on conceptual change (e.g., Prosser & Trigwell, 1999, 2006). Furthermore, it is sometimes suggested that there is a hierarchy between teacher-focused and student-focused approaches to teaching, in the sense that student-focused approaches mean a better quality of instruction and learning outcomes. For instance, Prosser and colleagues (2005) state that teachers who adopt a more teacher-focused perspective "lack an awareness of a more student-focused perspective in the situation in which they find themselves, while teachers with more student-focused perspectives have an awareness of the more teacher-focused perspectives" (p. 138). In addition, they found that teachers who reported a more 'information transmission-/teacher-focused' approach to teaching had students reporting a more surface learning approach, whereas teachers with a more 'conceptual change-/student-focused' approach had students reporting a deeper learning approach.

Increasingly, both the hierarchy and the one-dimensionality of this categorization have been questioned. For example, Meyer and Eley (2006) found that teachers generally will not be accommodated within single conception categories and Arenas (2009) advocated that the quality of student learning should be improved by a variety in teacher approaches to teaching. In addition, Struyven and colleagues (2010) pointed to the possibility that 'traditional' teachers, who adopt a direct instruction approach to teaching, might be as much oriented towards conceptual change as 'alternative' teachers, who adopt more activating teaching methods. The results of the present study showed that physics teachers' belief systems comprise beliefs about both teacher-regulated and student-regulated learning as well as transmission-/qualification-oriented and learning-/moral-oriented beliefs. In other words, it seems more realistic to consider both approaches to teaching as two independent dimensions instead of a binary opposition (cf. Denessen, 1999). Thus, the terminology of 'teacher-focused' and 'student-focused' might be confusing and not distinctive enough to describe the differences between teachers based on the content of their belief systems.

Therefore, policy makers, educational innovators, teacher educators, and/or designers of professional development programs should be aware of the fact that teachers' beliefs are a multidimensional construct, often related to a specific context (Denessen, 1999; Meyer & Eley, 2006; Pajares, 1992), and that teaching is a multifaceted activity (Doyle, 2006). The complexity of the actual instructional context, which is a dynamic interplay between particular concerns, practical constraints, and context-specific opportunities, might lead to a shift in teachers' first priorities and the centrality of particular teacher beliefs. Depending on individual students' needs, competences, or ambitions, and the content to be taught, teachers may differentiate between the goals they want to achieve, the selection of instructional methods, and the extent to which they let students regulate their own learning processes (cf. Prosser, et al., 2005). Or, to state it differently, if classroom teaching is compared to a play, "it is an act played by both parties (teacher and student), yet it is the responsibility of the teacher to write the script" (Wong, 2009, p. 382). In writing this script, every teacher is 'student-focused', but deciding what should be the content of the script, and to what extent students are allowed to improvise or to write parts of the script themselves, is a matter of continuous deliberation.