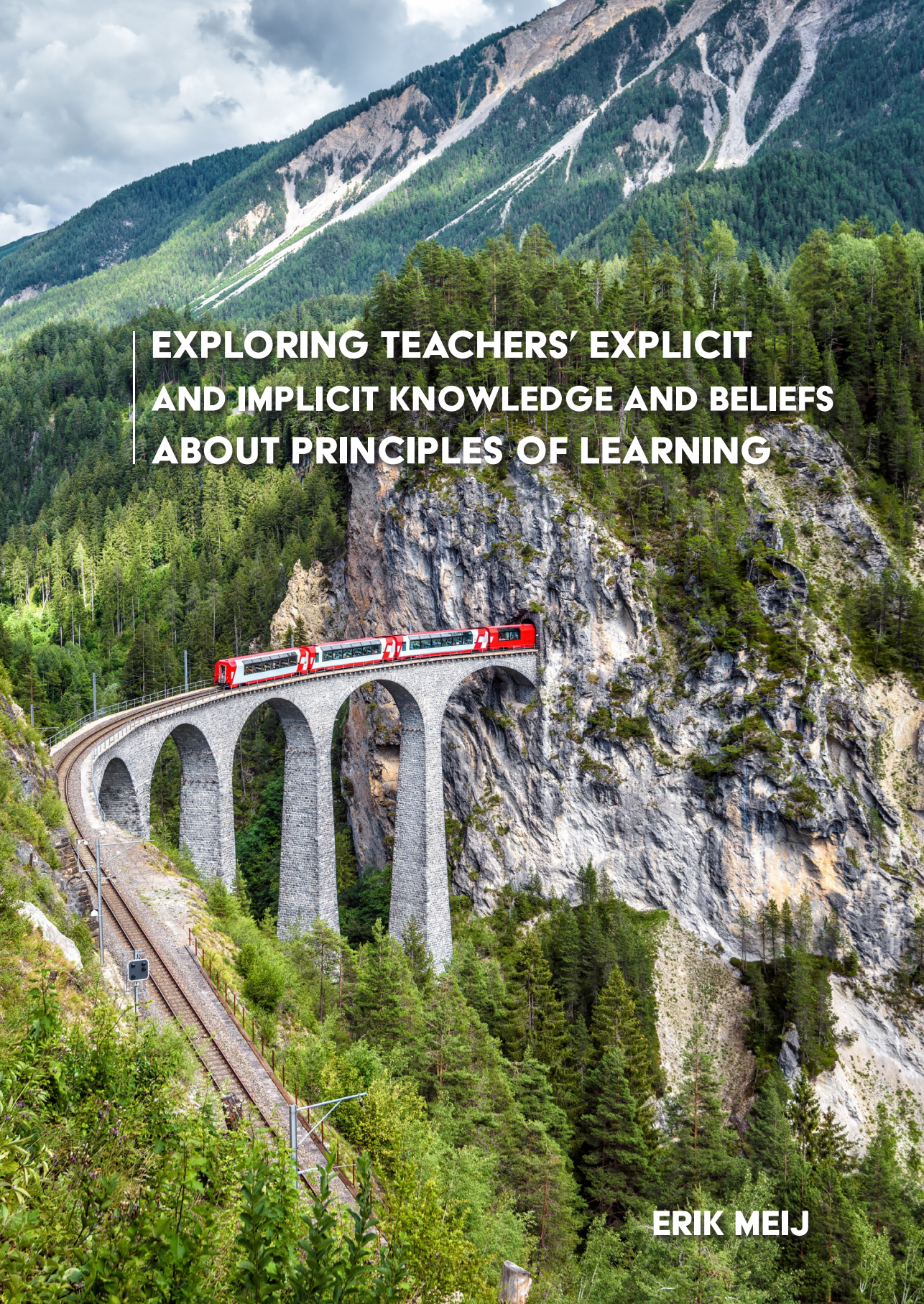
EXPLORING TEACHERS' EXPLICIT AND IMPLICIT KNOWLEDGE AND BELIEFS ABOUT PRINCIPLES OF LEARNING



ERIK MEIJ

Stellingen bij het Proefschrift

1. The kloof tussen theorie en praktijk is geen *probleem*; theorie en praktijk zijn onderling verbonden op een meer onbewust niveau. Het probleem is het niet weten hoe deze verbinding te vinden. (deze these)

2. Er is een kloof tussen de intentie en de haalbaarheid van het beoogde doelen voor het gebruik van leertheorieën in de lerarenopleiding. (studie 1).

3. Het fundamenteel uitgangspunt dat de praktijk van de lerarenopleiding altijd moet kunnen worden onderbouwd met theorie, vraagt opnieuw te worden bezien (deze these)

4. De zwakke correlaties tussen directe en indirecte metingen die meestal methodologisch worden beschouwd, zouden ook kunnen aanduiden dat impliciete en expliciete kennis daadwerkelijk niet correleren (studie 2).

5. *Conceptual change theory* is het meest complete en tevens kernachtige framework toepasbaar in *evidence based* onderwijs in natuur- en scheikunde (studie 4).

6. Gegeven de inherente complexiteit van het beroep van docent zou het leren over onderwijzen en leren voornamelijk via een inductieve route moeten plaatsvinden. (studie 4).

7. Zolang men in en over onderwijs in abstracte termen denkt en praat, is elk onderwijsconcept, zelfs twee ogenschijnlijk volledig tegengestelden, te verdedigen met de theorie uit de literatuur. Pas wanneer je je op uitvoeringsniveau durft te begeven, blijkt de werkelijke waarde en toepasbaarheid ervan.

8. Het leerprincipe ‘voorkennis bepaalt het leerproces’ is fundamenteel voor alle vormen van leren en onderwijzen, zoals reeds betoogd door David Ausubel. (Deze these)

9. Een lerarenopleider onderscheidt zich van een docent in het feit dat zij/hij, naast de vakinhoudelijke kennis, evenzeer kennis heeft van het onderliggende leerproces van het vak.

Propositions to the dissertation

1. The theory–practice gap is not a *problem*; theory and practice are interconnected at a tacit level. The problem lies in not knowing how to access this interconnection. (this thesis)

2. There is a gap between the intention to use learning theory and its feasibility in teacher education practice (study 1).

3. The higher education paradigm that students should explicitly underpin their practice with theory is now too detached from practice to be effective and should be reconsidered. (study 1)

4. The weak correlation between direct and indirect measures, typically attributed to methodological limitations, may suggest that implicit and explicit knowledge and practice-related experiences indeed do not correlate. (study 2).

5. Conceptual change theory is the most complete and yet concise framework to be applicable in evidence based science teacher education. (study 4).

6. Given the inherent complexity of the teaching profession, meaningful learning about teaching and learning should mainly happen through an inductive approach. (study 4).

7. As long as one thinks and speaks about education in abstract terms, any educational concept — even two that appear to be complete opposites — can be justified using theory from the literature. Only when one is willing to engage at the level of implementation does its true value and applicability become apparent.

8. The learning principle 'prior knowledge shapes the learning process' is foundational to all teaching and learning, as was argued already by David Ausubel (this thesis).

9. A teacher educator differs from a teacher in that, in addition to subject-specific knowledge, she/he also possesses knowledge of the learning processes underlying the subject.

Exploring teachers' explicit and implicit knowledge and beliefs about principles of learning.

Erik Meij

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Exploring teachers' explicit and implicit knowledge and beliefs about principles of learning.

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TABLE OF CONTENTS

CHAPTER 1 Introduction 7

CHAPTER 2 How and why learning theories are taught in current Dutch teacher education programs 31
Identifying a gap between paradigm and reality in teacher education

CHAPTER 3 Exploring teachers' beliefs about learning principles 61

CHAPTER 4 Which principles of learning do teachers and teacher educators use and how are they articulated in their pedagogical decision-making? 91

CHAPTER 5 How young adults' existing ideas about principles of learning develop during a teacher education programme 123
Chemistry Teachers' development of prior knowledge about principles of learning: nature or nurture?

CHAPTER 6 Summary, general conclusions, discussion and reflection 161

APPENDICES 191

DANKWOORD 213

NEDERLANDSE SAMENVATTING 219

OVER DE AUTEUR 233



CHAPTER 1

Introduction

We thus see clearly what is gained
and what is lost when percepts are translated into concepts.
Perception is solely of the here and now;
Conception is of the like and the unlike, of the future and the past,
and of the far away [...]
Who can decide off-hand which is absolutely better,
to live or to understand life?
We must do both alternately, and a man can no more limit himself to either,
than a pair of scissors can cut with a single one of its blades.

William James (1911, p.74)

I am a teacher, through and through. And although I rarely rely on monochromatic simplicity in most areas of life, this statement feels unquestionably true. Yet, when I ask myself which particular quality enables me to say this with such conviction, the answer is less straightforward. I do enjoy explaining things; I like intellectual challenge, I take genuine pleasure in helping others understand; I am creative in designing lessons; I empathise deeply with young people embarking on learning journeys that will shape their future lives. And I have loved chemistry for as long as I can remember. All of these are true, yet none of them seem to capture the essence of it.

Moreover, this awareness did not emerge immediately. It only developed once I began teaching; in my early years, the above mentioned gradually came to the fore. I designed (what I then believed were) effective and engaging lessons, supported my students with great dedication, and experimented with a range of approaches. After several years, however, I realised that I was seeking something more. I found myself posing ever more questions, wanting to understand what it truly means to *learn chemistry*. What happens in the mind when that learning takes place? And if I were to understand that process more deeply, would I become a better teacher?

That trait—my deep-seated curiosity (as a child, I was already notorious for asking too many "why"-questions)—was not something I initially associated with teaching. Only later did I come to understand that the act of questioning is in fact one of the fundaments of teaching itself: questions directed towards students, the subject matter, one's pedagogical approach, experts, and towards oneself. Questions!

But now, I am no longer certain whether my curiosity about learning stemmed solely from classroom experience. It was also nurtured by exposure to new conceptual frameworks. From the outset, I was fascinated by conceptual thinking in physics and chemistry, as it provided structure and intellectual scaffolding that I could readily connect to my classroom experiences. Similarly, notions such as networked learning and prior knowledge became visible and were immediately applicable in practice. But I learned what I needed at the moment it became relevant. And out of curiosity, I would read further, broadening my understanding of these general ideas—but still rarely beyond the issues that occupied me at that particular time.

Ultimately, this curiosity led me to pursue a Master's degree in Educational Science, where I encountered broader theoretical perspectives, often highly descriptive, intellectually very stimulating and thought-provoking, yet not always

personally resonant. Two sources that I recall as having a particularly profound influence were the book *How People Learn* (Bransford et al., 2000) and the landmark article by Posner et al. (1982). Both works introduced abstract ideas related to the learning that I had previously observed and experienced in my own teaching practice. In seeking further connection, I encountered the work of David Treagust and Reinders Duit (2012; 2013), whose research and advocacy actually aligned with the direction I was pursuing. At this stage, abstract theories and models *really* began to cohere meaningfully with my extensive professional experience, uniting percepts and concepts, mutually reinforcing each other. The quotation by William James on page 7 captures this beautifully and, - at least for the present, I think - provides an answer to the initial question. This, in essence, defines my identity as a teacher.

With this awareness, I began to explore ways of enabling my chemistry students to experience the same sense of connection between theory and practice. It was at this point that the American Psychological Association published the *Top 20 Principles from Psychology for Teaching and Learning*, which appeared at an opportune moment and has since served as a guiding framework in my teaching and throughout the studies presented in this thesis. Rather than comprehensive and complex theories, these principles offer practical, practice-oriented guidance and, especially for those in natural sciences, provide at least a sense that some parts of educational science rest on solid foundations.

The notion of *conceptual change* became my intellectual anchor. I had come to recognise a fundamental ground of my theoretical inquiry, which appeared, in retrospect, to be a consistent point of reference in my daily pedagogical practice. This led me to wonder whether my fellow science teacher educators were also familiar with such learning principles, and whether they recognised their relevance to their own teaching. My master's thesis yielded a somewhat disheartening answer. The principles I presented were seldom recognised, and at times their value and validity were even questioned. Yet these colleagues are undeniably excellent teachers who deliver high-quality education.

Could it be, then, that they carry the fundamental principles of learning and teaching within them—albeit in a largely tacit or unconscious manner? That question led to this thesis.

1. CONCEPTUAL FRAMEWORK

There are four theoretical concepts that are central to this dissertation as a whole and in the following section I will unfold them. Given that the object of this study concerns unconscious knowledge and beliefs, these two notions will be addressed first. Within these domains of knowledge and beliefs, the focus will be on learning. As a conceptual framework, learning theories might appear to be the obvious choice; however, since these are often broad in scope, a decision was made from the outset to concentrate on more concrete *learning principles*, which will be discussed accordingly. Subsequently, the role of knowledge and beliefs in everyday educational practice will be considered. Finally, a brief description will be provided of two models—Conceptual Change Theory and the Three-Level Model—that account for the emergence and development of such beliefs and learning-related knowledge throughout a teacher's professional career.

1.1 Teacher Beliefs and Knowledge

The concept of *teacher beliefs* has been defined in a wide variety of ways, grounded in notions such as intuition, gut feeling, implicit knowledge, truth, and paradigmatic thinking (Fives & Gregoire-Gill, 2015). It constitutes a well-established and extensively researched construct within the field of educational sciences, generating a substantial body of scholarship spanning more than half a century. Over the past decade alone, almost 10,000 publications have addressed the topic (eric.ed.gov). In recognition of its significance, a dedicated *Research Handbook on Teacher Beliefs* was compiled in 2015 (Fives & Gregoire-Gill, 2015). Despite this extensive body of work, the precise conceptual boundaries of *teacher belief* remain a matter of debate (e.g., Pajares, 1992; Fives & Buehl, 2012).

Fives and Buehl (2012) contended that, while complex, the construct is amenable to definition; nevertheless, several key issues remain unresolved. Among these are the questions of whether beliefs differ fundamentally from knowledge (e.g., Tanase & Dinsmore, 2023), whether they are stable or contextually contingent (Fives & Buehl, 2012), and how they function as interrelated components within a broader belief system (e.g., Vosniadou et al., 2020). Such systems are dynamic and continually evolving; the alteration of a single belief rarely results in a corresponding change in behaviour (e.g. Lawson et al., 2019).

The terms *knowledge* and *beliefs* are closely intertwined and partially overlapping, and the same is true for *implicit* and *unconscious*. As they play a central role in this thesis, it is essential to define them and to employ them consistently.

The notions of the *implicit* and the *unconscious* are largely interchangeable (Banaji et al., 2001, p. 135); however, the literature most commonly refers to *implicit beliefs*, and this terminology will therefore be adopted here.

The question of whether the concepts of knowledge and beliefs overlap or interact remains complicated (Spruce & Bol, 2015). Some scholars regard beliefs and knowledge as distinct constructs, whereas others consider them to be largely overlapping (Tanase & Dinsmore, 2023). According to the Oxford English Dictionary, *knowledge* is 'understanding gained by a range of information and experience', whereas *belief* is denoted as 'confidence, feeling that something is true or real'. The question of what is required for a belief to constitute knowledge is, of course, a philosophical one. Knowledge is often defined as *justified true belief* (Gettier, 1963), in other words, everything is belief until it can be argued to be true and then becomes knowledge. In this thesis, the aim is to trace ideas, beliefs, intuitions, and what might be termed 'established knowledge' concerning principles of learning from participants' written responses. As these principles will often be not articulated by the participants in the form of explicit statements or formal definitions, any strict differentiation between beliefs and knowledge would be problematic—if not impossible—and, moreover, would extend beyond the practical educational purposes of this study. For this reason, I will not differentiate between the two and the combined formulation *beliefs and knowledge* will be used consistently throughout.

A common distinction is drawn between *implicit* and *explicit* beliefs (Sykes, 2011; Wilcox-Herzog et al., 2015). Implicit beliefs are understood to develop and operate largely at the subconscious level, whereas explicit beliefs are consciously formed and accessible to awareness. The former emerge gradually through experience, while the latter may arise both from personal experience and from formally acquired information. Consequently, implicit beliefs are relatively resistant to change through consciously accessible information, whereas explicit beliefs are more malleable (Wilcox-Herzog et al., 2015).

Ellis (2005) proposed a set of criteria for distinguishing between implicit and explicit knowledge when operationalised for empirical investigation. Responses grounded in implicit knowledge tend to rely on intuition rather than on formal rules, manifest under time pressure, prioritise meaning over form, exhibit greater internal consistency, and typically originate from early learning experiences.

Bandura (1997) famously asserted that "people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true" (p. 2). This widely acknowledged principle underpins the prevailing

view that teacher beliefs are of central importance, given their strong influence on teacher behaviour and classroom outcomes (Sykes, 2011; Buehl & Beck, 2014; Zakaria & Ab. Wahid, 2023). Similarly, McAfee and Hoffman (2021) emphasised their impact, observing that "teacher beliefs exert direct influence upon curriculum development, pedagogy, and the construction of effective learning environments" (p. 1).

From a more applied perspective, a number of studies have examined the content and significance of implicit prior knowledge in shaping deliberate pedagogical reasoning (e.g., Glogger-Frey et al., 2018; Markauskaite & Goodyear, 2014). Teaching takes place within a highly knowledge-intensive and socially complex environment (Schoenfeld, 2020). Teachers must therefore possess extensive knowledge not only of subject matter but also of pedagogy and learning processes. As Shulman (1986) observed, possessing and applying knowledge of *both* content and teaching lies at the very core of professional teaching competence. Shulman and others have developed various typologies of teacher knowledge, distinguishing among explicit and implicit knowledge, and among practical, personal, and tacit forms. An influential framework for understanding teacher knowledge, adopted in this study, is that proposed by Cochran-Smith and Lytle (1999). They differentiate between *knowledge for practice*, *knowledge in practice*, and *knowledge of practice*. *Knowledge for practice* refers to formally taught theoretical knowledge; *knowledge in practice* is holistically constructed through experience; and *knowledge of practice* entails an understanding of the relationship between theory and practice, developed through deliberate reflection on professional action.

What has been investigated several times is if formally taught *knowledge for practice* is weakly coupled to existing beliefs and teachers rarely actively connect theory about learning to their classroom experiences, it will not evolve into *knowledge of practice*. That is, students will not be able to use the theory actively, it rather will stay and become more implicit knowledge (Verloop et al., 2001). As a consequence, it tends to wash out over the first few years of practice (Mellor, 2021; Zeichner & Tabachnik, 1981). This may explain why teachers' instructional practices in their later career are sometimes still heavily influenced by intuitive reasoning based on beliefs from personal experiences (Gleeson & Davison, 2016), often their own prior experiences as a learner (Oleson & Hora, 2012; Shahzad et al., 2017; Zakaria & Ab. Wahid, 2023; Kraft et al., 2024).

While there is a substantial body of research on teachers' beliefs, we found that most of the empirical studies focus on teaching. Studies on implicit knowledge and beliefs about learning are less frequent (e.g. Liakopoulou, 2011) and

with principles of learning as the research object, we found only one (Foster & Whittington, 2017). Moreover, both studies focused more on explicit knowledge where our studies try to shine a light on the implicit side.

1.2 Theories and principles of learning.

To examine beliefs and knowledge teachers regarding learning, we must first define a clear conceptual framework for understanding for the phenomenon of learning itself. Having a sound vision or theory of leaning is important for the teaching process and also guides the creation of schools and classrooms and influences teachers' personal development (Nasir et al., 2021). However, *learning* is a broad and multifaceted construct for which no universally accepted definition exists. Hence, there is no single, widely endorsed definition of what constitutes a *learning theory*. Schunk (2020) clarifies the notion of a learning theory by defining its constituent terms separately, describing it as "a scientifically acceptable set of principles offered to explain an enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience" (p. 3). Phillips and Soltis (2015) argue that the term *learning theories* should always appear in the plural, since there are distinct forms and processes of learning that cannot be adequately accounted for by any single theory.

Although there is no consensus concerning of what a learning theory entails, there is general agreement about the major theoretical traditions commonly recognised under this label—namely, behaviourism, cognitivism, the sociocultural or historical approach, and constructivism (e.g., van der Veen & van der Wal, 2016; Pritchard, 2017; Phillips & Soltis, 2009; Woolfolk, 2020; Schunk, 2020).

Bates' *Learning Theories Simplified* (2019), for instance, provides an overview of more than 130 detailed theories, models, and conceptual frameworks that describe or influence specific aspects of learning and teaching (including those of e.g. Ausubel, Rogers, and Festinger). Not all of these would be universally accepted as *learning theories*, and their sheer number highlights the continuing lack of agreement about the boundaries and completeness of the field. One theory of particular relevance to this dissertation is *Conceptual Change Theory*, which addresses learning from both cognitive and affective perspectives. Despite its strong connection to learning processes, it is rarely classified as a formal learning theory, nor is it included among the 130 examples identified by Bates (2019).

While a *theory* may be understood as a scientifically acceptable set of principles that seek to explain a given phenomenon, *principles* are defined as "established relationships between two or more distinguishable factors, for example, a particular teaching strategy and student achievement" (Woolfolk, 2020, p. 47). Principles are derived from converging empirical findings that consistently support a given relationship.

Several compilations of such principles of learning have been published, often with the explicit aim of providing teachers with practical, evidence-informed guidance. Among these, the *Top 20 Principles from Psychology for PreK–12 Teaching and Learning* (APA, 2015) represents one of the most comprehensive and methodologically rigorous collections. It encompasses both cognitive and affective dimensions of learning and was developed through a systematic consensus process. Comparable initiatives have been developed by various authors and organisations, including Vosniadou (2001), Resnick and Hall (2000), Caine et al. (2009), Hattie and Yates (2013), Deans for Impact (2015), and the Department of Education and Training of the State of Victoria (2020). In the Netherlands, a practical handbook for student teachers based on twelve principles of learning was published by Surma et al. (2019). Our decision to adopt the APA *Top 20 Principles* as the theoretical foundation for all empirical studies presented in this dissertation was twofold. It was based, on the one hand, on the thorough methodology and broad consensus extending beyond a single institution, and, on the other hand—and more importantly—on the well-defined affective principles of learning. This choice was made to avoid the implication that measurable learning is purely cognitive. In this regard, Korthagen (2017) refers to the 'inconvenient truth' that in teacher education we may place too much emphasis on teachers' cognitive learning.

Although the focus of this dissertation is on the knowledge and beliefs that teachers hold about *learning*, most learning principles in fact invariably imply something about teaching. Throughout the various studies it will become evident that teaching and learning are so closely interwoven that the description of knowledge and beliefs is often presented in terms of both.

1.3 Pedagogical reasoning

To investigate teachers' beliefs about learning, it is first necessary to determine where in the teaching process knowledge and beliefs become observable and measurable. Teachers, whether consciously or unconsciously, draw upon these knowledge and beliefs when making pedagogical decisions about how to teach particular content. This process of drawing on knowledge and beliefs for pedagogical decision making is referred to as *pedagogical reasoning*.

Shulman (1987) introduced the concept of *pedagogical reasoning and action*, identifying several sequential phases within the act of teaching: comprehension, transformation, instruction, evaluation, and reflection. Reflection, in turn, should generate new and improved insights, thereby leading back to deeper comprehension and forming a continuous cycle of professional growth and educational quality improvement. Thinking about how learning happens is particularly salient during the phases of *transformation*—the process of converting subject matter into teachable and meaningful learning activities—and *reflection*—the process of critically evaluating and making sense of the relation between one's teaching and students' learning.

However, given the inherent complexity of teaching, many aspects of this practice tend, over time, to become routine (Ericsson, 2008). To sustain high-quality teaching and to avoid regression into unexamined routines, teachers must engage in what Ericsson termed *deliberate practice*. Pedagogical reasoning encompasses such deliberate, conscious, and reflective processes of thought, characterised by slow, effortful consideration focused on facilitating learning. Several authors have argued that pedagogical reasoning constitutes the very core of the teaching profession (e.g., Loughran, 2019; Langsford, 2020; Trevisan & Smits, 2023). However, many studies show that although seeing value in reflection, teachers tend to resist approaches that move them out of their comfort zone to deeper, evidence-based levels of reasoning. Instead, they prefer to engage in a more superficial reflective process that even reinforces their existing preconceptions of effective practice (e.g. Lloyd, 2019). Without such deliberate reasoning, instruction risks being reduced to a 'fingers crossed' paradigm, in which the teacher merely hopes that learning occurs as though he or she has no influence over the process.

A brief review of the literature indicates that empirical research on pedagogical reasoning has been conducted across a wide range of disciplines, including geography, history, mathematics, chemistry, and educational technology (e.g., Selmer & Lindstrom, 2022; Hartati, 2020; Trevisan, 2019). Studies have examined pedagogical reasoning across educational levels, from primary to tertiary education, as well as in relation to broader issues such as the influence of sociocultural factors and curriculum design (e.g., Mohamad et al., 2019). However, we are not aware of empirical studies that specifically explored the role or application of *principles of learning* within the process of pedagogical reasoning.

1.4 Pedagogical decision-making

During the methodological design phase of this study, a challenge arose from the inherently deliberate and reflective nature of pedagogical reasoning, which

makes it difficult to assess *implicit* beliefs. Once a person engages in deliberate thought, the process is, by definition, no longer implicit (Sykes, 2011). The measurement instrument developed for this research—based on rapid responses—was therefore more suited to capturing fast, intuitive decisions rather than reflective reasoning.

The construct that captures such *real-life, on-the-spot decisions* is referred to as *pedagogical decision-making*. Although pedagogical reasoning and pedagogical decision-making have developed as distinct strands within the literature, the two constructs are interrelated (Lloyd, 2019; Saeedian et al., 2025). Pedagogical decision-making places greater emphasis on teachers as *decision-makers* operating in dynamic classroom contexts (Phillips et al., 2021; Saeedian & Ghaderi, 2023). Given the complexity and knowledge-intensive nature of teaching, Bakshi (2023) argues that teachers often rely on *heuristics*, *shortcuts*, or *rule-of-thumb strategies* to reduce cognitive load and arrive at satisfactory decisions. However, such heuristic processing may also introduce *cognitive biases* into professional judgement. Exactly that process would be suitable input for our investigations. As far as we are aware, no previous studies have directly measured the use of principles of learning in such heuristics.

1.5 Change of beliefs and knowledge

In addition to the concept–experience connection described in the opening paragraph of my personal narrative, another significant aspect warrants consideration. My learning trajectory largely progressed from deriving understanding through experiences and contexts towards developing more conceptual and abstract ideas. This path was not intentionally chosen; rather, it naturally evolved in that manner. In educational practice, however, the prevailing approach often reverses this order: theories are introduced first, followed by illustrative examples and work placement assignments for students.

Jerome Bruner already described conceptualisation as the network of inferences that are or may be set into play by an act of categorization and the route thereto as "the cognitive-psychology perspective on concept formation and induction (how people form categories and infer rules from examples), which grounds the construct in human cognition rather than instruction" (1956, p.244). Theories concerning the origins of understanding and knowledge transfer, grounded in the paradigm that memory functions as a network, lead to the widely accepted conclusion that the inductive path—from the concrete to the abstract—reflects the natural organisation of knowledge (e.g. Mollet, 1978; Williams, 1999; Zull, 2002; Kornell & Bjork, 2008; Shafto et al., 2014). This inductive approach has been widely researched in education as part of the search for

more sustainable learning. (e.g. Nugroho et al., 2021; Richter et al., 2022; Sana et al., 2017).

Both *inductive learning* and *inductive teaching* are well-established terms in the literature (e.g., Shafto et al., 2014). *Inductive teaching* generally refers to student-centred pedagogies such as inquiry-based or project-based learning, in which learners engage with authentic contexts that facilitate the construction of abstract concepts (e.g., Duit et al., 2013; Schreurs & Dumbraveanu, 2014). In contrast, *inductive learning* denotes the cognitive process through which knowledge is constructed in a bottom-up manner—where abstract principles and, potentially, theories emerge from experience and observation. Although inductive teaching may lead to inductive learning, the latter can also occur independently. Indeed, when learning takes place informally—outside formal education—it is inherently inductive in nature.

As Korthagen wrote already in 1999, "Although the transfer problem in teacher education is well known and its causes have been thoroughly researched, it is remarkable that many teacher education programmes still reflect the traditional 'application-of-theory model'" (Korthagen & Kessels, 1999, p. 5). From a biological perspective, Zull (2002) also strongly advocated for an inductive approach to teaching and learning. A particular finding from the first study in this thesis (Chapter 2) concerned the perspectives of teacher educators in the Netherlands regarding when and how theories of learning are taught. They reported that such theories are typically introduced at the beginning of the curriculum, yet they themselves believed these should be taught later—after students have gained practical experience during work placements—so as to enable stronger connections between theory and practice.

Korthagen et al. elaborated the inductive learning from experience and developed the three-level model (Korthagen & Lagerwerf, 1996; Korthagen & Kessels 1999; Korthagen, 2010). The model was proposed as a means of reconciling two perspectives on how teachers develop theoretical understanding: the *cognitive approach*, in which theory is introduced prior to application, and *situated learning*, characteristic of apprenticeship models (Lave & Wenger, 1991).

Korthagen introduced this model to explain the persistent gap between theory and practice observed in teacher education (Korthagen, 1999; 2007)—a challenge that continues to be a major focus of research in the field (e.g., Resch & Schrittesser, 2023). Since its introduction, the model has been extensively employed to examine cognitive and conceptual learning processes and the professional development of pre-service teachers (e.g., Kërënxhi & Gjoci, 2015;

Westrick & Morris, 2016; Hennissen et al., 2017; Kostiainen et al., 2018; Phung & Michell, 2022; Ergogo et al., 2023; Chen, 2024).

The Korthagen model was originally developed within research on professionalisation in teacher education. The central idea of building knowledge and beliefs inductively from experience and prior knowledge was, during the same period, more generally described by conceptual change theory. However, this theory has become a major strand of research and is still used as a theoretical underpinning for many studies in pedagogy, mostly in science education. Findings are are often translated into teaching principles and activities (e.g. Duit et al., 2013).

The similarities and differences between these two theoretical frameworks are discussed extensively in Chapter 5.

2 RESEARCH CONTEXT

All studies presented in this dissertation were conducted within the Dutch educational system. The research question originates from the field of teacher education for secondary schools. Dutch secondary education comprises three levels: *pre-vocational education* (four years), *senior general secondary education*—preparing students for universities of applied sciences (five years)—and *pre-university education* (six years).

In the Netherlands, teacher education programmes preparing candidates for secondary school teaching are offered by two types of institutions. Research universities provide one- to two-year programmes focusing primarily on pedagogy and pedagogical content knowledge (PCK), typically following a master's degree in the subject to be taught. These programmes lead to what is known as a *first-degree teaching qualification*, which authorises graduates to teach at all levels of secondary education and universities of applied sciences (known in Dutch as *hogescholen* or *HBO*).

Next to that, universities of applied sciences offer a four year integrated teacher education programme that combines disciplinary content, pedagogy, and pedagogical content knowledge. These programmes lead to a *second-degree teaching qualification*, which entitles teachers to work only in the lower grades

of pre-university secondary education, general secondary education for adults, and (pre-)vocational education[1].

In the first three studies, teacher educators from both first- and second-degree programmes participated. The final study focused on students enrolled in the second-degree chemistry teacher education programme. Such programmes typically span four years, with students entering at approximately 17 or 18 years of age after completing five years of secondary education. Over the course of four years, they spend roughly half of their time studying subject-specific content and the remaining half on general pedagogical and educational courses, complemented by a continuous work placement throughout the programme.

During these work placements, students are coached by experienced in-service teachers whose teaching experience ranges from only a few years to near retirement. Given the students' young age and the complexity of classroom situations, the focus during the first and second years is often on classroom management and building relationships with pupils. Consequently, the pedagogical and reflective aspects of the teaching profession sometimes receive less emphasis, leading to the risk that student teachers merely replicate the instructional practices of their mentors. This phenomenon prompted the investigation into student teachers' existing ideas and beliefs about learning, with the aim of fostering awareness of these beliefs as early as possible in their training.

3 RESEARCH DESIGN

The main research question guiding this thesis is: *What is the influence of teachers' explicit and implicit conceptual knowledge and beliefs of the principles of learning on their pedagogical reasoning?*

This overarching question encompasses two sub-questions:

1. What explicit and implicit conceptual knowledge and beliefs of principles of learning do in-service and pre-service teachers hold?
2. How do teachers' knowledge and beliefs of principles of learning manifest within their pedagogical reasoning?

Four studies were conducted to explore these beliefs and their influence. The first study sought to obtain a comprehensive understanding of how—and more

1 the description of the Dutch educational system here has been condensed to what is applicable to comprehend the participants groups in these studies but entails many more specific routes leading to teaching qualifications.

importantly, why—learning theories and principles are taught in teacher education programmes. What is the underlying rationale for including such theories in teacher education curricula? Addressing this question served two purposes: first, to ground our research within the context of Dutch teacher education; and second, to provide insights that could inform the development of an assessment instrument.

The exploration of implicit beliefs and knowledge was undertaken through both quantitative and qualitative approaches. The second research question—concerning the manifestation of knowledge and beliefs in everyday pedagogical practice—was investigated through the analysis of written responses to classroom scenarios.

3.1 Implicit Measurement

While explicit beliefs and knowledge have been widely investigated and documented in the literature, implicit knowledge poses distinct methodological challenges. As Tobin (2008, p. 228) aptly observed, "those seeking to shine fresh light on an issue first must find the light." Investigating unconscious processes requires the use of *indirect measurement* techniques, as such knowledge and beliefs operate below the level of conscious awareness. Commonly reported methods in the literature include approaches involving either rapid responses (e.g., the Implicit Association Test, IAT) or interpretative analyses of rich qualitative data (e.g., stimulated recall, narrative interviews, video or photo elicitation). In our studies, both approaches were employed.

Measuring implicit knowledge, beliefs, attitudes, or convictions is inherently complex. The most apparent difficulty lies in the paradox that, once an outsider probes for an implicit belief, it becomes conscious and it ceases to be implicit (Sykes, 2011). Consequently, indirect methods have been developed to elicit implicit beliefs. Indirect measurement entails "an inference of a construct without instruction to report it, assuming no introspective awareness of the construct" (Greenwald & Lai, 2020, p. 420).

Determining whether an indirect measure genuinely captures only implicit beliefs remains highly problematic and, in many cases, questionable (Corneille & Hütter, 2020). Moreover, the relationship between direct and indirect measures continues to be debated. Low correlations between such measures have been reported by Nosek and Smyth (2007) and by Van den Bergh et al. (2010). Nevertheless, Jost (2019) has argued that, despite these concerns, the measurement of implicit beliefs remains essential, given the significance attributed to them by educational researchers. Supporting this view, Denessen et al. (2022) reviewed

49 studies and concluded that indirect measurement techniques continue to hold potential for enhancing our understanding of teachers' attitudes.

4 OUTLINE OF THIS DISSERTATION

This dissertation comprises four individual studies, each addressing a distinct research question designed to contribute to the overarching research objective. As three of the four empirical chapters have been published as independent articles, some degree of overlap in the theoretical frameworks is inevitable.

Chapter 2 presents a qualitative study exploring *what*, *how*, and *why* learning theories are taught in Dutch teacher education programmes. The *what*-question entailed a descriptive inventory of the relevant literature, courses, and theories. The *how*-question examined the role of teacher educators, the position of learning theory within the curriculum, and the pedagogical models and activities employed. The *why*-question sought to uncover the underlying rationale concerning the importance and applicability of learning theories. Eight teacher educators were interviewed, and the data were subjected to open and subsequent axial coding. The analysis yielded six key reasons provided by the participants; however, the most striking finding was a persistent cognitive tension between the participants' ideas and opinions, and their experiences in everyday educational practice. This discrepancy is captured in the chapter's subtitle: *"Identifying a Gap between Paradigm and Reality in Teacher Education."*

Chapter 3 reports a quantitative study employing a self-designed online instrument comprising several tasks. In the indirect measure, 257 participants responded to words associated with learning using a rapid "YES" or "NO" keystroke. Subsequently, participants explicitly endorsed various principles of learning. Both response times (in milliseconds) and the degree of endorsement were analysed, and correlations between implicit and explicit measures were calculated. This study represents one of the first attempts to investigate teacher beliefs through such a measurement approach.

Chapter 4 explores the principles of learning invoked by pre-service teachers, in-service teachers, and teacher educators when making rapid decisions in classroom situations. The study examined the language participants used to describe these principles. Data were collected using the same online instrument as in Chapter 3, involving a quick-response task based on two short vignettes—one focusing on cognitive learning and the other on affective learning. Of the

responses, 186 were deemed suitable for analysis. Principles of learning were identified through closed coding, after which frequencies were calculated. The language used by participants was further analysed using a lexical approach.

Chapter 5 investigates the knowledge and beliefs held by first-year teacher education students, and how these differ for students with three years of training. Additionally, the study examined whether *changes* could be detected in beliefs about learning held by third-year students following an eight-week intensive intervention. Forty-nine participants each spent approximately one hour writing detailed responses to a series of six extended vignettes, describing problems observed in classroom scenarios and their advised solution for the teacher. The analysis followed a procedure similar to that used in Chapter 4; however, to capture both correct and incorrect ideas, the data were subjected to open coding. Korthagen's three-level model and conceptual change theory constitute the theoretical framework of this study, and their interrelationship is elaborated upon in this chapter.

Chapter 6 provides an integrative synthesis of the findings from all four studies, drawing general conclusions, addressing issues of validity, and discussing the dissertation's contribution to the academic literature as well as its implications for educational practice.

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CHAPTER 2

How and why learning theories are taught in current Dutch teacher education programs.

Identifying a gap between paradigm and reality in teacher education

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ABSTRACT

A teacher should arguably know about learning theories (LTs) in order to make daily pedagogical decisions. However, little literature exists on the role of LTs in teacher education. Eight Dutch teacher educators were interviewed on LTs in their curriculum. LTs were unanimously considered important but huge variation was found in what and how LTs are taught. Several functions of LTs were mentioned, with underpinning of pedagogical decisions using LT considered to be the essence of higher education. However, respondents doubted whether this is ever achieved. This suggests an additional paradigm – reality gap in teacher education.

1. INTRODUCTION

As a teacher educator, one of us frequently visits students in their internships to observe lessons. Such a visit always ends with joint reflection with student coach (an in-service teacher) with the important question, "What do think your pupils learned today?". Most students explain how they developed their lesson using an educational model; a safe base to justify their choices. The question about what was actually learned, however, reveals that only a few students have insight into what the result of their activities is. Pupils' learning is not explained by an educational model, and most students are not acquainted with its theoretical underpinnings. When queried as to what principles of learning were at work, usually neither students nor coaches have any idea.

The above observations have been an impetus for us to try to understand the origins of such deficits of knowledge of learning. Similar observations were found by, e.g., Noel (2011) for teacher education in the UK. It is generally believed that teacher educators should teach theories of learning but there seems no specific direction as to which theories to use. This results in teacher educators making personal choices and to questionable use of theories. Villarreal (2008) reported comparable results in Argentina for language teachers: lack of knowledge of learning theory (LT) was due to lack of proper information in teacher education but also a lack of interest. Meij (2018) questioned Dutch teacher educators about their knowledge of LTs and how they make them explicit to students during teacher education. The result was that, generally, they did not use LTs explicitly in designing and teaching courses or lessons.

Hennissen et al. (2017) investigated to what extent pre-service teachers could apply theory in classroom practice assignments during internships. They found that students indeed grew in cognitive development and used practical and cognitive knowledge when it was explicitly addressed in a course. A suggestion was to further research whether the "material of the program is in accordance with the intended curriculum" (p. 324), with the latter being that experiences from practice are linked with knowledge. That question is subject of the research in this paper.

This led us to question the role that LTs have in the current curricula of teacher education and the visions upon which choices with regard to the place and function of LTs are based. The study starts with a straightforward assessment of *what* is offered:

RQ1: What theories and principles of learning are offered in teacher education curricula?

The next question is *how* learning theories are taught during the two or four years of education and training. Are theories offered and assessed only once, or do they serve as a leading model for pedagogical reasoning in practice?

RQ2: How are theories and principles of learning offered in teacher education curricula?

After these inventories, we aim to shed more light on the underlying rationales and the role of LTs in educational practice. The distinct fashions of teaching LTs adopted by curriculum developers are based on their visions and beliefs, which necessitates questioning *why* LTs are taught:

RQ3: What is the relation between the vision and beliefs of the role of LTs held by those responsible for the curriculum and the implementation of LTs in teacher education?

2. THEORETICAL FRAMEWORK

To study the use of LTs in teacher education, we first describe what a learning theory and principles of learning are, and provide a brief overview of literature on the use of LTs within teacher education.

2.1 Theories and principles of learning.

There is no widely accepted definition of learning theory (LT). Schunk (2020) clarifies the meaning of LT by separately defining the words learning and theory. He defines theory as "a scientifically acceptable set of principles offered to explain a phenomenon (p.11) and learning as "an enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience (p.3). A consensus definition of learning, however, is difficult to give as there are many perspectives on learning. Any definition of learning, and thus also of a Learning Theory, always reflects the particular perspective on learning. Panasuk & Lewis (2012) state that a definition cannot

be given without discriminating systematic and non-systematic learning. Phillips and Soltis (2015) assert that 'LTs' is always in plural because there are very distinct forms of learning that cannot be explained by one theory.

Thus, while there is no consensus definition of what counts as an LT, there is some agreement about which theories would fall under the label. Most educational textbooks that introduce LTs are organised around the main four: behaviourism, cognitivism, social historical approach, constructivism (e.g. van der Veen & van der Wal, 2016; Pritchard, 2017; Phillips & Soltis, 2009; Woolfolk, 2016). However, Bates' "Learning Theories Simplified" (2019) provides an overview of 130 more detailed theories, models and concepts that describe and influence specific aspects of learning and teaching (e.g., those of Ausubel, Rogers or Festinger).

Not all of those theories would be accepted by all as a learning theory, and there are still omissions that might raise the question of completeness. Conceptual change theory, for instance, describes learning from a cognitivist as well from an affective point of view but is never described as a LT (it also does not feature among the 130 of Bates, 2019).

Whereas a theory is a scientifically acceptable set of principles offered to explain a phenomenon, principles are "established relationships between two or more factors, e.g., a certain teaching strategy and student achievement" (Woolfolk 2016, p.47). Principles derive from numerous empirical findings that lead to a same conclusion. Several sets of isolated principles of learning have been published to provide teachers with hands-on support. The 'Top-20 principles from psychology for PreK-12 teaching and learning' (APA, 2015) is the most comprehensive, supplying not only cognitive but also affective principles. They were derived according to a thorough methodology and captured in a consensus document. Comparable initiatives were composed by, e.g., Vosniadou (2001), Resnik & Hall, (2000), Caine et al., (2009), Hattie & Yates, (2013), Deans for Impact (2015) and the Department of Education and Training of the State of Victoria (2020). Recently, a students' handbook on teaching based on 12 principles of learning was published in Dutch (Surma et al., 2019).

2.2 How curricula should be based on LTs.

In a brief literature review we could not find papers that investigated the role of learning theories in teacher education curricula. On the other hand, a body of research exists on what LTs should be offered and how that should be done. In that body of research, we could distinguish two perspectives on LTs in education. One perspective in which a normative view on how LT should be integrated

in teacher education is confronted with reality, and a second perspective in which the role of theory in teacher education is studied and critiqued around the concept of the gap between theory and practice.

In the '80s and '90s, there was a rethinking of teaching based on LT (Abdal-Haqq, 1998; Richardson, 1997). A normative perspective came from both the educational sciences with a constructivist perspective, and research in learning psychology with a cognitivist approach.

In the educational sciences, numerous practice-based studies considered constructivist teaching in secondary school subjects (Steffe & Gale, 1995), pointing to a new role for teachers, along with different competencies and pedagogy. Such a new role required new perspectives on teacher education. Olsen (1999) compiled research of the 90s that translated the constructivist LT to principles for education, and wrote that "most scholars agree that constructivist principles promote increased student thinking" (p. 350).

However, proponents of basing teaching on constructivism also expressed negative views of their progress in reforming teaching and teacher education. For example, one study suggested that teacher professional development to improve teaching practice frequently yields disappointing results (Opfer & Pedder, 2011). In their seminal review, Cochran-Smith and Villegas (2014) stated that "despite a steady shift towards these new views...more traditional views remained entrenched" (p. 10).

At the same time, cognitive psychologists argued for bringing their findings to learning and instruction, often in the form of condensed principles of learning. The actual application of such principles of learning in teacher training was studied by Klein (1991). He found that pre-service teachers came to better instructional designs when using principles of learning as a basis (although this did not occur for in-service teachers). However, De Corte (2000) concluded in 2000 that cognitive science was still poorly used in education. He advocated for an approach that better integrated content and educational principles, and more presence of educational research in daily teacher education. Willingham (2017) has similarly advocated teaching educational psychology in teacher education from empirical generalisations, rather than from complete theoretical models.

Following this strategy, the American Psychological Association (APA) compiled a list of 14 psychological principles deemed important for teaching (Alexander & Murphy, 1998). That initiative grew to "Top 20 Principles from Psychology for

PreK-12 Teaching and Learning" (APA, 2015), which has now been translated into 10 languages.

However, here the disappointment is also palpable. In 2016, the US National Research Council on Teacher Quality investigated whether six principles for effective teaching and learning were offered to students in teacher education (Pomerance et al., 2016). The result was poor; few of the six were found in educational materials. Surma et al. (2018) performed a comparable study in the Netherlands and Flanders with the same result: the two effective learning strategies they focused on were present in few of the 61 investigated textbooks in Dutch and Flemish teacher education. They recommended that teacher education programs select materials that provide insight into the science of learning.

2.3 How theories are learned and used and consequently are to be offered.

The second perspective seen in literature is one in which researchers discuss the arduous application of (learning) theory in teachers' daily practice. This disconnect is referred to as "the gap between theory and practice" (Korthagen, 2007; Hennissen et al., 2017).

Korthagen and Kessels (1999) found it remarkable that many teacher education programs still reflected the traditional deductive application-of-theory model. They advocated the practical training of teachers, where instead of theories being offered and subsequently applied in practice (deductively), those theories should rather develop via holistic images perceived when students are immersed in practice. Such holistic images might evolve into more theoretical frameworks (inductively) with experience and frequent use. More important, the images are more connected to personal beliefs, explanations and experiences, which Korthagen and Kessels refer to as theory with the small t. Over time, these small theories develop with more experience to the more conceptual theory with the big T, hand-in-hand with more expert teaching (for a study based on such an approach, see Dole et al., 2015).

It is important to mention here the vast body of knowledge on how teachers' personal beliefs about teaching and learning direct their daily pedagogical reasoning. Such beliefs are usually based on their own experiences of learning as a student (Huibregtse et al., 1994) or of teaching in their practice Kragh (1998). Beliefs are perceived as facts or truths, or as Pajares (1992) said, "People believe them because, like Mount Everest, they are there" (p. 309). Cheung and Ng (2000) studied science teachers' beliefs specifically about curriculum design, reporting that different perspectives on curriculum were all based on personal

beliefs. Craddock et al. (2013) also reported that practical reasons dominated in curriculum development, but that LTs were used implicitly.

After the LTs offered during initial teacher education, few teachers keep themselves informed on the recent state of research on learning, for various reasons, e.g. the belief that new ideas about learning or even the whole literature are irrelevant and unreliable because researchers are too far away from actual daily practice. More commonplace reasons include lack of time or motivation (Broekkamp & van Hout-Wolters, 2008). Several authors, for example, Boyd (2017), have urged that an in-depth inquiry attitude for new teachers become the focal point in the design of teacher education curricula, in order to prepare student teachers for making sound pedagogical choices. Such professional inquiry involves critical engagement with learning theory and educational research evidence.

3. METHODS

This study aims to shed light on how and why LTs are incorporated into teacher education curricula. As there is hardly any literature on the specific role of *learning* theories in teacher education, a methodology was needed that explores the situation inductively. For this particular context, we were interested in understanding how situations and experiences were interpreted by participants and in identifying possible unanticipated phenomena. Such research calls for a qualitative interactive approach (Maxwell, 2013).

3.1 Context of the study

In the Netherlands, teacher education preparing for teaching in secondary schools is offered by two kinds of institutions. Universities offer one- to two-year programs that focus on pedagogy and pedagogical content knowledge (PCK), typically following a master's degree in the subject to be taught. These programs lead to what is known as a first-degree teaching qualification, which qualifies one for teaching at all levels, including in universities, universities of applied sciences (known in Dutch as HBO), and pre-university secondary education. Universities of applied sciences, on the other hand, offer dedicated teacher education programs in which content, pedagogy and pedagogical content knowledge are offered. These lead to what is known as a second-degree teaching qualification that allows teachers to work in only the lower grades of pre-university secondary education, general secondary education for adults and vocational education. This paper concerns both *first-degree* and *second-degree* programs for secondary education.

For the sake of quality control, second-degree programs have agreed on a knowledge base that describes all of the content that they will all cover. On LTs, this agreement stipulates: "Teachers are able to explain their actions based on a pedagogical reference that is based on principles from, amongst others, learning theories" (10voordeleraar, 2017). The first-degree academic programs do not have such a shared knowledge base.

Another context-specific phenomenon in Dutch teacher education is a separate line of instruction in general teaching pedagogy. It is usually offered detached from the content-area subjects (e.g., science or history), by teacher educators with a master's degree in educational sciences. PCK and subject content are taught by teacher educators who are themselves experienced teachers of the subject. This separation of pedagogy and content often leads to ineffective integration.

In the last 10 years, teacher education in the Netherlands has significantly shifted from happening only in universities towards joint education by universities and schools. This is a government-driven initiative, called *Educating together* (Dutch: Samen Opleiden).

3.2 Participants

A sample of eight large teacher education programs was selected that cover a range of different programs. Four were first-degree university programs (out of 10 in the Netherlands) and four are second-degree programs (out of 11). Six participants were female, two were male. Following Maxwell (2013), we can describe our sampling as a "purposeful selection" as we selected a "panel of people who are uniquely able to be informative because they are expert in the area or were privileged witnesses to an event" (p. 97). For each program one respondent was selected with knowledge of and significant influence over a program's curriculum. All were teacher educators, but their other functions at the university differed (see table 1). They had an average of 10.9 years of experience in teacher education (SD = 4.5). All respondents signed an informed consent form. They were each assigned an ID code to preserve anonymity.

Table 1 Characteristics of the 8 respondents in this study.

Program level	Pseudonym	Function at university (besides teacher educator)	Years of experience in teacher education
1st	Caroline	program manager	13
1st	Jack	teacher educator	6
1st	Brenda	program coordinator	20
1st	Hilda	teacher- generic educational sciences	6
2nd	Jenny	teacher- generic educational sciences	10
2nd	Fran	program coordinator	10
2nd	Maria	program coordinator	10
2nd	Tom	teacher- generic educational sciences	12

3.3 Data collection

To investigate underlying visons and beliefs we used semi-structured interviews in which first a brief inventory of curriculum and materials was made and then the respondents were interviewed to elicit rich data allowing deeper insight.

A semi-structured interview protocol (Appendix A) was constructed around the three main research questions, with several sub-questions. Respondents were asked to focus on the current curriculum and any changes made in the past 5 years. Interviews were individual, and were conducted by the first author. A pilot interview (not included) was conducted in October 2019, which led to changes in the setup. The eight interviews included in this study were conducted from November 2019 to January 2020. At least two weeks in advance, respondents were supplied with information on the research and the protocol, to give them the opportunity to prepare. Interviews took around 60 minutes and were recorded with Sonocent™ software and an extra audio recorder for security. The software displays the interview in blocks of sentences spoken, where each sentence can be marked with key words immediately, during the interview. After coding the first three interviews, the interview protocol was slightly adapted by adding two sub-questions that had been more implicit in the previous interviews (see Appendix A).

3.4 Data analysis

The analysis was conducted in three steps. First, all relevant sentences in the Sonocent™ software were colour-coded, indicating one of the four main questions and these sentences were transcribed into four corresponding data tables. Respondents' exact words were denoted; some longer sentences were summarized. These data tables were shown to the respondents for approval as a member check.

Second, the data tables were loaded into QDA Miner™ software. Results on the *what* and *how* were coded deductively (see appendix B for codebook) and then reported as such in tables. Text fragments for the *why*-question (RQ3), were open coded (inductive), following the grounded theory principle (Babbie, 2013). In the whole process, we aimed to stay close to participants' words and expressions. The codes allotted were substantive, representing own meanings and understanding of the interviewees (Maxwell, 2013). Also rereading memos made during the process led progressively to more insight. Such an open and inductive approach leads to a dynamic and interactive research process as described and advocated by Maxwell (2013).

Third, allotted codes on RQ3 were considered for possible merging using axial coding strategy (Babbie, 2013). Axial coding was a slow process of searching for meaningful perspectives that covered and justified all data (Maxwell, 2013). That resulted in six, more general themes. A new cycle of (re)coding was conducted to check whether these themes still described phrases correctly. To check reliability, co-authors were asked to assign the new codes to randomly chosen phrases. A discussion took place, based upon which the descriptions in the codebook were fine-tuned.

All quotes and codes were translated from Dutch to English.

4. FINDINGS

4.1 RQ1: What theories and principles of learning are offered in teacher education curricula?

Table 2 shows a summary of what is offered in the eight programs, first- and second-degree, chosen for this study. Different aspects of LTs are mentioned and described. The variety of what was found does not allow detailed description of every program. Therefore, findings are presented as general descriptions.

Table 2 Overview of what learning theories are offered in the eight programs, what literature is used and how it is assessed.

What is offered?	**One- to two-year *first-degree* programs (*n* = 4)**	**Four-year *second-degree* programs (*n* = 4)**
The major LTs (e.g. behaviourism, cognitivism, constructivism, connectivism)	In one program explicitly, merely mentioned in 1 or 2 classes in one program, optional course or workshop offered in two programs	In three programs, connectivism in one program, nothing on learning theories in one program
More specific or detailed theories on learning (e.g. Ausubel, Rogers or Festinger)	Not anchored in programs, some respondents say it "might be", respondents not sure about exactly what is offered	Extensively in two programs, one program mentions them when applicable, one program offers none
Specific theory on the brain and memory functions.	Extensively in one program, little or none in three programs depending on available expertise	Basics in two programs,little in two others, depending on available expertise
Explicit application of general learning theories to other theories such as behaviourism in classroom management or connectivism in blended learning	Own emphasis in every program, when it comes up	Explicit examples for two programs, done implicitly for other two
Literature on learning theories	All programs use a selection of teacher education textbooks in Dutch on general pedagogy (e.g., Ebbens & Ettekoven, 2020; Geerts & van Kralingen, 2020; Teitler, 2017). In all programs, teacher educators also use articles or smaller texts according to their personal preference. Three programs use a textbook on learning theories in practice (van der Veen & van der Wal, 2016). All respondents considered most textbooks on LTs as too complicated and/or too theoretical and reported students having problems connecting the content of the texts to their practice.	
Assessment on learning theories	Included in a general knowledge base exam in one program, not tested in other three	Included in a knowledge base multiple choice test in one program, written test on practical situations in one program, not tested in other two

Table 2 shows large differences in what is offered in the programs. The choice of topics covered in the curriculum was mainly determined by personal preference, textbook content or available expertise, as shown in these quotes from respondents:

> We try to use each other's expertise as much as possible. (Jack)

> In every general course we try to invite a researcher who presents a theoretical introduction. (Fran)

Although second-degree teacher education has a well-defined compulsory knowledge base, this knowledge base does not mention to what extent the content needs to be taught. Two respondents declared that learning theories were only in the curriculum because of the compulsory knowledge base. The one program without any LTs deliberately decided to avoid teaching LTs because of their pedagogical vision that practice should be leading.

A second observation is that the second-degree programs generally offer LTs to a larger extent than the first-degree programs. As the first-degree programs are academic, one might expect a more solid theoretical underpinning. The reason that LTs are nevertheless not emphasized, mentioned by all four respondents from first-degree programs, is the limited duration of the programs (1-2 years), part of which is spent on a substantial internship. In contrast, the second-degree program covers four years. As one respondent from a first-degree program said:

> We have a short program and students need concrete guidelines how to do it in class tomorrow. Of course, it is good to tell them about learning, but that's not what they need. (Hilda)

In assessment of knowledge of LTs, a clear shift over time was observed. Almost all programs used to have an exam on it, but have dropped it in the past few years. Respondents from the two programs that still feature an exam on LTs called these exams "controversial" (Maria), questioned the effect on daily practice (Caroline), and reported reconsidering continuing the exams. The only consideration that was mentioned in favour of holding onto the exam was compliance with the required knowledge base.

In response to the open-ended question, 'What theory on learning is offered in your program?', several respondents pondered (and asked the interviewer) whether theories such as Bloom's taxonomy or Kolb's learning styles or personalised learning could be considered a learning theory. Because the objective of the study was to register *what* is offered, as well as personal vision and beliefs, no definition of learning theory was supplied in advance. The responses to this question show that teacher educators do not always distinguish between models from educational sciences and learning theory.

When the choice of a certain textbook is made, its content seems to determine what LTs are offered. Only two first-degree programs and one second-degree program use a separate Dutch textbook (van der Veen & van der Wal, 2016) on translating LT into practice. Respondents from all three programs reported that students do not like it, even "hate it" (Maria). Therefore, discontinuing use of the book is being considered. One academic program previously used a master's level textbook on educational psychology (Woolfolk, 2016), but that was discontinued because it went too deep for the short course. Respondents were more in search of (even more) practice-oriented books.

4.2 RQ2: How are theories and principles of learning offered in teacher education curricula?

Table 3 shows an inventory of how blocks, courses or modules on LTs are offered, concerning their place in the timeline and whether they are separated or intertwined with specific content subjects, in separate classes and/or also in internships.

Table 3 Overview of how learning theories are offered in the programs

How is theory on learning offered?	**One- to two-year *first-degree* programs (*n* = 4)**	**Four-year *second-degree* programs (*n* = 4)**
How are LTs placed in the time line of the program? (when are they taught)	Because of the limited timespan of these programs (max. 2 years), all programs start with practical classroom issues. LTs are never offered at the start; two programs offer them at the end of the first year, two in the second year.	The three programs offering LTs do so at the beginning, in the first year. Two programs have a second course on LTs in the third or fourth year.
Generic line (general educational) or subject-specific content line (PCK)	Two programs teach LTs in a separate generic line of educational sciences with a fixed set of topics. Two perceive LTs as integral to PCK and delegate the subject to content teacher educators; respondents don't have an overview on topics and methods.	One program has a theoretical generic line in which LTs are covered and tested, two cover it in the generic program with intertwined field assignments.
Connection to practice	All four programs require students to make LT visible in practice: preparing materials, teaching, classroom management. Two programs require LTs to be used in theoretical framework of research assignments.	Historically, all four programs adhered to the deductive "apply theory in practice" model; one still does so. Due to the *Samen Opleiden*-program, all four are experimenting with more intertwined assignments in internships.
Inductively or deductively	Two programs more inductively, two have both inductive and deductive approach.	One program fully inductive; only when the topic comes up in practice. One program fully deductive, "from theory to practice". The other two follow both lines.
Boundary conditions mentioned that influence pedagogical decisions	How LTs are taught: - depends on the available expertise (five programs) - depends on teacher educators' personal preferences (all programs) - needs to be adapted in response to the diversity of the students entering the program, which makes it difficult to have one c ompulsory program (three first-degree, two second-degree) - is strongly influenced by time constraints (all first-degree programs) - is influenced by differences in students' interest: more teaching-focused or more theory-focused (all first-degree, three second-degree)	

Here again, the most obvious observation is the diversity of routes and educational forms in which LTs are offered; no program is similar in approach. The different decisions about when to offer LTs are worth noting; on the one hand, they are not offered in the beginning because of time and priorities, but on the other hand, that is precisely when they are offered, because they are the basis of education and learning.

A fully deductive approach was advocated by one respondent (Tom), while most others acknowledged that (ideally) it should be an inductive and ongoing process:

> "Teach as you preach! Make that deeper layer underneath visible, in *every* class. I really would hope that all teacher educators do that. I hope... It's not a rule, not agreed upon in our program to do so" (Fran).

Despite the diversity in how LTs are taught, a general shift was observed as far as increasing attention to LTs within the internships. The approach to this shift, again, was diverse. Four examples are:

> Teacher educators offer theory classes inside the internship schools (Tom).

> The entire practice program is fully focused on student concerns and theory comes up when necessary (Brenda).

> The new curriculum is fully focused on internship assignments that contain some theory (Fran).

> There is a joint design of blended learning and practical assignments with secondary school teachers (Jenny).

Finally, it is striking that the boundary conditions mentioned may largely explain the observed variety; they seem more determinative than actual pedagogical decisions.

4.3 RQ3: What is the relation between the vision of the role of LTs held by of those responsible for the curriculum and the implementation of LTs in teacher education?

Surprisingly, all respondents considered LTs to be essential and indispensable in teacher education. Even though two respondents mentioned the nationally agreed-upon knowledge base as the sole reason for offering LTs, they still acknowledged the relevance in teacher education. All respondents also agreed that there should be no difference between first- or second-degree programs with regard to the role of LTs. Differences in emphasis were considered acceptable, but LTs were seen as one of the pillars of teacher education. However, when conversations developed, all participants voiced doubts about the role of LTs in teacher education. Immediately or later, more or less. These remarks were coded *#doubts* in the open coding. In the axial coding then, we decided not to use *#doubts* as a separate theme because these doubts differed greatly in their origin and using this as a central theme would provide a wrong and fairly negative perspective on the entire study. Axial coding, thus, found six themes, each having their visions, opinions, beliefs and doubts.

According to the interviewees, the role of LTs in teacher education can be:

1. to become aware of what *learning* actually is, resulting in a richer vision on learning;
2. to substantiate pedagogical reasoning in daily practice, thereby enriching teachers' repertoire of actions;
3. to make or strengthen the link between theory and practice in the teacher education program;
4. to become aware what a theory is in itself and what the role of theories is in (daily) education;
5. to enhance the quality of education in secondary schools;
6. to sustain the development and deepening of professionality in student teachers' future role as teachers.

We will discuss each in turn.

4.3.1 Forming a vision on learning

"Students becoming aware of the central role of learning" was mentioned by all respondents, albeit from different perspectives. The following perspectives were distinguished in the interviews. Students become aware of:

1. teaching and learning as two distinct processes;
2. what learning entails;
3. how the word "learning" can describe different processes;
4. how they themselves learn, and have learned in the past;
5. what difficulties there can be in the learning process.

Most respondents described the vision on learning that students develop as a general vision on education and teaching, not just on learning. This vision is never based on a single LT: "LT is a very important perspective to look upon education, but it's never the theory itself, you'll need a vision and a goal what to achieve with your pupils" (Caroline), and "Finally it's all about 'how do you organise the learning of students' and if you want to understand and acquire that, you should know something about learning" (Brenda). Three respondents qualified the absence of knowledge about learning as hazardous for teachers: "If you leave the classroom thinking 'I told them, so it's learned', ... well ... that seems really dangerous to me" (Jenny). Five programs require students to write vision documents; one asks for an autobiography: "writing such an autobiography and finding out that your neighbour learns different things in a completely different way, that's such an eye opener" (Brenda).

At the same time, all eight respondents acknowledged that the majority of students are not yet ready to really understand the significance and relevance of LTs during the program. Only after a few years of practical experience, when students have acquired a firm grasp of classroom management, will there be room for more reflection and considering their teaching from a broader perspective, according to the respondents: "During training of experienced teachers - even shortly before retirement! - it is remarkable how interested they are in the underpinning of their practice and how motivated they are to reconsider their teaching and try things tomorrow" (Jenny). But all eight were also sure that interest in LTs "has to be sown during the education program" (Caroline), but that their place (often in the first year) in the program is too early. In internships, this manifests itself when students prove unable to integrate LT when designing lessons or writing a personal vision on their future profession. Or worse, they are "often even denying they ever heard of [LTs]" (Maria).

4.3.2 Substantiating pedagogical reasoning in daily practice

In all programs, students are asked to underpin their pedagogical and classroom management decisions with what they have learned in theory. This is driven by a strong consensus that the ability to connect theory and practice is the bedrock of higher education, including in teacher education. All respondents stated in varying wordings that LTs help teachers with pedagogical decision-making: "LTs help to design tests and assignments" (Caroline), "help to choose your personal way of planning lessons" (Brenda), "can help you to understand things in other contexts like in a minor program" (Hilda) or "help to take a stand on blended learning and designing new digital courses" (Maria).

However, when asked whether they see students in internships as capable of connecting their practice and theory, six respondents said no. As respondent 7 explained, "Let's be honest, these are applied-sciences students after all, practical, not first-degree university" (Tom), while other respondents had these comments: "In the end I'm not so interested whether someone can explain that his approach is constructivist, I'm happier to hear him or her explain it works for them" (Jack), and "...and I'm afraid the majority of in-service teachers are doing the same tricks for years and will not be able to explain or substantiate the 'why'" (Jenny). Two respondents omitted an explanation and said students just "have to": "that's not an issue, it's higher education level to be able to explain why you do things as you do. Full stop." (Maria). All respondents acknowledged that only a few students have truly adopted theories; more often, "students are often skilful in putting up literature citations afterwards because it is obligatory, without having these theories internalised" (Brenda) or "They cite that author x says so on page 25, which is true, but that's not the real underlying principle" (Fran).

The use of LTs in practice is also believed to enrich teachers' repertoire of actions when dealing with pedagogical challenges, according to five respondents. Examples of such challenges are "being confronted with a highly gifted student where your standard pedagogy appears not being effective" (Caroline) or "when your school changes to a new educational concept that requires another approach and design of new materials" (Tom). Here, LTs could be helpful, but when asked for concrete experiences, none of the respondents had any examples from practice.

4.3.3 Strengthening the link between theory and practice in the teaching education

In teacher education programs, LTs might also play a role as a more general theoretical framework. As respondent 6 noted, "Connecting theory and prac-

tice is *the* biggest challenge of teacher education". Upon being asked whether they thought their colleagues could connect their pedagogical reasoning with (learning) theories, all referred to the "Teach as you preach" motto; at the same time, all but one had doubts whether that was being applied in practice. As respondent 4 commented, "LTs should be visible in every course, but that's an ideal; I see even my own colleagues finding these theories quite difficult". Only respondent 6 said, "I think the majority of educators are conscious of their own personal way of learning and the theoretical background of it, certainly those who teach PCK".

The interviewer then presented the APA "Top 20 Principles from Psychology for PreK-12 Teaching and Learning" (APA, 2015) and asked whether it would be more helpful to offer principles of learning rather than theories. All eight respondents acknowledged that offering principles would be a good idea for practice; however, just offering principles is "scratching the surface" (Jack), "is not showing the bigger picture and underlying way of thinking" (Maria) and "presents a danger that students think that this is 'how it should be done'" (Caroline). However, when confronted with a concrete example of one of the 20 principles (e.g., what one already knows largely determines how one learns), all respondents started to doubt their own prior considerations. They stated that such a principle is of the utmost importance and should be known by every teacher. They also acknowledged that it is implausible that (pre-service) teachers would be able to deduce such principles from broader LTs.

4.3.4 The role of theories in daily teaching

The role of theories in teaching was introduced by the question whether one can be a good, competent teacher without theory. All eight respondents needed time to think this over. Four educators came to a positive conclusion: "Of course you can, look at practice. But they would probably be better teachers if they knew about LTs" (Jack) and, "Finally it comes down to training the attitude of reading literature during work. Theory is forgotten after five years" (Brenda). Four educators had strong doubts:

> Maybe one in a thousand who understands intuitively how it works" (Fran)
>
> I think without LTs you might be too restricted in your action repertoire" (Maria)
>
> In-service teachers who don't use theory are not bad teachers, but it's such a pity that learning is not at the forefront" (Jenny).

All initial answers were followed by more reflective considerations and answers that diverged from a clear yes or no. That suggests there is a firm belief (which is often primary and leads in discussion) that LTs would support practice and are indispensable, which is contradicted by their experiences from daily practice, where the application is at least doubtful. This leads, on second thought, to questioning the relevance of LTs. When it came to classroom practice, they were less positive:

> You can teach them LT, but that's not what they need. (Hilda)

> Our profession [teaching] is incredibly complex and fitting theory within the dynamics of a lesson is very difficult; practice is always more stubborn. Complete application [of theory] is probably impossible. (Caroline)

> I really think that most [pre- and in-service] teachers cannot do this. (Brenda).

> In the pragmatism of daily work and time pressure, teachers' LT-based principles and vision are simply skipped, and teachers make different, more practical choices than those based on their beliefs. (Jack)

> That is called apprenticeship of observation, I think, that you created a concept of something [i.e., teaching] for so long a time that it becomes impossible to break it down completely and build a new one. (...) Because they [students] as receivers of education have had experience with teachers for 12 years, [I'm sure that] what we tell them in teacher education does not make any difference. I sometimes doubt the impact of a teacher education program. (Fran)

When reflecting on teaching students to apply LTs in practice, three respondents stated that using LTs in practice takes time and experience; as respondent 7 noted, it is "behaviour and behaviour must be trained ... and we all know that you need a lot of flying hours. It cannot be learned from a book and a few lessons".

4.3.5 Enhancement of regular secondary education

In order to enhance the quality of education in secondary schools, "LTs could help when sharing experiences and pedagogical knowledge because you have a mutual language" (Caroline). However, discussing pedagogical content in daily educational practice is not very common. Respondents mentioned, analogous to what is stated in the literature (e.g., Broekkamp & van Hout-Wolters, 2008), that in-service teachers rarely read educational literature and do not have a

reflective and critical attitude towards learning. For example, respondent 7 noted, "If a student works with an internship coach who doesn't know and use LT principles and is not able to discuss them, students learn implicitly that it apparently is not used in practice". To change that, in-service teachers who are internship coaches should be trained frequently. Respondent 8, however, qualified what the aim of such training should be: "A critical attitude, now and then reading an article (...) that's much more important than being able to explain what LT is underneath".

In this regard, respondent 9 felt that, "school management can shape the pedagogical climate in the school; they should be first to focus on LTs!", while respondent 2 noted, "Working in a school has changed considerably in the past ten years; if you want to keep up with the changes and be flexible enough, a broad knowledge of LTs helps".

4.3.6 Deepening of professionality in the future role as teacher

Another role of LTs may be a guidance for advancing teachers' professionality. The focus here is on the complexity of the profession (content, pedagogy, education, communication, coaching, leading, and more). Because of this complexity "LTs might help to acquire overall competence faster and with deeper understanding" (Jenny). All respondents stated at some moment or other in the interview that if furthering the learning of children is your profession, you should know about how people learn.

As stated earlier, the idea of teaching as you preach was acknowledged by all respondents. Teacher educators should make theories and principles of learning visible in their classes on a daily basis, but all doubt whether that happens and whether all teacher educators are able to do so.

5. DISCUSSION AND CONCLUSIONS

In this study, we used interviews with teacher educators who had a good overview of the curriculum of their program to investigate what learning theories (LTs) were offered, how they were offered, and what vision was behind the role that LTs played in the curriculum.

5.1 What and how LTs are offered

On *what* and *how* LTs are offered, we can conclude that, despite a mandatory knowledge base in second-degree programs and a shared vision of the importance of LTs, no program treated LTs alike. Every program made different

choices, quantitively and qualitatively. Programs varied from dedicating entire courses to LTs to leaving them out, from assessing LTs with and without exams or in other forms to not at all, from using dedicated academic textbooks on learning to no texts at all, from being soundly based in educational science or psychology to leaving it to every teacher educator's personal choice. It can be advocated that staying close to teacher educators' personal choices and beliefs may lead to effective teaching, and consequently to conceptual change, but there is no common theory, model or idea about LTs among the respondents from the different programs, or even about learning itself.

Consensus is also lacking on how LTs should be taught. No program took the approaches laid out in the theoretical framework of either offering a strong constructivist foundation or presenting learning principles, as advocated by cognitive psychologists. Instead, textbook contents and boundary conditions often seemed more determinative than actual pedagogical decisions. Surma et al. (2018) found that textbooks covering learning strategies are used in a minority of teacher education programs. That and the struggle we saw to find textbooks on LTs that connect them with practice suggest that there is a need for textbooks that integrate LTs with either classroom practices or subject content.

It seems that de Corte's conclusions (2000) that cognitive science is poorly used in education still holds true, although the strategies he advocated (a more holistic approach, more reciprocal communication and changing fundamental beliefs) have been partially implemented: a more holistic approach is developing in the form of the *education together* approach in the Netherlands, where universities and schools work together in teacher education. However, more reciprocal communication between practitioners and researchers is still absent. The researcher or "theorist" role should be represented by teacher educators being aware of latest research (Willingham, 2017), but respondents in this study doubted strongly whether that can be achieved. Finally, most difficult to change are teacher beliefs and convictions, because they are basically unchanging; if they do change, it is not because of argument or reasoning, as they are often implicit and unconscious (Pajares, 1992). Therefore, old ideas probably remain entrenched despite a steady shift toward new views of teaching (Cochran-Smith et al., 2014). To achieve change here, existing implicit beliefs about learning should first be brought to conscious awareness.

Some change relative to the recent past was observed in how LTs are offered. Deductive approaches (theory courses at the beginning of the program because they present the basics, with later "application" in internships) are still there, but a shift to more inductive approaches was seen (first offer what they need

in tomorrow's practice, let student concerns lead or integrate LTs into content subjects). This is more according to the Korthagen and Kessels (1999) approach, where first holistic images and small theories evolve from daily experiences. Such inductive growth, however, needs conscious and rich experiences, which might explain one respondent's observation that experienced teachers later in their career are more enthusiastic when LTs are discussed than starting student teachers. At the same time, all respondents agreed that any coupling of theory and practice should start within the teacher education program, in classes in which teacher educators make their daily pedagogical decisions explicit. Teach as you preach! But most of them doubted whether their colleagues are capable of doing so. This doubt is not unfounded, as indicated by earlier interviews with a sample of teacher educators (Meij, 2018).

5.2 Why LTs are offered: a gap between paradigm and reality

The question whether one can be a good teacher without theory was difficult to answer for all respondents, as it exposes a conflict between experiences from daily practice on the one hand, and the agreed-upon curriculum and personal beliefs on the other. In that way, it questions the higher education paradigm that teaching needs theory.

Convictions about LTs' importance were strong and several roles of LTs were acknowledged by our respondents. Coupling theory with practice and substantiating practical work with theory was even considered the essence of higher education. At the same time, experiences in daily practice often suggest the opposite; all respondents doubted the explicit effects that LTs have on practice. Most respondents questioned whether we should still demand theoretical underpinning to be done by students, while the other respondents did recognise the discrepancy, but persevered in demanding this as up to "the level of higher education". This might be seen as an additional gap in teacher education, between paradigm and reality, that could explain the difficulty we currently face with the theory-practice gap in classroom teaching. This is a gap between the official, the taught and the learned curriculum (Cuban, 1993), between intention and feasibility, between a paradigm and personal convictions, between "should be" and "is". How can we require theoretical substantiation of all practice by students if we, as teacher educators doubt that this is feasible?

This all needs further research. We need more insight into the implicit knowledge of learning that teachers hold. Maybe the theory-practice gap is not a perennial problem (Korthagen, 2007), but a given condition, that we must take as a starting point for reasoning about the curriculum and quality of teacher education.

In the meantime, as our respondents suggest, it may help when teacher educators teach as they preach: make your own pedagogical reasoning explicit and make the connection between teaching and learning visible to pre-service teachers on a daily basis. If we want mindful pedagogical reasoning to happen, daily practice tools such as supervision, peer-to-peer coaching, learning communities and reflection may need maximum attention in every program, preferably with pre-service teachers, in-service teachers and teacher educators working together.

5.3 Limitations of the study

With regard to limitations of this study, first it must be acknowledged that it describes only the Dutch situation. It is unclear whether these findings generalize to countries that have different approaches to teacher education, especially when it comes to a more theoretical or practice-driven program (Darling-Hammond, 2017).

Second, we only studied the perspective of teacher educators in tertiary education. The views of in-service teachers who function as coaches, student teachers and secondary school management were not explored, even though they play important roles in teacher education. They might have no opinion on *what* and *how* LTs are offered in the teacher education programs, but certainly they have some on learning and on the implications of (learning about) LTs in daily practice. It would be interesting to explore their vision on inductive learning and whether one can be a good teacher without knowledge of theory.

Third, there was just one respondent from each program studied. Although respondents were selected for having a broad view on the program and its underlying vision, it can be questioned if their answers and explanations are representative for the entire program, especially given the finding in this study that content and vision depend to some degree on personal preferences.

5.4 Conclusions

There is considerable variety in what and how LTs are offered in Dutch teacher education programs. The level of content varies from intensive courses to total absence, and teaching methods from theoretical courses with or without exams to assignments in internships. It is striking that textbook contents and boundary conditions often seem more determinative of these choices than having them be based on actual pedagogical decisions.

There was a consistent vision that LTs are important in teacher education, which was acknowledged by all respondents, although their reasons may vary. Most remarkable is the difficulty that respondents have with the question whether one can be a good teacher without theory. The question seems to invoke a conceptual conflict between a bedrock belief that in higher education one should substantiate one's pedagogical choices (e.g., as outlined in student work) with theoretical underpinnings and their perceptions that in daily practice such underpinning is seldomly authentic. All respondents had a conclusive explanation of their particular curricular choices, and at the same time doubts about the practical significance intended. They questioned whether pedagogical reasoning in practice is based on LTs offered in teacher training.

This leads us to diagnose an additional second theory–practice gap: teacher educators believe in theory that theoretical underpinning of teacher practice is necessary, but their practice has shown them that it does not succeed and they doubt its necessity. That raises the question whether the paradigm of connecting theory and practice in higher education should be rethought.

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CHAPTER 3

Exploring teachers' beliefs about learning principles.

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ABSTRACT

Teachers hold conscious or subconscious beliefs about pedagogy, education and learning that are deeply ingrained and steer their daily pedagogical reasoning. Numerous studies have aimed to reveal these beliefs, but whether specifically principles of learning are part of teachers' beliefs has not yet been addressed. This study investigated whether teachers' explicit and implicit beliefs are consistent with scientific principles of learning.

For that purpose, a multiple-component online test was constructed. In an implicit word association task, participants had to categorize words as being linked with learning or not, with the responses and their speed analysed for what they might reveal about beliefs about learning. In an explicit classroom statement task, participants were presented with a statement about actions in the classroom that either were or were not in line with principles of learning and asked how firmly they believed it was true (or false) and on what basis. Finally, in an explicit principle endorsement task, participants were asked how convinced they were that 10 principles of learning taken from an American Psychological Association consensus list were correct. A total of 257 pre-service and in-service teachers, teacher educators and educational scientists completed the test.

Results showed that on average, 80% of the teachers did believe that the 10 principles presented were correct, although not all were endorsed with a high degree of conviction. In the implicit word association task, response times for words associated with learning were generally shorter than for other types of school related words. One principle, that adaptation of existing concepts is a slow process, was an anomaly on both tasks. Correlations between the implicit and explicit results were low.

In conclusion, implicit and explicit responses reflect teacher beliefs about learning that are generally consistent with scientific learning principles, although the backing for some principles is less strong than for others.

1. INTRODUCTION

> *Learning in schools does happen [...] and an understanding of the ways in which we believe learning takes place is really essential for those responsible for planning and implementation of programmes of learning: Teachers. (Pritchard, 2017, p. xi)*

The above quote makes two things clear: Learning happens at school and the key figure in it is the teacher. Obviously, a teacher uses knowledge about learning to make the appropriate choices for a lesson that leads to learning (e.g., American Psychological Association, 2015; Schunk, 2020; Shulman, 1986; Veal & MaKinster, 1999). This choice making is called pedagogical reasoning and action (Loughran, 2019; Shulman, 1987). Ideally, teachers make their teaching decisions based on their knowledge about teaching and learning known as evidence based teaching. That knowledge can originate from formal taught theories derived from research and from experienced practice.

However, daily classroom practice does not always adhere to this ideal; teaching decisions are more often based on beliefs that originate from personal past classroom experiences (e.g., Markauskaite & Goodyear, 2014; Mellor, 2021). Although theories about learning are a standard component of most teacher education curricula, it seems notoriously difficult to let (newly) taught theory prevail over these personal beliefs in daily classroom practice decisions (e.g., Fives etal., 2015; Gleeson & Davison, 2016; Basckin etal., 2021; Meij etal., 2022). Positive practice experiences may lead indeed to a willingness to become more innovative, develop insight in the relation between theory and experiences (Mellor, 2021) and provide an opportunity to *unlearn* possible flawed beliefs (Gleeson & Davison, 2016). However, beginning teachers start in an environment that often aligns with their pre-existing beliefs. Even when a teacher initially is unwilling to conform to a - rigid - school system, social factors such as marginalization and isolation may still lead to fitting in, hampering personal development (Mellor, 2021). The theoretical knowledge formally taught then seems to "wash out" as already described 40 years ago by Zeichner and Tabachnik (1981) leading to gradual disconnection of formal theory and daily practice and more unconscious decisions based on implicit beliefs. This 'gap between theory and practice' is widely known in many fields as a persistent problem (Arteaga etal,, 2024) and for teacher education is acknowledged (e.g. Korthagen, 2007) and broadly researched (e.g. Resch & Schrittesser, 2023; Hennissen et al., 2017; Korthagen, 2007; Korthagen & Kessels, 1999).

Internationally the focus in education has shifted in the last few decades from teacher- and content-centred instruction towards more student-centred learning (Schreurs & Dumbraveanu, 2014). Formative action around the question "What did your pupils actually *learn* today?" now gets more attention in teacher education and classroom practice. Formative action on this question requires theory based pedagogical reasoning with therewith knowledge of theories and principles of *learning* (PoLs) like e.g. the role of prior-knowledge, cognitive load theory or knowledge about recalling and forgetting. More practical and comprehensible textbooks about learning in education for teachers have become available that stay close to daily classroom practice (e.g., Didau, 2015; Kirschner & Hendrick, 2024; Willingham, 2021) and even textbooks with more condensed PoLs that student teachers can use for tomorrow's lesson plan (e.g., Bates, 2019; Surma et al., 2019). Such texts that communicate research findings in a accessible and comprehensible way and are easily applicable probably have contributed to the shift of focus on learning in the classroom (Schmidt, 2024).

However, what if these principles clash with the conscious or subconscious convictions and beliefs teachers hold about teaching and learning, which are deeply ingrained (Pajares, 1992).

According to conceptual change theory, deeply rooted concepts linked with numerous personal experiences, beliefs and mental images are difficult to change (Vosniadou etal., 2020). Introducing new ideas about learning, such as those presented during teacher training, do not plainly replace existing concepts. Conceptual change is slow and stepwise and even parallel concepts may exist next to each other for a long time (Vosniadou, 2013). Therefore, daily pedagogical decisions are often persistently based on teachers' implicit personal ideas of "good teaching" from their own past school experiences (e.g., Karavas & Drossou, 2010; Loughran, 2019, Zakaria & Ab Wahid, 2023).

While many teachers may thus teach lessons based on beliefs rather than evidence-based pedagogical reasoning, certainly not all these lessons are ineffective. The question arises: if these lessons are effective nonetheless, do those guiding beliefs perhaps reflect correct scientific principles of learning? The objective of this study is to explore such beliefs about principles of learning. The question we focus on in this paper is: *Are teachers' beliefs, either implicit or explicit consistent with scientific principles of learning?* Such insights might be directly helpful in finding more effective teaching strategies for theories and principles of learning being offered in teacher education as the prior knowledge of starters and teacher educators can hinder as well as enforce each other.

2. THEORETICAL FRAMEWORK

2.1 Teacher Beliefs

Teacher beliefs are considered important because of their strong influence on teacher behaviour and classroom outcomes (Sykes, 2011; Zakaria & Ab Wahid, 2023). Several studies have reported on the content and significance of implicit prior knowledge for deliberate pedagogical reasoning. (e.g., Glogger-Frey et al., 2018; Markauskaite & Goodyear, 2014). McAfee and Hoffman (2021, p. 1) stated that teacher beliefs are especially "egregious because teacher beliefs exert direct influence upon curriculum development, pedagogy, and the construction of effective learning environments."

Teacher beliefs have sustained a huge body of literature (2100 articles reported in eric.ed.gov in 2023) and inspired a dedicated research handbook (Fives & Gregoire Gil, 2015). Despite this abundant research, the construct of teacher belief has always been considered ambiguous (Pajares, 1992). In their lucid summary of the literature, Fives and Buehl stated:

> ...defining the term 'teachers' beliefs' is not difficult because several authors have done so. What is difficult is getting authors to consistently define and use terms within and across fields that examine these. (2012, p. 473)

Nonetheless, there are some unresolved issues: whether beliefs differ from knowledge, whether they are fixed or prone to change in different contexts (Fives & Buehl, 2012) and how they are part of larger belief systems. Beliefs are seldomly tightly delimited, and are assumed to be elements of a larger complex and interrelated belief system. Lawson et al. (2019) stated that such a system is constantly evolving and that change in one belief is unlikely to be decisive for changing behaviour. Fives and Buehl (2012) also highlighted the importance of recognising that a belief is likely to be interconnected with other beliefs (e.g., Vosniadou et al., 2020). Fives et al. (2015) warned that such interlocking beliefs must first be clarified, as they might blur the research on teachers' beliefs, for example, whether the focus is on beliefs about learning or about teaching.

A distinction is typically made between implicit and explicit beliefs (Sykes, 2011; Wilcox-Herzog et al., 2015). *Implicit beliefs* are considered to develop and reside in the subconscious, whereas *explicit beliefs* are deliberately formed and known to the holder. Implicit beliefs are forged gradually through experience, while explicit beliefs can be formed through personal experiences as well as information acquired by the individual. Implicit beliefs are therefore not malleable by con-

sciously available information, whereas explicit beliefs are (Wilcox-Herzog et al., 2015). Ellis (2005) defined criteria to distinguish the two when operationalised for measurement. Responses based on implicit knowledge are more based on the feel than on rules, emerge under time pressure, focus more on meaning than on form, are more consistent and stem from early learning.

McAfee and Hofmann (2021) stated that many teachers fail to realise that their messages to their students may not be evidence-based, but reflect their personally entrenched beliefs developed over a lifetime. They showed that many teacher beliefs about teaching and learning are based on misconceptions about pertinent topics in educational psychology, illustrated by an extensive list of misconceptions and neuro-myths. They stated that although misconceptions are often studied, misconceptions among teachers regarding effective teaching are neglected. That is where our focus lies. We aim to focus on implicit as well as explicit beliefs about the basic principles of learning.

2.2 Measuring Implicit Beliefs

Measuring implicit knowledge, beliefs, attitudes or convictions is fraught with difficulties. One inherent difficulty is that when outsiders probe for an implicit belief, it becomes conscious and stops being implicit (Sykes, 2011). Therefore, indirect methods of eliciting implicit beliefs have been developed. *Indirect measurement* means "an inference of a construct without instruction to report it, assuming no introspective awareness of the construct" (Greenwald & Lai, 2020, p. 420).

In measures of implicit memory, response speed is assumed to reflect the strength of implicit beliefs, associations, or memories. The reasoning behind this is that reaction time correlates with accessibility, reflecting the strength of implicit associations. Accessibility has been defined as:

> The likelihood that an attitude will be automatically activated from memory on encountering the attitude object. Accessibility is assumed to depend on the strength of the associative link in memory between the representation of the object and the evaluation of the object: the stronger the memory link between the object and its evaluation, the more quickly the attitude will come to mind. Attitudes that come quickly to mind are believed to be better guides to behaviour. (American Psychological Association, 2018, attitude-accessibility).

Holland et al. (2003) investigated this correlation between response time (RT) and attitude strength. They concluded that the strength of a conviction may indeed be inferred from its accessibility and, thus, from RT data.

Whether an indirect measure truly reflects only implicit beliefs is very hard to establish, and often highly questionable (Corneille & Hütter, 2020). Moreover, how direct and indirect measures relate is still an open question. Low correlations between direct and indirect measurements around a construct were reported by Nosek and Smyth (2007) and by van den Bergh et al. (2010). For implicit memory, Martens and Wolters (2002) found that circumstances reducing explicit memory also reduced some forms of implicit memory (known as repetition priming), but not another (semantic priming). This suggests that whether direct and indirect measures of a given construct are correlated is an open question.

Nevertheless, Jost (2019) advocated that, despite the concerns, attempting to measure implicit beliefs remains necessary because of the importance that educational scientists attribute to such implicit teacher beliefs. Denessen et al. (2022) reviewed 49 studies and concluded that indirect measurements remain potentially interesting for understanding teachers' attitudes.

2.3 This Study

In sum, teachers' pedagogical reasoning is affected by their beliefs, some of which may be implicit. Eliciting implicit beliefs requires indirect measurement, even though the reverse inference – that implicit measures reflect only implicit beliefs – is invalid. We therefore set out to explore indirect measurement of beliefs about principles of learning and their relations with direct measurement. The first research question is:

RQ1: What do indirect measurement based on reaction times reveal about beliefs about principles of learning?

To answer this question, we constructed a word association task, where we studied if participants associated words with learning by measuring RTs. These words were taken from principles of learning that summarize scientific knowledge on learning (American Psychological Association, 2015). We then tested to what extend the participants could apply these principles in classroom situations and whether they endorsed them and how strongly, to answer the following question:

RQ2: *To what extent are teachers convinced of validated principles about learning?*

Then we tested whether the outcomes of the indirect and direct measurements were correlated:

RQ3: Is there a correlation between the results of the indirect and direct measurements?

Positive correlations would be an indication that the beliefs are recognised both consciously and unconsciously and that someone's knowledge and conviction are probably based on equal principles. Negative or absence of a correlation would imply that (later) acquired knowledge is not in accordance with – prior – beliefs and that parallel concepts might be present.

3. METHOD

3.1 Participants

Responses were collected from an exploratory online test instrument in Dutch that was open for everyone in the Netherlands, between March and July 2022. There was no active recruitment other than sending invitations to all teacher education institutes in the country with the question if they would bring it to the attention. Anyone aware of the survey was allowed to respond to it; a specific question asked for participants' role of which one option was 'not in education'). Due to legislation on personal data, only characteristics that could be relevant to the research were asked and therefore not, for example, home or workplace and gender. It was strictly stated that participation was anonymously. Participants all provided informed consent before starting. The study was performed in accordance with protocol #2019-151, approved by ethical review board of Vrije Universiteit Amsterdam, Faculty of Behaviour and Movement Sciences.

516 people started the survey, 307 of whom fully completed all four components (see Instrument). Ten participants answered with below-chance accuracy in the implicit word association task (all questions had equal answers and/or all reaction times < 10 ms) or had an average reaction time ±3 *SD* outside the overall average RT and these participants were dropped from the sample. Since the study was about teacher beliefs, 22 participants who indicated that they do not work in education were excluded for this study. This was also done for the 16 participants who indicated "I'm reading really slowly," since in this study response speed was the central dependent measure. (These participants were indeed 10.5% slower than the others, on average.)

This left 257 participants: 60 pre-service teachers, 104 teachers from secondary education, seven teachers from vocational education, 28 teachers from higher education, 47 teacher educators and 11 educational researchers. Participants taught a variety of different subjects. Ages ranged from 17 to 68 years (M = 38.5, SD = 14.5). Student teachers had completed 1 to 4 years of internships (average 2.1). Teachers had an average of 15.5 years of classroom experience (SD = 11.1).

3.2 Development and validation of the instrument

To be able to compare different measures of teacher beliefs about learning in educational contexts, a standard for comparison is needed on which there is broad consensus, despite the bewildering variety of learning theories (Bates, 2019; Schunk, 2020). Because in the Dutch teacher education no standard on theories or principles of learning exists (Meij et al., 2022), we therefore based our instrument on the American Psychological Association report, *Top 20 Principles from Psychology for PreK-12 Teaching and Learning* (American Psychological Association, 2015), developed as a consensus summary of what is known about learning. This had as an additional advantage that the principles reflect established relationships between a specific teaching strategy and student achievement (Woolfolk, 2020). Therefore, they translated more easily into words and statements close to daily teaching practice.

For this study, an online instrument was developed that consisted of four parts. The instrument was in Dutch, for translation see Appendix C. All four parts were based on the same set of principles of learning (American Psychological Association [APA], 2015). To keep the length of the questionnaire manageable, we focused on five cognitive and five affective learning principles. Since the APA Top-20 list does not include principles that deal with the influence of memory in a school situation, we decided to use three APA Top-20 cognitive principles and added two other principles that have been extensively studied in education. The first is that "Verbal and visual information combined in learning can mutually activate each other," based on dual coding theory (Paivio, 1991) and empirically tested in education (e.g., Wu & Puntambekar, 2012). The second is "Adapting existing (mis)conceptions is a slow and laborious process," which stems from conceptual change theory (Duit & Treagust, 2012; Vosniadou, 2013). Next to these, we chose the cognitive PoLs: "Long-term learning and skill is largely dependent on practice" (APA Principle 5: practice); "Prior knowledge affects learning" (APA Principle 2: prior knowledge); and "Learning is based on context and transfer of contexts needs to be facilitated" (APA Principle 4: context). The affective PoLs we chose were: "Students beliefs about their intelligence affect their cognitive learning" (APA Principle 1: belief); "Students tend to enjoy and learn better when they are intrinsically motivated" (APA Principle 9: motivation);

"Emotional well-being influences educational performance" (APA Principle 15: emotion); 'Setting goals that are short-term (proximal), specific, and moderately challenging enhances motivation more than establishing goals that are long-term (distal), general, and overly challenging' (APA, # 12); and Learning is situated within multiple social contexts. (APA, #13).

The choice for these PoLs was twofold: they are each easily identifiable on their own, but they have a strong interrelationship between them. Uncovering such interconnection in responses may point to deeper understanding of learning mechanisms. For instance, if someone understands the role of both prior knowledge and transfer, an even deeper insight could be expected where learning is seen *as* the transfer of previous experiences (Bransford et al., 2000) and that is the base of conceptual change (Vosniadou, 2013).

The first test was a word association task. Respondents were shown 60 words, one at a time, and asked "Do you *associate* ... *with learning?*". Participants were asked to answer YES or NO by clicking as fast as possible, and response time (RT) was measured in milliseconds. Of the total of 60 words, 20 "learning words" were about learning and were directly derived from the selected principles. Twenty "school words" were about school, but not specifically about learning (e.g., white board or classroom), and 20 "nonsense words" were related to neither education nor learning (e.g., chicken or car door). For all words, see Appendix C.

Selection and validation of the 20 learning words was done by asking eight experts on learning (four researchers and four teacher educators, all in the educational sciences) which of the 40 candidate words best captured the essence of each of the 10 learning principles. The 20 words that scored highest and were also rated as unambiguous were presented to a second group of 14 experts, who were asked which words matched which of the 10 principles. More than 90% of the words were placed correctly for eight principles; for the other two principles, words were chosen after a discussion with 4 of the respondents. The 40 words not related to learning (school words and nonsense words) were picked by the first author and checked for familiarity and being in the right category by the other two authors. Words were presented in a fixed random order for all participants.

The second part of the instrument, which will not be discussed further, was a classroom-situation query that consisted of two open-ended questions in which a daily situation in the classroom was briefly described, followed by the ques-

tion, "What do you think is going on here?". Qualitative results are to be reported in a separate paper.

The third component was a classroom statement task, which was a three-tier test in which respondents were presented with 10 statements, one at a time, describing either recommended or non-recommended teaching practices. Each statement was based on one of the 10 chosen principles of learning. Six items were formulated to be consistent with the principle, and the other four were inconsistent. In the first tier, respondents were asked to use a 5-point Likert scale to rate how confident they were that the statement was true or false. In the second tier, respondents were asked why the statement was true or false, and were given four options to choose from, with the correct answer corresponding to the learning principle. (The third tier asked participants to rate their confidence in their choice, but this will not be discussed further). For the statements, see Appendix C.

Validation of this component took place in two steps. The authors formulated three statements for each learning principle, and these were presented to the same eight experts who validated the previous task. They were asked which statement they thought was the best educational translation of the principle. We picked the one chosen by most experts. Then, four of the statements were reversed to represent a non-recommended practice. The statements were then presented to 10 pre-service teachers, who were asked why they thought the statements were correct or not. In this way, an inventory was made of possible correct and incorrect answers (misconceptions). The literature was checked for all statements to determine whether more known misconceptions existed. In that case, they were also included as alternative answers in the Tier 2 question. If the student interviews and the literature did not provide four possible answers, the first author formulated the remaining response options.

The fourth component was an explicit principle endorsement questionnaire. The 10 learning principles were translated literally into Dutch and presented as such. Respondents then had to rate the extent to which they were convinced the principles were correct, on a scale from 0 to 100%.

The order of presentation of the four components of the test, from more implicit to more explicit, was chosen to minimise the likelihood of answers on one component influencing those on the later ones (e.g., first presenting the principle endorsement questionnaire might have made learning principles salient, altering the answers for the other components).

3.3 Procedure

The four assessment components described were offered in one online test using Qualtrics© software, under the title, "What Do I know about Learning?" (in Dutch: 'Wat weet ik van leren?'). It was described to participants as a 15- to 20-minute anonymous test for scientific purposes. We promised participants that they would receive their personal score in terms of percentage of correct answers for Components 1 and 3 upon completion.

A pilot run was done in November 2021 with 34 respondents. Some minor language changes were done, and the test was launched in March 2022 and given wide publicity via email and social media.

3.4 Data analysis

First, the data from the word association task were cleaned. Scores for the first four words on the test were discarded because the RTs were notably longer than all others, due to participants getting started up. The last word from the test also had to be deleted because the tool did not correctly register the RT on this item. Therefore, only 19 learning words, 18 school words and 18 nonsense words remained. Then logarithms of RTs were taken, and values more than 3*SD* below or above participants' personal average RT were winsorised at 3*SD*. In order to reliably compare representative results, RTs of incorrect responses for the 19 learning words (= NO) were removed. To remove the effect of personal response speed, RTs for learning words were divided by the average personal RT for the 18 nonsense words. These values are further referred to as 'corrected RTs'.

To address RQ1, (*What do indirect measurement based on reaction times reveal about beliefs about principles of learning?*), RTs and number of correct YES-answers were calculated for the word association task, and the results for the three different word categories were compared.

For RQ2 concerning the degree to which teachers explicitly endorse validated learning principles, we analysed scores on the classroom statement test and the principle endorsements separately for each principle. We then calculated the average scores for all 10 principles, as well as for the cognitive and affective principles separately.

For RQ3, correlations were calculated between RTs and percentage of correct YES-answers of the word association task and the levels of agreement from the principle endorsement questionnaire.

4. RESULTS

4.1 What do indirect measurement based on reaction times reveal about beliefs about principles of learning?

For this research question, we focused on RTs and percentage of correct YES-answers from the implicit word task. "Correct YES-answers" refers to all YES keystrokes indicating that participants associated a learning word with learning. If strength of beliefs can indeed be inferred from shorter RTs (Holland et al., 2003), shorter RTs for responding YES for the learning words would indicate stronger belief that a learning word was indeed a learning-related word. Participants with beliefs in alignment with the learning principles should react faster to the learning words than the school words that might not be strongly linked with convictions about learning. Shorter RTs and fewer YES-answers would be expected for the nonsense words that are clearly not connected with school or learning. Mean RTs and % Yes-answers for the different word categories are in Table 1.

Table 1. Average reaction time and percentage of words for which participant answered that it is connected with learning (YES-answers) for the three categories of words in the word association task (N = 257).

Word categories	Mean RT (SD) [log sec] (SD)	Mean YES-answers [%] (SD)
Learning words (*n* = 19)	0.262 (0.091)	92 (11)
School words (*n* = 18)	0.289 (0.099)	67 (22)
Nonsense words (*n* = 18)	0.266 (0.110)	7 (11)

As expected, RTs for the learning words were on average shorter than for the school words, $t(256) = -7.57$, $p < .001$, suggesting that the former were more strongly associated with learning. Nonsense words (e.g., chicken, car door) also had shorter RTs than the school words, $t(256) = -4.58$, $p < .001$. The learning words and nonsense words had comparable RTs, $t(256) = 1.06$, $p = .288$. In addition, for the learning words, the percentage of correct YES-answers was correlated, with RT (Pearson $r = -.385$, $p < .001$).

Having established that participants associated the learning words with learning, we analysed the learning words by type of learning principle, as shown in Table 2.

Table 2 Average values for RTs, correct YES-answers for words related to the 10 learning principles (N = 257).

Principle	Mean corrected RT (two words per principle) [1]	SD's away from overall mean	correct YES-answers [%]
Overall 10 principles	1.017 *SD* = 0.214	--	92.6
5 Cognitive principles	1.049	0.15	91.1
5 Affective principles	0.990	-0.13	94.0
Prior knowledge	1.018	< 0.01	95.7
Repetition	0.911	-0.50	96.9
Learning context [1]	0.936	-0.38	98.8
Conceptual change	1.013	0.02	84.6
Dual coding	1.132	0.54	85.8
Beliefs	0.923	-0.44	95.3
Motivation	0.901	-0.54	98.8
Goals	0.990	-0.13	97.5
Emotions	1.103	0.40	89.5
Social context	0.991	-0.12	89.3

[1] For this principle, only one word was available. Numbers are not averages.

Table 2 shows the data for individual principles. As explained, raw RTs reflect personal reaction speed and other cognitive factors and therefore are unreliable measures of cognition. (In fact, we found a relation between raw RT and age: r = 0.295, p < .001). Therefore, we normalised RTs by dividing those for the learning words by the average personal RT for the 18 nonsense words, which produced values around 1, with lower values indicating faster responses for the learning words and higher accessibility. We can see that words linked with some principles had shorter RTs and might thus reflect stronger beliefs, such as "Repetition is important," "Motivation affects learning" and "Students' personal beliefs about their capacities affect their learning," In contrast, learning words related to the principle concerning "Dual coding theory," "Slow conceptual change" and "Emotions affect learning" had longer RTs. These RT-values also corresponded to higher and lower percentages of YES-answers, respectively, which was in line with by the positive and statistically significant Pearson correlation between RTs for learning words and correct YES-answers (r = -.385, p = .000).

A repeated-measures ANOVA was conducted for the corrected RTs to check for differences across the individual learning principles. Mauchly's test for sphericity was violated, so a Greenhouse-Geisser correction (ε = 0.70) was applied. Differences between the principles were found, $F(6.3, 793) = 20.7$, p < .001, η_p^2 = 0.141. Post-hoc testing (Bonferroni) showed a cluster of principles with short RTs

that did not mutually differ (motivation, repetition and context) and one with long RTs (dual coding, conceptual change and emotions). The RTs for the other principles differed significantly from those two clusters.

4.2 To what extent are teachers explicitly convinced of principles about learning?

This question was answered based on responses to the principle endorsement questionnaire, where participants were asked how convinced they were about the selected learning principles. A second indicator was the response to the classroom statement test, with educational situation statements based on the selected learning principles. Table 3 shows the total results from these two components for all 10 principles, and then the results are split up for cognitive and affective principles. The three variables reported were all significantly positively correlated; Pearson *r* values were between .200 and .596; all $p < .05$.

Table 3 Mean strength of beliefs and % correct answers from all participants (N = 257).

Principle	Level of confidence (%) in truth of classroom statements Mean (SD)	% correct on classroom statements	Level of conviction about principle endorsement (%) Mean (SD)
All 10 principles	83.0 (8.2)	77.6	84.5 (8.8)
5 cognitive principles	82.5 (11)	79.8	79.7 (11)
5 affective principles	83.4 (8.5)	75.4	89.6 (9.3)
Comparison of cognitive and affective	$t(256) = -1.32$, $p = .019$	$t(256) = 2.59$, $p = .010$	$t(256) = -10.8$, $p < .001$

These results showed that, on average, participants were 85% convinced of the validity of the learning principles and were 83% confident about the truth of the principles expressed in the classroom statement test. A difference between cognitive and affective principles was observed, where participants seemed more convinced of the latter. When asked if the classroom statements were true or not and why, around 78% connected the classroom situation with the correct principle of learning. However, when results were analysed per principle, further differences emerged as shown in Table 4.

Table 4 Mean confidence/conviction levels and % correct answers per principle (N = 257).

Principle code	Principle as described in the literature	Level of confidence in truth of classroom statements (%) Mean (SD)	% correct classroom statements	Level of conviction about principle endorsement (%) Mean (SD)
Prior knowledge	What students already know affects their learning. (APA, #2)	94.1 (12)	91.4	89.2 (13)
Repetition	Acquiring long-term knowledge and skill is largely dependent on practice. (APA, #5)	84.0 (27)	95.7	82.1 (17)
Learning context	Learning is based on context, so generalizing learning to new contexts is not spontaneous, but instead needs to be facilitated. (APA, #4)	86.2 (22)	77.4	81.8 (15)
Conceptual change	Learning requires substantial change in existing concepts, which happens slowly and in a stepwise manner. (Vosniadou, 2013)	67.5 (24)	52.5	61.4 (26)
Dual coding	Cognition involves verbal and non-verbal information that reinforce each other. (Paivio, 1991)	80.6 (19)	82.1	82.9 (16)
Beliefs	Students' beliefs or perceptions about intelligence and ability affect their cognitive functioning and learning. (APA, #1)	63.2 (24)	68.5	89.1 (13)
Motivation	Students tend to enjoy learning and perform better when they are more intrinsically than extrinsically motivated to achieve. (APA, #9)	90.0 (15)	91.8	90.4 (15)

Table 4 Mean confidence/conviction levels and % correct answers per principle (N = 257). (*continued*)

Principle code	Principle as described in the literature	Level of confidence in truth of classroom statements (%) Mean (SD)	% correct classroom statements	Level of conviction about principle endorsement (%) Mean (SD)
Goals	Setting goals that are short-term (proximal), specific, and moderately challenging enhances motivation more than establishing goals that are long-term (distal), general, and overly challenging. (APA, # 12)	87.4 (16)	61.9	84.6 (17)
Emotions	Emotional well-being influences educational performance, learning, and development. (APA, #15)	90.6 (13)	85.2	94.9 (10)
Social context	Learning is situated within multiple social contexts. (APA, #13)	86.0 (16)	69.6	89.0 (14)
Goals	Setting goals that are short-term (proximal), specific, and moderately challenging enhances motivation more than establishing goals that are long-term (distal), general, and overly challenging. (APA, # 12)	87.4 (16)	61.9	84.6 (17)
Emotions	Emotional well-being influences educational performance, learning, and development. (APA, #15)	90.6 (13)	85.2	94.9 (10)
Social context	Learning is situated within multiple social contexts. (APA, #13)	86.0 (16)	69.6	89.0 (14)

Differences between confidence levels and endorsements were tested by repeated measures ANOVA. For both tests, Mauchly's test for sphericity was violated. A Greenhouse-Geisser correction ($\varepsilon = 0.73$) was applied to the mean classroom statement scores. Confidence in the correctness of the classroom statements was not equal for all principles, $F(6.58, 1670) = 360$, $p < .001$, $\eta_p^2 = 0.586$. Post-hoc testing (Bonferroni) showed that means differed significantly for most pairs of principles, except between motivation, goals, emotions and social context and between motivation, emotion and prior knowledge.

A Greenhouse-Geisser correction ($\varepsilon = 0.5$) was applied for the mean scores for conviction regarding principle endorsement. The scores were not equal across the principles, $F(5.48, 762) = 58.1$, $p < .001$, $\eta_p^2 = 0.296$. Post-hoc testing (Bonferroni) again showed significant mutual differences between the means for most principles, except between dual coding, goals, contexts and repetition and between prior knowledge, beliefs, motivation and social.

The learning principle from conceptual change theory (that adapting existing misconceptions is a difficult and time-consuming process) was an anomaly, because it received the lowest scores for both mean conviction regarding principle endorsement and percentage correct for classroom statement.

The correlations between confidence in the truth of the classroom statements and conviction about principle endorsement showed weak to medium values, as reported in Table 5. The classroom statements were, of course, just one possible example of using the principle in a classroom situation. It may be that a larger sample of classroom situations would have led to higher correlations. Alternatively, it is also possible that endorsing abstractly phrased principles is not the same as being confident about their truth with regard to their application in the classroom. The correlation between confidence in the truth of the classroom statements and correctly answering their tier 2 why-question was much higher ($r = 0.620$, $p = .01$), showing that participants were relatively well-calibrated in their confidence.

Table 5 Pearson correlations between confidence about the truth of classroom statements and conviction regarding principle endorsement (N = 257).

Principle	Correlation between level of confidence in truth of and level of conviction regarding endorsement of principle Pearson r (p)
Average for all 10 principles	.258 (< .001)
Average for 5 cognitive principles	.120 (.039)
Average for 5 affective principles	.314 (< .001)
Prior knowledge	.204 (0.01)
Repetition	ns
Learning context	ns
Conceptual change	.351 (<.001)
Dual coding	ns
Beliefs	ns
Motivation	ns
Goals	.307 (< .001)
Emotions	.177 (.029)
Social context	.382 (< .001)

Note: ns means not significant.

4.3 Is there a correlation between the results of indirect and direct measurements?

We then calculated correlations between the mean RTs from the word association task, on the one hand, and the level of conviction about principle endorsement and confidence in the truth of classroom statements. Table 6 shows correlations between the RTs and proportion of correct YES-answers in the word association task on the one hand and level of conviction about the principles and confidence about the truth of the classroom statements on the other, all split for the five cognitive and the five affective principles and per principle.

For the average of all principles (affective and cognitive), small- to medium-sized correlations were found between the average corrected RT, the percentage of correct YES-answers and the level of conviction regarding endorsement of the principles. For the two categories and for the individual principles, no correlation reached significance between corrected RT and the other variables. However, for most principles, the number of correct YES-answers was significantly positively correlated with the level of conviction regarding endorsement of the principle (although not with the classroom statement outcomes).

Table 6 Pearson correlations between implicit word association test outcomes (corrected mean RT and number of correct YES-answers) and outcomes of direct tests (level of conviction about endorsement of principles and confidence in the truth classroom statements) (N = 257)

Principle	Corrected mean RT / Level of conviction regarding endorsement of principle r (p)	Mean number of correct YES-answers / Level of conviction regarding endorsement of principle r (p)	Corrected mean RT / Level of confidence in truth of classroom statement r (p)	Mean number correct YES-answers / Level of confidence in truth of classroom statement r (p)
All 10 principles	-.180 (.026)	.327 (< .001)	ns	ns
5 cognitive	ns	.170 (.035)	ns	ns
5 affective	ns	.408 (< .001)	-.127 (.043)	.161 (.010)
Prior knowledge	ns	ns	ns	ns
Repetition	ns	ns	ns	ns
Learning context	ns	.141 (.05)	ns	ns
Conceptual change	ns	.139 (.059)	ns	ns
Dual coding	ns	.130 (.077)	ns	ns
Beliefs	ns	.242 (< .001)	ns	ns
Motivation	ns	.456 (< .001)	ns	ns
Goals	ns	.131 (.073)	ns	ns
Emotions	ns	.142 (.050)	ns	ns
Social context	ns	.294 (<.001)	ns	ns

Note: ns means not significant

5. DISCUSSION AND CONCLUSIONS

This study examined whether indirect measures might reveal teachers' beliefs regarding learning principles. Based on the difference in reaction times (RTs) between learning- and school-words in the word association task, and given the correlations found—though modest—the instrument appears to offer at least a partial indication of beliefs related to the tested principles.

Taken together, participants' high confidence in the truth of classroom-related statements, their explicit endorsement of scientific principles, the frequency of correct affirmative responses, and the RTs suggest that most teachers' belief systems broadly align with selected principles of learning. However, this conclusion must remain limited in scope, as it is unclear whether implicit beliefs

influence explicit responses (cf. repetition priming; Martens & Wolters, 2002). Whether such beliefs predict classroom behaviour remains an open question and requires further investigation (Denessen et al., 2022).

Two narrower observations in the data might support one more narrow conclusion. First, RTs for previously learned words are similar to those for nonsense words, while the number of correct YES-responses remains high (Table 1), suggesting that participants needed little time to produce positive responses. According to Holland (2003), such a pattern may reflect strong implicit associations. Secondly, although endorsement of principles does not correlate with RTs, it does correlate with the number of YES-responses (Table 6). This implies that participants *can recognise* the principles, but the method used does not allow a quantifiable assessment *of the extend* of that recognition. These results are consistent with previous findings that demonstrate difficulty in establishing strong correlations between explicit and implicit measures (Nosek & Smyth, 2007; van den Bergh et al., 2010).

Interestingly, the affective principles elicited shorter reaction times and a higher percentage of YES-answers than the cognitive principles. Although the origins of beliefs lie beyond the scope of this study, it is worth considering possible implications for teacher education. Are affective learning principles explicitly taught? The textbooks mentioned in the introduction seldomly address them explicitly; the APA's *Top 20 Principles of Learning* is one of the few exceptions. Moreover, affective principles are probably least used in explicit pedagogical reasoning. Nevertheless, our data suggest they are more readily associated with learning, perhaps indicating that they form part of a broader, more deeply embedded belief system (Pajares, 1992). This would align with Ellis's (2005) criteria, suggesting such beliefs have developed from early experiences both within and beyond formal education.

When considering specific principles, it is striking that all measures about conceptual change theory scored consistently lower. Conceptual change theory describes that changing existing (mis)conceptions is challenging and requires time and repetition. This notion does not appear to be a prevalent belief among the participants. Curiously, the two foundational principles underpinning the theory—"Prior knowledge determines learning" and "Long-term knowledge depends on repetition and practising"—were strongly endorsed, indicating they are firmly held. Two explanations are possible: either teachers were never explicitly introduced to the theory and thus lack any associative memory for it, or they are familiar with it but reject it. Both scenarios would likely result in longer RTs and a higher proportion of NO-responses, which was indeed observed. A lack

of knowledge then would show a variety of correct and wrong answers across both the classroom and endorsement tasks, whereas disagreement would lead to low endorsement but more correct responses in the classroom task. The results appear more consistent with the latter explanation, though no definitive conclusion can be drawn. This interpretation is supported by previous findings showing that science teacher educators in the Netherlands were largely unfamiliar with conceptual change theory and, in some cases, even sceptical of its value (Meij, 2018).

Another principle that scored somewhat lower was dual coding. It was included because it is part of everyday classroom practice and teacher education programmes (e.g., Bates, 2019; Wu & Puntambekar, 2012), although it is not featured among the APA's *Top 20 Principles*. Given its relevance to everyday practice, we expected it to be readily accessible; however, the results showed particularly long RTs, despite high accuracy in the classroom and endorsement tasks (above 80%). This may indicate that the words we used in the association task were not sufficiently representative of the principle itself.

Regarding the role of emotions, a notable discrepancy emerged between the different measures. While the terms "emotion" and "positive" received high rates of YES-answers, they were not rapidly associated with learning. Nonetheless, teachers demonstrated clear agreement, in both endorsement and classroom contexts, that emotional well-being influences learning outcomes. This suggests that while teachers are able to reason about the importance of emotion, the accessibility of this association remains relatively weak. It is plausible that such general principles have been learned inductively through experience, rather than through formal instruction, resulting in a degree of context dependency, as noted by Fives & Buehl (2012).

The role of motivation scored highest across all three test components. Although correlations between implicit and explicit measures were generally low, they were slightly higher for motivation words and statements. Intriguingly, while motivation is often prioritised in teacher discourse, the empirical literature presents a more cautious picture. Meta-analyses tend to report only modest effects of motivation on academic achievement (Vu et al., 2022), and some researchers argue that these may be attributable to methodological artefacts (Núñez-Regueiro et al., 2022). Nonetheless, our findings suggest that motivation holds a central place in teachers' belief systems.

Overall, the study supports the view that teachers implicitly hold both accurate and inaccurate beliefs regarding learning principles. Given the significant influ-

ence such beliefs exert on pedagogical reasoning, we argue that teacher education should begin by explicitly eliciting student teachers' existing conceptions before introducing theoretical models. This recommendation has been made repeatedly (e.g., Korthagen & Kessels, 1999; Wilcox-Herzog et al., 2015; Gleeson & Davison, 2016; Shahzad et al., 2017; Qiu et al., 2021) and is reinforced by our earlier research (Meij etal., 2022), in which teacher educators expressed uncertainty about the practical application of formal learning theories. Moreover, when flawed beliefs or misconceptions are elicited early, conceptual change becomes more attainable. Confronting these beliefs through authentic practice-based conflict from day one is likely more effective than offering correct theory that risks becoming parallel concepts thus widening the gap between theory and practice.

We join Jost (2019) and Denessen et al. (2022), who advocated that, despite the concerns, indirect measurement remains necessary given the impact these beliefs have on teachers' pedagogical reasoning.

5.2 Limitations of the study

Although the instruments were carefully constructed and validated in several rounds, they are still some way from being a universal validated instrument. Teachers' beliefs regarding the APA principles of learning have not been investigated before. Hence, we made a first attempt to explore these beliefs. Although the words, statements, and questions we offered participants in the test were checked by experts and in the pilot round, participants' personal interpretations may have played a role. In particular, participants may have interpreted our classroom statements and the principles in various ways based on their own practice. The relatively high number of participants would mean that idiosyncrasies in interpretations would average out, but such disparate interpretations may be a factor in the low correlations between scores on explicit and implicit test components.

The low correlations between explicit and implicit measurements replicate those in other studies and feed into an open discussion (Nosek & Smyth, 2007). Whether these are a result of low test reliability cannot be established. Another explanation for low correlations may be that teachers unconsciously hold beliefs that contradict what they say consciously. For example, social desirability may have affected their explicit endorsement of the statement that emotional well-being influences learning, when this is not truly their belief.

The decision to have the data collection be through a "test yourself" module via the internet was intended to make it more motivating than just another

scientific questionnaire. Although participants were clearly informed about the use of data and asked for consent, this might have led to selection bias against people with higher test anxiety, leading to a sample with more participants who are self-assured and/or are explicitly outspoken about their knowledge and convictions.

Although there are thus some methodological limitations, these do not negate our exploratory findings that most of the participants endorsed, implicitly as well as explicitly, the selected principles that reflect the science of learning.

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CHAPTER 4

Which principles of learning do teachers and teacher educators use and how are they articulated in their pedagogical decision-making?

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ABSTRACT

Teachers face daily pedagogical dilemmas requiring on-the-spot decision making guided by practical and theoretical knowledge. This study investigates how teachers, student teachers, and teacher educators spontaneously apply six principles of learning in their response to teaching dilemma vignettes. Among 186 participants who responded to two vignettes—one focusing on cognitive principles and the other on affective ones—four principles were frequently employed across all groups. However, notable differences emerged in applying principles about 'transfer' and 'prior knowledge'. Qualitative analysis reveals modest variations in meanings and underlying knowledge among groups. Also, there is a difference in the use of language; (pre-service) teachers employ more everyday language, whilst teacher educators use more formal terminology.

1. INTRODUCTION

Can someone be a good teacher without any theory of learning? In a previous study, we posed this question to teacher educators, and their responses consistently revealed a sense of cognitive dissonance (Meij et al., 2022). On one hand, there exists a widely held view that teachers should be able to justify their pedagogical decisions with sound theoretical reasoning. On the other, all participants could readily recall examples of excellent teachers who appeared to work without any formal theory—some even lacking teacher training altogether—yet intuitively making the right decisions in classroom dilemma's. This contradiction questions the importance of formal theory for on-the-spot decisions in classroom. The question about the importance of formal theory in daily teaching lies at the heart of our broader project, which focuses on making implicit knowledge about learning explicit and examining the use of Principles of Learning (PoLs) in teacher education. In this study we wonder whether intuitive teaching can still be linked back to underlying principles of learning. More specifically, when a teacher makes a quick decision, is that decision grounded in any identifiable principle of learning?

When studying this, we wonder if there may well be differences depending on the stage of a teacher's career. Students, for instance, have typically encountered PoLs recently as part of their training, and are required to articulate and reflect on their pedagogical choices. This combination of recent learning and frequent use suggests that PoLs may be embedded in their professional knowledge and recalled easily. Supporting these students in connecting theory to practice is a key role of teacher educators, who themselves should be able to draw on both formal theory and a wide range of practical experiences (e.g., Korthagen, 2010).

In contrast, in-service teachers are no longer routinely asked to reflect on the theoretical basis of their decisions and we know that formal theory tends to wash out over the first few years of practice (Mellor, 2021; Zeichner & Tabachnik, 1981). Unless they often actively connect PoLs to classroom experiences, these principles may probably not be well integrated into their practical knowledge and be more implicit (Verloop et al., 2001).

This study aims to explore what PoLs are used by teachers at three different career stages: pre-service teachers (further: students), in-service teachers (further: teachers) and teacher educators (further: educators). We explore how, or whether, PoLs are traceable in quick pedagogical decision-making. While there is a substantial body of research on teachers' beliefs, we found that PoLs have

only been explicitly examined in one study (Foster & Whittington, 2017), and comparative research between different career stages was not found.

Through this study, we aim to shed light on the implicit and explicit knowledge about learning that underpins teachers' decisions in the classroom. Gaining such insights could offer practical guidance for developing more effective strategies for teaching theories and principles of learning in teacher education as prior knowledge of both, teachers and educators, can either support or hinder the learning process (Verloop et al., 2001).

1.1 Teaching and knowledge

Although some researchers argue that besides all sorts of knowledge, personal factors such as beliefs, wishes, emotions and motivation are probably even more influential (e.g. Korthagen, 2017). Good teaching is widely recognized as being grounded in the deliberate application of theoretical knowledge to inform lesson planning and instruction. Teaching is working in a highly knowledge-intensive and social environment (Schoenfeld, 2020), and a teacher must therefore possess extensive knowledge of both the subject matter being taught and of didactics and learning processes. Or, according to Shulman (1986), having and using knowledge of content and teaching is the essence of the teaching profession.

Moreover, teaching is an extremely complex endeavour, and describing it within a model is not straightforward. Teaching begins with the deliberate design of a lesson, during which the teacher follows a series of steps (Lloyd, 2019). The conscious application of reasoning based on this knowledge in practice is known as pedagogical reasoning — deliberate thinking that underpins informed professional practice (Shulman, 1987). Since the concept was introduced, it has been linked to the quality of teaching in numerous publications (e.g., Darling-Hammond, 2017; Loughran, 2019; Trevisan & Smits, 2023).

Shulman argued that knowledge was a key component in describing teaching quality (Shulman, 1986; 1987; Leijen et al., 2022) and identified a knowledge base consisting of seven types of knowledge that a teacher should possess: content knowledge, pedagogical knowledge, curriculum knowledge, knowledge of learners, knowledge of contexts, knowledge of educational ends, purposes, and values, and pedagogical content knowledge. This knowledge base has since been widely accepted as a standard (Phillips et al., 2021).

Shulman (1987) emphasized the importance of both formal understanding (based in research) and practical knowledge ("the wisdom of practice") in the

teacher knowledge base. Practical knowledge is defined as knowledge that teachers construct out of the personal experiences in practice (Fenstermacher, 1994) through an inductive process (Korthagen & Kessels, 1999). It contains a variety of cognitions from conscious rational arguments to unconscious intuitions (Verloop et al., 2001; Phillips et al., 2021). Eventually it leads to a set of concepts or "practical wisdom – a quality or excellence that spreads through and features the whole person enabling to become educationally wise" (Škėrienė & Augustinienė, 2018, p.7).

Several studies have explored knowledge in practice across a diverse range of contexts, e.g., practical knowledge of teaching lab work in chemistry (Chen & Chen, 2021), the curriculum, teacher, instructions, and classroom (Ferry & Romar, 2022), learning and feedback (Thurlings & van Diggelen, 2021), knowledge about self, disciplines, students and context (Wei et al., 2023), or the social context (Aspbury-Miyanishi, 2022).

Evidently, a flawed knowledge base may lead to incorrect pedagogical action. The presence and influence of misconceptions about teaching and learning have been extensively researched and overviewed by McAfee and Hoffman (2021). Menz et al. (2021) investigated whether the many existing misconceptions in student teachers can be changed through refutation with empirical evidence and found that while some change occurs, it is often slow and not consistently maintained.This slow and difficult change is in line with conceptual change theory (Vosniadou, 2013) which describes that change of existing prior knowledge conceptions and beliefs is a slow and laborious process.

1.2 Making decisions based on practical knowledge of learning.

If teaching were merely presenting content without pedagogical reasoning, it might be relatively easy. However, the goal of facilitating *learning* necessitates thoughtful reasoning and consideration, or "deliberating teaching to enhance learning" (Bronkhorst et al., 2011, p. 1127). That deliberate reasoning requires foundational knowledge of learning and simultaneously fosters the inductive development and reinforcement of personal practical knowledge (Bakshi, 2023; Gleeson & Davidson, 2016; Korthagen & Kessels, 1999). The idea of personal practical knowledge marked a shift in how teachers were viewed. Instead of being seen merely as implementers of curriculum, the teaching profession was reframed and teachers were recognised as active professionals, constructing knowledge through their lived experiences and make personal decisions (Clandinin & Husu, 2022). The objective of student learning warrants the deliberate use of knowledge of *learning* to connect content and teaching (e.g., Liakopoulou, 2011).

While the comprehensive framework of pedagogical reasoning describes the process of teaching across the board and the underlying steps and knowledge effectively — and has therefore served as the theoretical foundation in much research since — it does not provide guidance in specific practical situations. It does not describe how the connection between which particular aspects of the individual knowledge base influences specific types of decisions (Phillips et al., 2021). Due to the complex nature of teaching, teachers are continually confronted with a most diverse variety of pedagogical dilemmas that require decision-making (e.g., Mansfield & Loughran, 2018; Gotwalt, 2023). Lampert (1985) calls teachers "dilemma managers". These dilemmas, small and large, occur constantly and the numerous "on-the-spot decisions" can have a direct constructive but also detrimental influence on students' learning (Saeedian & Ghaderi, 2023), especially when the underlying knowledge contains misconceptions about learning (McAfee & Hoffman, 2021).

The construct that describes such real life on-the spot-decisions is pedagogical decision making (PDM). Although pedagogical reasoning and decision-making both have separate strands of literature, the two constructs do overlap (Lloyd, 2019; Saeedian et al., 2025) where PDM focuses more on teachers as decision makers in the classroom (Phillips et al., 2021; Ghaderi, 2023). Schneider-Kavanagh et al. (2020) describe pedagogical reasoning as a routine of different decisions made: facing a pedagogical dilemma, make a professional judgement and decide on a an instructional move. Lloyd (2019) states that PDM "links thought and action to optimise a range of valued outcomes, foremost amongst which is learning" (p.166). But given the complexity and knowledge intensity of teaching, Bakshi (2023) says that in decision making, in order to reduce cognitive load, people resort to using heuristics, short-cuts, or rule-of-thumb strategies so as to make a satisfying decision which, however, may lead to cognitive biases or systematic errors.

Lloyd (2019) also illustrates that the literature broadly agrees upon a broad spectrum of knowledge being involved. Loughran (2019) endorses that the essence of the teaching profession lies in this professional knowledge of teaching but that procedures often are more leading and that the explicit knowledge remains tacit but becomes evident when a teacher engages in overt pedagogical reasoning.

Although it is agreed widely that knowledge of teaching is a key, other factors, such as the teachers' own prior experiences as a student, have been identified that influence PDM (Borg, 2003). Škėrienė & Augustinienė (2018) provide an overview of four groups of factors that influence PDM and foreground the im-

portance of personal development of the teacher. Phillips et al. (2021) outline a framework that connects knowledge, practice, skills and epistemology. Saeedian & Ghaderi (2023) describe PDM affected by how teachers view their own role as agents of change and decision-makers. Young (2020) examined more in detail the role of emotions in PDM and Porter (2025) that of PDM in online contexts.

1.3 Learning about learning

How knowledge of learning becomes part of one's personal practical knowledge has been extensively researched. However, there is limited research that specifically targets the integration of *theories and principles of learning* (e.g., Meij et al., 2022; Liakopoulos, 2011).

A widely accepted model of knowledge acquisition is by Cochran-Smith and Lytle (1999). They distinguished knowledge *for, in*, and *of* practice. Knowledge *for* practice is formally taught theory, knowledge *in* practice is holistically formed out of experiences and knowledge *of* practice is comprehension of the relationship between theory and practice that emerges from deliberate thinking and reflecting on practice. In teacher education, learning theories are usually taught as formal theories: as knowledge *for* teaching. Whether that theory connects with teachers' personal knowledge *in* and eventually becomes part of knowledge *of* teaching practice has been debated and studied extensively (e.g., Meij et al., 2022; Hennissen et al., 2017; Gleeson, 2016; Korthagen, 2010; Korthagen & Kessels, 1999). Assuming that this "line of knowledge development" has indeed taken place, we are curious if we would find differences between students (almost only having knowledge *for*), teachers (being more experienced and can be expected to have more knowledge *in*) and educators who have experience and may be assumed to have a deeper understanding and knowledge of theory leading to knowledge *of*.

In addition to the question whether learning theories are part of one's personal practical knowledge, it is even more interesting to study their practical use regarding classroom situations. Studies where knowledge and application of learning theories and principles are subject of research in the classroom, are scarce. Thurlings (2021) used theories of learning to define profiles with the aim to label teachers' practical knowledge of feedback. DiSessa (2018) described knowledge in pieces within conceptual change theory applied to mathematics. Foster & Whittington (2017) studied the frequency of principles of learning applied during lessons in agricultural education.

1.4 The present study

The present research draws upon a subset of the APA (2015) top 20 principles of learning. Our aim is to shine a light on cognitive and affective principles of learning within teachers' practical knowledge. Parallel to the deductive approach of Foster & Whittington (2017) we will try to identify previously defined principles of learning in practical situations, but with three importantly different foci. First we are interested in decision making and therefore we prompted our participants with short vignettes of classroom situations. Secondly, our study is based in teacher education. As literature describes, acquiring knowledge *of* and *in* follows an inductive process (Korthagen & Kessels, 1999) and is built up with experience (Korthagen & Kessels, 1999; Verloop et al., 2001; Phillips et al., 2021). We therefore choose to split our sample in students, teachers and educators and we are curious if a difference, perhaps advance might be visible in these three groups.

RQ1: Which of the chosen principles of Learning do students, teachers and educators use when making pedagogical decisions?

Thirdly, we follow Verloop etal., (2001) that such knowledge might be implicit and used unconsciously and therefore we follow a qualitative approach. Analysing the responses more verbatim might reveal if principles have become indeed knowledge *of*.

RQ2: *How do students, teachers and educators articulate PoLs when describing their decisions about a teaching practice situation?*

2. METHOD

2.1 Participants

Responses were collected from an exploratory online test instrument in Dutch that was open for everyone in the Netherlands, between March and July 2022. There was no active recruitment other than sending invitations to all teacher education institutes in the country and secondary schools connected to our institute with the question if they would bring it to the attention of students, teachers and teacher educators. We used convenience sampling as anyone aware of the survey was allowed to respond to it (a specific question asked for participants' role; one option was 'not in education'). Due to legislation surrounding personal data, only characteristics directly relevant to the research questions were included in the survey; whereas demographic details such as home address, workplace and gender were excluded. It was clearly stated

that participation would be completely anonymous. Participants all provided informed consent before starting. The study was performed in accordance with protocol #2019-151, approved by ethical review board of Vrije Universiteit Amsterdam, Faculty of Behaviour and Movement Sciences.

516 people started the survey, 307 of whom fully completed all four components (see Instrument). To make a valid comparison in the data for this study we chose participants in one comparable level of education. Given our immediate working environment and the largest number of participants, we chose secondary education. The total number of responses from self-identified students, teachers and educators in Dutch secondary education was 186: 72 students, 76 teachers and 38 educators. Participants taught a variety of school subjects. The average age of students was 19.8 (SD=2.4), of teachers 41.3 (SD= 15.7) and of educators 45.8 (SD=10,9) years. Students had completed 1 to 4 years of internships (average 2.1). Teachers had an average of 15.5 (SD= 11.0) years of classroom experience.

2.2 Instrument

This study was part of a larger endeavour probing teacher implicit knowledge of learning. For this overarching objective, we developed the aforementioned exploratory instrument in Dutch that consisted of four different test components. Three quantitative components were reported on in a separate paper (Meij et al., 2025). Here we focus on the fourth qualitative component, a classroom situation decision test.

To have a unified and valid set of PoLs to have a good reference we drew upon the *Top 20 Principles from Psychology for PreK-12 teaching and Learning* (American Psychological Association [APA], 2015), which supplies not only cognitive, but also affective principles. They were derived according to a thorough methodology and captured in a consensus document.

Participants were prompted with two short vignettes in which a daily classroom situation was briefly described, followed by the open-ended question: "What do you think is going on here?". The vignettes were intentionally kept as short as possible in order to prompt participants for quick decision-making. One vignette focused on three cognitive PoLs, the second vignette on three affective PoLs. Translations of both vignettes into English are supplied in Appendix D.

Both vignettes were designed with 3 PoLs implicitly incorporated. As cognitive PoLs we chose: "Long-term learning and skill is largely dependent on practice" (APA Principle 5: practice); "Prior knowledge affects learning" (APA Principle

2: prior knowledge); and "Learning is based on context so transfer of contexts is not spontaneous and needs to be facilitated" (APA Principle 4: context). The affective PoLs we chose were "Students beliefs about their intelligence affect their cognitive learning" (APA Principle 1: belief); "Students tend to enjoy and learn better when they are intrinsically motivated" (APA Principle 9: motivation); and "Emotional well-being influences educational performance" (APA Principle 15: emotion). There were two main reasons for choosing these PoLs: they are each distinct and easily identifiable in their own right, and they are also deeply interconnected with strong interrelationships between them. Uncovering such interconnection in responses may point to deeper understanding of learning mechanisms.

Aiming for validation, we ascertained that the vignettes could indeed elicit the intended six PoLs. Validation was done in two rounds. The original vignettes were written by the first author with the help of three teacher educators. Then four other teacher educators and two educational researchers were offered the situations, together with a list of eight given PoLs from the *APA top 20 principles of learning*. The correct principles were almost unanimously recognised. In a second round, the two vignettes were offered to eight pre-service teachers with the same task that was to be given in the question, namely, to describe what was going on. For analysis, see next section. The responses demonstrated a range of principles, typically focusing on one of the three that were intended per vignette. However, all the principles that were mentioned were appropriately connected to the vignette in which they were intended. Based on this analysis the final vignettes were set.

2.3 Analysis of the Data

Responses contained, on average, 146 characters (*SD* = 95). Three responses were ignored as inappropriate (e.g., 'He shouldn't b.s. but do something' or 'You should beat those kids more'). One- or two-word responses were studied and despite their limitation in words they nevertheless gave a clear message (e.g., "More practice" or 'Safety!") and were included.

For the first research question, *Which of the chosen principles of learning do students, teachers and educators use when making pedagogical decisions?* the responses were copied to QDA Miner© software, uncategorised for the groups to prevent biased coding. Responses were partially open- and partially closed-coded (Babbie, 2013). In the closed coding, we deductively looked for the six PoLs that were intended in the vignettes and, separately coded for explicit or more implicit wording. In the subsequent round of open coding we aimed to identify additional principles, theories or concepts that describe learning. Sev-

eral concepts were only occasionally identified but three concepts, unrelated to our chosen PoLs, appeared to be used frequently: memory function, social classroom processes and active learning. These three substantive categories were incorporated into the codebook (Maxwell, 2013). For all codes, see the codebook in the Appendix E.

Inter-rater reliability was estimated with the two co-authors each coding 25 responses with the final codebook, calculating the extent to which the codes assigned matched. That resulted in Cohen's $\kappa = 0.73$, which is considered good. All results were transferred to Excel, where they were categorised by students, teachers and educators and counted. Although this study is exploratory in nature and the observed numbers do not give evidence of differences, it is still important to determine whether the reported differences are indeed significant. To that end, a chi-square test was conducted.

For the second question, "*How do students, teachers and educators articulate PoLs when describing their decisions about a teaching practice situation?*", previously coded phrases were downloaded in Excel and grouped by PoL and participants group. For each PoL and subsequently for each group, both explicit and implicit responses were analysed in a lexical approach (Bolden & Moscarola, 2000) on particular words and phrases used. With these words and phrases, typical aspects could be identified like the use of everyday language or more formal jargon, and to examine whether longer responses also contained more meaning or multiple PoLs. For instance, it turned out that a relatively small number of conditional constructions were present that could point towards more or less confident answering. Therefore, all answers were searched again for a series of phrases like 'it could be that...' or words like maybe or possibly. The answers containing the particular words found were then reread to elicit knowledge and understanding of the PoLs. This total analysis was a slow process of searching for words that might reveal meaningful perspectives that covered and justified the data. Rereading memos made during the coding process led progressively to more insight. To check that this analysis was reliable, notes and annotations were discussed with the co-authors to satisfactory agreement.

3. RESULTS

3.1 Which of the chosen principles of learning PoLs do students, teachers and educators use when making pedagogical decisions?

For this first question, we counted the PoLs mentioned in the responses. Table 1 shows the percentages of participants who used a PoL in their response to both

vignettes. Percentages are broken down by students, teachers and educators. Responses counted are those where PoLs were explicitly mentioned, as well as those where a PoL could be deduced from the text. Participants often referred to multiple PoLs in a response. The Chi-squared test shows whether difference in percentages was significant.

Apart from the six targeted PoLs , a substantial percentage of the participants identified memory as the underlying reason for what was going on (e.g., not remembering, forgetting, not stored, etc.) or the social classroom situation (e.g., unsafe, not daring to go off in front of the group, peer pressure, etc.) or gave explanations of learning, correct or flawed, that could not be connected specifically with a PoL (e.g., not internalised, no processing, loose unstructured information, not connected with the network).

Table 1. Percentages of respondents mentioning PoLs in their responses for the first (cognitive) and the second (affective) vignette. N = 186. n.s. = not significant

Principle of Learning	**Vignette**	**Students** *n* = 72	**Teachers** *n* = 76	**Educators** *n* = 38	**Chi squared test** $\chi^2(2,186) = \chi^2$, p
Prior knowledge	1	28%	22%	26%	n.s.
	2	5%	5%	11%	n.s.
Practice	1	30%	18%	21%	n.s.
	2	0	0	0	
Context	1	35%	61%	71%	16.3, <.01
	2	0	0	0	
Belief	1	3%	3%	8%	n.s.
	2	55%	55%	50%	n.s.
Emotion	1	0	7%	13%	8.8, .01
	2	45%	51%	42%	n.s.
Motivation	1	8%	4%	8%	n.s.
	2	30%	9%	11%	13.2, <.01
None of the 3 cognitive PoLs mentioned	1	23%	18%	16%	n.s.
None of the 3 affective PoLs mentioned	2	8%	14%	13%	n.s.
Descriptions based on memory	1	35%	22%	34%	n.s.
	2	0	0	0	
Descriptions based on social classroom situation	1	13%	16%	8%	n.s.
	2	33%	42%	29%	n.s
Descriptions about learning	1	25%	28%	24%	n.s.
	2	0	0	0	

On average 1,9 cognitive codes were assigned across all three groups. 1,7 affective codes were assigned for students and teachers and 1,4 for the educators.

Only 3% of all participants responded without referring to any PoLs overall; no one referred to all 6 PoLs. Where participants did not use any PoL we targeted, the answers were mostly based on memory (e.g., forgotten, not stored in memory) or focussed on an irrelevant part of the context. Some students based their response entirely on the teacher's behaviour ('He should...') without underpinning.

Clearly, the most striking result is that across the board there was not much difference in the frequency of PoLs being used between the three categories of teachers. Four out of six principles were recognized more or less equally by beginners and more advanced participants. Statistics show only three exceptions that require further investigation. Besides, for context and emotion there seemed to be an ascending line from students to teachers to educators as one-third of the students referred to motivation as an underlying principle, while the more advanced teachers no longer mentioned it as often.

3.2 How do students, teachers and educators articulate PoLs when reasoning about teaching practice situations?

In this section, we analysed the actual words and phrases, which, for the purposes of this article, were uniformly translated from Dutch using DEEPL® software. The translations were reviewed and manually corrected where Dutch expressions were inaccurately translated or where the intended meaning was not adequately conveyed. An initial overall observation was that only 26 of the 372 responses contained conditional constructions such as 'It could be that...', 'I think...', or words like 'maybe' or 'possibly'. The responses therefore appeared to be expressed with a high degree of confidence across all three groups.

Cognitive PoLs

For this question, we sought to determine *how* the three cognitive PoLs were articulated in the responses to both vignettes.

3.2.1 Prior knowledge

For this principle frequencies were quite equal but there was a clear division of explicit and implicit answers. The majority of educators referred to this principle more explicitly, e.g.

No transfer because prior knowledge is not connected

No link with what was learned earlier, prior knowledge not activated where students mostly named it more implicitly, for example:

There was one-way traffic. He explained and gave examples, but the class did not bring its own input.

Pupils see no connection between the factual definitions around democracy and personal images they hold about democracy.

Teachers' also primarily responded in an implicit manner but their answers were more longer than those of students:

Teacher expects students to follow "his" definition of democracy, while students themselves probably have a different view of it.

Good to look at students' ideas first, to listen and then to refer to them in relation to the previously mentioned conditions and see if there are connections and perhaps nice additions from the class.

Only a few teachers referred to this principle for the second, affective vignette, and mentioned "prior knowledge" explicitly there:

Really has no idea and is not addressed on prior knowledge he might have.

Teacher doesn't really invite the student to make explicit what the student already knows.

3.2.2 Practice

Almost all responses used the words "repeating" and/or "practising," simply stating "There was no repeating" or more implicitly "It was only offered once." There were hardly any longer responses here, implying that there was fast decision making without much deliberate thought. Apparently, simply repeating the material is more obvious than other PoLs.

Only three participants did link it, implicitly, with a broader perspective:

Overwriting a concept once does not lead to learning. No processing has taken place. (teacher)

Students learn for a test, if the concept of democracy is not covered by (un) conscious repetition they will have forgotten the meaning after 1/2/3 weeks. (educator)

For 2 months' time they did not have to use their transcribed terms. So these were not stored in their long-term memory. (teacher)

3.2.3 Context

This PoL was mentioned most often. This makes sense as linking to everyday life is likely to be visible and a natural element of the teaching and learning process that everyone has experienced; and this was the aspect that was salient in the vignette. However, APA Principle 4 says:

> Learning is based on context, so generalizing learning to new contexts is not spontaneous but instead needs to be facilitated. Take the time to focus on deep, underlying concepts in a domain and promote learning by understanding rather than focusing on surface-level elements in a learning situation or by memorising the specific elements. (APA, 2015, p. 10)

This definition of the PoL transcends just giving examples. It says that deep understanding occurs when concept and context are connected and organised so that the concept can be recognised and applied in other situations (transfer). The actual term "transfer" was mentioned very rarely (6 times), which was similar to "abstract" (5 times) and "context" (6 times), all by educators where teachers used the words "children's world of experience" and "apply in practice". Most teachers and students say that "he should give examples" but a few implicit answers revealed a more in depth understanding of the principle:

> The teacher made the class only copy the concept, not process it. [...] and therefore the concept has not come to life (student).

> They [...] heard it in one way, but not discussed. Possibly the news story is about something just outside this one way, so the students can't make the connection to their experiential world (teacher).

These responses indicate that this PoL was implicitly present beyond referring to just giving examples, but the academic language to express it was still lacking.

A number of participants actually said that the *language* used in the book and/or by the teacher was the cause for low transfer:

> Presumably the terms are not in student language, so they cannot link them to the event. (teacher)

> Explanation [of] 2 months earlier was too abstract, students did not *understand* it. (teacher)

> That a term, such as 'healthy' [democracy] is misunderstood. (student)

Affective PoLs

For this question we examined how the three affective PoLs were articulated in both vignettes. Three observations stood out when analysing these PoLs: The responses were noticeably shorter, different PoLs were more frequently mentioned in combination and, again, the wording of responses rarely included conditional constructions.

3.2.4 Belief

This PoL was used in descriptions of the second vignette by more than half of the participants. Over three-quarters of those responses could be categorised using a few terms:

> Not having confidence/self-confidence (30%),

> To fail/failure/fear of making mistakes (23%),

> Having a negative (fixed) mindset (15%),

> Insecurity (9%),

> Lack of competence (8%).

These responses suggest that most participants saying this, consider the reason for what happens being just a characteristic of the fictive pupil, rather than a pupil's *belief* that hinders *learning*. Responses in accordance with the APA description in terms of "believing that …" and "holding the idea that …" were given by only 6% of participants:

> Convinced himself that he cannot do maths and firmly believes in it. (educator)

The learner is convinced "I can't do this." (educator)

The pupil has the idea that he/she cannot do math [...]. (student)

3.2.5 Emotion

The APA principle says "Emotional well-being influences educational performance and learning". We searched for words describing emotions. Three clusters of words underpinned half of the responses: "scared" and synonyms (25%), "fear/math anxiety/fear of failure" (19%) and "don't dare" (10%).

Teachers and students mentioned these emotion words equally often, but educators and teachers had more elaborate responses than students. Whether the connection between emotion and actual learning was made could not be concluded from these answers. Two educators were the only participants who explicitly mentioned learning:

does not dare to take risks, and thus is prevented from learning .

so overwhelmed by this explicit question that he or she feels no room to really think and learn, no matter how friendly the teacher is.

In some responses there was no explicit emotion mentioned, but it was clear that it was about emotional well-being:

Learner feels so overwhelmed. (educator)

She doesn't feel safe enough. (educator)

Blocks completely. Does not experience enough mental and emotional space. (educator)

Stressed out. (student)

Cornered. (student)

Put under pressure. (educator)

Freezes up on hearing 'give a good approach'. (student)

Some responses also described a different emotion than fear:

> Accepting the situation (I can't do maths) and bringing the teacher into it (You know that, right?) seems to be the easiest and thus now the *safest* way. (educator)

> Can be *embarrassment* for the pupil for something that has nothing at all to do with maths. (teacher)

Finally it is observed that some teachers do describe emotion in the their reaction on the first, cognitive vignette:

> students are not given a chance to express their feelings/emotion/emotion, but are referred directly to theory. That blocks them.

> Maybe pupils don't dare to discuss.

> Students find it exciting to answer. Are afraid they won't answer correctly. [...] Maybe it also affects them personally or they are afraid it will affect others personally. And if you answer, you stand out. Not every student likes that.

Some educators use the word emotion in a more abstract way, connected to learning:

> understanding, definition and conditions are dry stuff and do not connect with perceptions; later they do; also emotionally.

> reactions and emotions of the students should be probed and discussed and if this is not done, there is no bridge to the theory discussed earlier.

Note, the dividing line between the previous PoL, belief, and this one is thin. For example, the concept of fear of failure is an expression of one's own conviction and fear is also an emotion. In 19% of cases, the responses were coded with both principles.

3.2.6 Motivation

This PoL was referred to by all three groups of participants for both vignettes 1 and 2. In a number of responses, students named poor motivation alongside another interpretation:

> It seems that the learner does not have much motivation. Also, the learner does not think he/she can do it.
>
> The learner has a problem with motivation/execution and not necessarily (only) with the knowledge/skills of the calculation.
>
> [pupil] doesn't feel like *because* he then has to make an effort and cannot stay in a consuming attitude [...].
>
> Just not interested in the subject
>
> Lack of motivation
>
> Pupil has a problem with motivation, not with skills of solving the sum.

These responses were noteworthy for their normative slant. With responses such as "The student does not feel like it", "is not motivated", or "has no interest", students made a pupil trait or state the cause of an unsuccessful lesson, and thus laid the blame on the pupil. These responses seem to stem not from reflection on learning, but from a more instinctive personal conviction that pupils are responsible for bringing the right attitude to the lesson. Again, almost nowhere were the responses conditional.

In contrast, teachers and educators had responses, where motivation was referred to in a less normative way. Answers are more implicit but not connected to learning:

> In the second lesson, the teacher goes back to theory too quickly, instead of using and deepening students' *interest*. (educator)
>
> Because [democracy] is now in their environment it becomes real and the *interest* is there! (educator)
>
> [...] Another option is the relationship with the teacher due to previous events. (teacher)

Other Frequent Themes

During the process of coding, it turned out that other statements were made that could not be directly linked with an APA PoL. Thus, three new codes were created.

3.2.7 Memory and forgetting

Memory related answers were only found in the first vignette, mostly about forgetting. A distinction was visible between brief, statement-like responses and more descriptive ones. Two-thirds of the responses were short and contained just short phrases such as: "forgotten," "not remembered," "it has not stuck," "they no longer have it in mind." "they have lost it," "it is not ingrained," "not have it ready anymore," "hasn't stuck," "no longer a recollection," "it has faded away." Remarkable was that here longer and shorter answers were equally distributed over the three groups. It suggests that ideas about the function of memory in learning are already hold by students as often as with the more experienced and also the latter do not have much more words than students.

The more elaborate responses did describe short- and long-term memory:

Information not processed, so it is not in long-term memory (student)

Stored in short-term memory. Then if it has only been covered once and not repeated, students don't remember it. (student)

Pupils have not delved into the material and have not moved the prerequisites from short-term to long-term memory, so they don't remember it now. (teacher)

It is little remembered because long-term memory was not addressed in the earlier lesson. (teacher)

The information has not been integrated into long-term memory. (student)

From this description, there does not seem to be a sustained transfer from working memory to long-term memory. (educator)

3.2.8 Social classroom situation

A third of the students, half of the teachers and a quarter of the educators described the context, the classroom situation, as the reason that students fell silent in Vignette 1 and that the student did not answer in Vignette 2. Responses coded in this way often included implicit PoLs as well, especially pertaining to emotional well-being. The code #*classroom*was also assigned when explicit words such as the class, classroom, peers or the group were used, for example:

> Would not dare in front of the class
>
> Afraid to give a wrong answer because [...] they might be judged for it by their peers.
>
> Peer pressure.
>
> Can be hindered by classroom atmosphere.
>
> Not to do with maths but with social behaviour.

Half of teachers used the word "safe" in their answer whereas only 10% of students did:

> Does not feel safe to make mistakes.
>
> A student has to be in a safe climate to answer in such a way.
>
> Feels safer to say you can't do it than to show something.
>
> [...] May also say something about an unsafe atmosphere in the classroom.

3.2.9 Learning

This code was assigned to responses in which participants, used descriptions of active *learning*, whether clearly linked with a PoL or not. The remarkable observation is that all these answers came from responses to the first cognitive vignette:

> Students did not actively engage with the term at the time. (teacher)
>
> It was probably worked through too quickly instead of students actively thinking about it in class. (student)
>
> Concept could not be stored in memory because it was not offered in a rich context. (educator)

Examples of more implicit mentions of active learning include:

Learner is not given a chance to think for himself, but has to perform.

More attention should have been paid to working from different learning principles

(experiencing, thinking, creating)

information not processed, so it is not in long-term memory.

These answers show that, although presented in terms of pedagogical strategies, the underlying view seemed to be that active involvement plays a pivotal role in the learning process.

4. CONCLUSIONS AND DISCUSSION

We began this article with the proposition that an important foundation of good teaching is the use of theoretical knowledge, and that such knowledge plays a key role when pedagogical decisions are made (Bakshi, 2023; Gleeson & Davidson, 2016). Our aim was to explore what specific knowledge of *learning* is used by teachers at three different career stages students, teachers and educators—and how, or whether, this knowledge is traceable in their pedagogical decision-making.

To this end, we presented participants with short vignettes, in order to respond promptly. While it is impossible to determine whether participants consciously reasoned about their responses, the results do reveal some clues. The relatively brief formulations, together with the absence of conditional or uncertain phrases, suggest that participants indeed employed rule-of-thumb strategies to make satisfactory decisions (Bakshi, 2023). Their answers, therefore, are likely based more on routine and implicit beliefs than on deliberate theoretical reflection. For our purpose, this is a positive outcome, as we sought to elicit both explicit and implicit knowledge.

4.1 General Findings

Overall, the most notable finding is that there was little variation in the frequency with which the principles of learning (PoLs) were employed across participants; statistically significant differences were found in just three PoLs. Only a few responses lacked any observable underpinning. This suggests that our six se-

lected PoLs are generally part of teachers' knowledge at all career stages and is consistent with the broader view that this knowledge is more deeply rooted in ingrained beliefs formed through early life experiences than through formal teacher education (e.g., Bakshi, 2023), though this cannot be conclusively determined from the data.

When analysing the content, again, differences were modest. In none of the PoLs we observed completely distinguished answering between the groups in terms of consistently more elaborate wording or more PoLs in an answer. Variations were found in some words and more or less implicit answering.

Apart from quick responding, students tended to give more brief responses. Answers like "repeat" or "use examples" or "don't feel like" reflect that their (prior) knowledge is what they have seen and experienced in their own school days. This prior knowledge was built up inductively and is sustained by an enormous number of experiences and probably become a belief (Korthagen, 1999). The difference with more experienced teachers was particularly noticeable in the PoLs concerning context and repeating. Besides more than twice as many teachers and educators referring to this PoL than students, educators use more abstract terms than students did. These findings indicate that students apparently were aware that repeating materials and giving examples do induce the learning process, but their responses did not reveal whether they understood the mechanism underneath. In the model by Cochran-Smith & Lytle (2009) their knowledge might be described as knowledge *in* practice as it is holistically formed out of experiences where educators' answers seem to be more knowledge *of* practice. More abstract language and richer answers show comprehension of the relationship between theory and practice. This may stem from, besides experience, the fact that educators teach about pedagogy and thus may have greater familiarity with PoLs and be more accustomed to thinking in abstract terms about learning.

4.2 Cognitive principles

Interestingly, for the PoL "context" the frequency of using increased clearly from students to teachers. Most of the responses coded as linked with this PoL were descriptions about examples and "connect to pupils experience world". Words such as "transfer" and "abstract versus concrete" were rarely used. Two possible explanations might underpin these findings. Firstly, using examples is highly visible and has been part of the students' own educational history for years. Even connection to pupils experience world might have been sensed without ever being mentioned explicitly but it can also be that students recently learned about it. Secondly, "transfer" is a daily language word but the particular

educational meaning requires explicit instruction, as knowledge *for*. The fact that an increase in use is observed most likely says that the PoL has become more influential in conscious thinking and unconscious decisions (Phillips et al., 2017; Verloop et al., 2001). What Škėrienė & Augustinienė (2018) call "practical wisdom"; growing awareness over time finally being effectively integrated into practice. This reasoning does apply specifically to abstract concepts that must first be learned (as knowledge for) before they can inductively grow into knowledge of. It is hardly conceivable that teachers would discover it inductively and spontaneously only from their experiences. The other PoL having an abstract concept is the role of prior knowledge. However, connecting to prior (cognitive) knowledge was probably not as visible in everyday teaching compared with pupils experience world and the use of examples.

Language plays an important role in the interpretation of teachers' beliefs. The words and formulations that teachers use do not always confirm whether principles of learning are really understood, as we saw with transfer. In our quantitative study (Meij et al., 2025), we observed a low correlation between beliefs about the correctness of actual learning principles when described in classroom terms versus the more formal language of the APA top 20 principles. That observation may explain why many responses were more implicit in this study. For teacher education, this finding suggests that making important concepts and terms such as transfer, concept, or prior knowledge part of everyday language.

Answers that contained both context and prior knowledge were observed three times as often in teachers and educators as in students. The combination of these two concepts indicates a broader and more abstract theoretical understanding of learning as adaption of an existing conceptual network. If someone understands the role of both prior knowledge and transfer, an even deeper insight could be expected where all learning is seen *as* the transfer of previous experiences (Bransford et al., 2000). Knowing that concrete contexts are integrated and organised into existing conceptual networks, thereby enriching and organising abstract concepts, teachers might see that such enrichment and organisation leads to students' deeper understanding of material or, to the contrary, hinders it (Vosniadou, 2013). Such deeper understanding by teachers might lead to linking daily classroom practice with memory function. While directions such as "Repeat and practise" or "Use examples" might support effective lessons, they do not necessarily indicate a deeper understanding of learning.

4.3 Affective principles

The affective principles on average elicited short and seemingly intuitive responses. This can be understood from the fact that these principles are perceived and understood not only within the school context, but as part of everyday life. They might have been learned informally far more often beyond education. This means that teachers may hold an intuitive understanding of these principles, without realizing the impact to the learning process.

Beginners – again- are more likely to have an easy explanation and/or look for the cause in pupil behaviour rather than in the teaching and learning. They often reduced the meaning of motivation to "like it or do not" and an externalizing view of motivation as a fixed student characteristic, probably due to experiences and intuition. That might explain the that students used motivation more often as a reason than teachers and educators. The answers reflect a normative attitude towards the pupil in the vignette although no clues or suggestions were given. In the more implicit answering by teachers this normative feeling is not observed. However, compared to the PoLs belief and practising, in the responses that contained motivation a connection to learning was hardly found. A reason might be that motivation is a complex construct. Following self-determination theory for instance, belief and also social class-room situations might be components of motivation.

4.4 Teacher Education

We believe the results of this study provide some clear indications for teacher education. Firstly, although teaching of learning theories seems not effective (Meij et al., 2022), this study shows the importance of teaching the most abstract principles of learning such as transfer and prior knowledge in connection with memory and conceptual change. These concepts cannot be observed and understood from students' own school experiences, and may become fragmented knowledge *for* when they do not become knowledge *of* practice. Making the connection by, for example, discussing students' daily teaching experiences, pedagogically reasoning together and explicitly attaching experiences to PoLs, would prevent this, as advocated earlier by Korthagen (2010). However, the results here do not show an outstanding knowledge *of* practice for educators compared to students. For teacher educators, this suggests three tenets. First, a strong overall paradigm of learning is required that overarches theories and principles to understand the interconnection and have deeper understanding, and thereby become able to distinguish between superficial and deeper understanding by students and intervene appropriately. Second, educators would need epistemic knowledge of where knowledge *of* comes from. Following Korthagen and Kessels (1999), they ideally know that knowledge *of* practice

emerges out of knowledge *in* practice following an inductive pathway. A rich network made up of a diversity of practice-experienced contexts anchored to principles leads to greater understanding. Such understanding develops in only a limited way from a deductively offered educational psychology knowledge-*for* course. It should permeate daily didactic conversations among teachers. During teacher education, PoLs with their abstract terms like e.g. transfer should become daily used language. Thirdly, they must know what would be a successful approach to teach and coach students to develop and enrich this knowledge. That would require first of all being very competent in pedagogical reasoning themselves, and then starting from the engrained knowledge and beliefs that almost all students hold. The most clear observation from these findings is that students bring *many* correct beliefs and knowledge about learning with them but they often lack the deeper understanding of the role towards learning. Following Korthagen and Kessels (1999), their knowledge is emerged inductively during many years in classrooms and richly sustained by experiences and emotions and therefore part of a strong belief system. A more detailed investigation of what this prior knowledge exactly entails might be interesting. But, when teaching new knowledge about learning in teacher education (knowledge *for*), this prior knowledge and beliefs have to be explicated to prevent parallel conceptualisation of existing and new knowledge. Teaching will probably be more changing, refining and deepening existing concepts and ideas rather than adding new. In the text it was already mentioned that language plays an important role. Abstract terms that have to be taught explicitly before they can be understood should become words of daily use. We agree with Wilcox-Herzog et al. (2015) and Verloop et al. (2001) that teacher education should start with the explicit elicitation of the ideas that students bring with them before starting to teach theory of learning. Existing flawed beliefs or misconceptions can be elicited early; conceptual change of such beliefs is much more achievable by having them consciously conflict with practice situations from day one than by offering new "correct" theory.

4.5 Limitations of the Study

A key decision in this study was whether to include implicit responses in the analysis. We decided to incorporate them to enrich the dataset and capture more teacher beliefs. If we had limited our coding to responses that strictly used the jargon outlined in the original APA description, the data would have been sparse. Such an approach might have measured not actual teacher beliefs, but instead the extent to which teachers had knowledge of the jargon. By including implicit responses, we recognized that some of these responses could be inferred to align with relevant PoLs. This inference introduces uncertainty about whether the inferred principle and its underlying process genuinely reflect the

respondent's belief system. Conversely, the inability to articulate a principle in precise jargon does not necessarily mean it is absent from a person's belief system. For instance, statements such as "Treating or transcribing a concept does not lead to learning" or "This is not learning because learning is for the long term" implicitly embed several PoLs. These examples raise important questions about the extent to which participants hold these principles as true beliefs.

The decision to select six PoLs from the APA top 20 means others were not targeted here. We chose these six because we considered them as basics and because they are interrelated, which gave us the opportunity to distinguish superficial from more complex and deeper understanding. The vignettes were written with these principles in mind. In doing so, we explored only part of a much more complex belief system, and generalisation to a broader understanding of learning cannot be inferred from these data. However, the fact that all six principles were equally mentioned by students, teachers, and educators, that students answered more briefly and often more normatively than teachers, that more theoretically abstract and concrete PoL were distinguishable, and that most of the responses were formulated with firmness are conclusions that extend beyond this choice.

The diversity of responses, particularly for the second vignette, underscores the role of language. Different vignette descriptions, maybe with just another word might have yielded different responses.

Richness of responses here was partly the basis for our conclusions, but also depends on personal and situational characteristics such as interest, memory, commitment, or motivation. Wordiness is also a personal trait; some individuals (believe they) need more words to explain something.

Finally, it is possible that some participants, especially students, had recently engaged with relevant theory or practice, making it fresh in their minds. This was not visible in the study.

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CHAPTER 5

How young adults' existing ideas about principles of learning develop during a teacher education programme.

Chemistry Teachers' development of prior knowledge about principles of learning: nature or nurture?

ABSTRACT

Previous research has shown that teachers at all stages of their careers possess knowledge and beliefs concerning principles of learning. The present study examined the development of these principles during a teacher education programme. Participants (N = 49) comprised two groups of secondary school students—those who enrolled in a teacher education programme and those who explicitly did not pursue a teacher career—as well as a group of final-year teacher education students who were assessed both before and after an eight-week intervision intervention. All participants were asked to explain what occurred in six vignettes depicting everyday situations in chemistry classrooms. Principles of learning were inferred from the written responses using a qualitative analytical approach.

The results yield three overarching conclusions. First, prospective starters who intended to pursue a teaching career consistently produced richer and more elaborated responses than their counterparts, suggesting that individuals who actively choose a teaching pathway may already possess greater awareness of classroom processes based on their own schooling experiences. Second, a clear distinction emerges between starters and final-year students: the latter demonstrate a shift from fragmented, teacher-centred thinking towards more integrated, student-focused pedagogical reasoning. Third, the eight-week focused intervision programme does not appear to produce a substantial change in the knowledge of final-year students; however, the findings indicate that intervision may have contributed to slightly more coherent pedagogical reasoning.

1. INTRODUCTION

"First, take a serious, normal example and properly explain theory instead of using all those creative examples". (first year science student, not engaged in teaching)

More connections to the students' world, more engaging real-life examples of chemistry in practice will make them recall easier. (first year starting science teacher student)

"I think that if you give students more challenges, they can focus more on themselves and think. Just like when it's quiet at the table during a nice meal." (final year chemistry teacher student)

The three quotations presented above are responses to a classroom scenario provided by different student participants in this study. These three responses illustrate the trend that is the focus of this study: a progression from teacher-centred perspectives (e.g., "the teacher should better...") towards more student learning-centred viewpoints (e.g., "would be better for them"), towards a broader view and abstract understanding of principles of learning (PoL).

As part of our broader research programme exploring teachers' knowledge and beliefs concerning core PoLs, we examined which principles teachers hold either implicitly or explicitly (Meij et al., 2025a), and how they articulate these when making pedagogical decisions in classroom contexts (Meij et al., 2025b). This knowledge and its application were studied across different stages of teachers' careers and, although these were not as pronounced as anticipated, we did identify differences. Core PoLs—such as the influence of prior knowledge on new learning, or the impact of emotional well-being on cognitive performance—were found in the responses of both pre-service and experienced teachers. However, novice teachers tended to express these principles in less explicit terms, often indicating a superficial knowledge or even an unconscious feeling but it suggests that many trainees begin their teacher education with some degree of prior knowledge already in place (Meij et al., 2025b).

The more explicit and elaborated responses provided by in-service teachers suggest that, over the course of the typical four-year teacher education programme (in the Netherlands), these initial principles develop into more sophisticated conceptualisations, along with the ability to translate and apply them effectively in classroom practice. In line with Clarke and Hollingsworth's (2002) assertion that "If we are to facilitate the professional development of

teachers, we must understand the process by which teachers grow professionally and the conditions that support and promote that growth" (p. 947), we are particularly interested in how such conceptualisations of PoLs evolve, and which factors support or hinder this developmental process. In other words, which prior knowledge they have and how that changes under the influence of circumstances.

The foregoing suggests that a substantial shift occurs between the outset of initial teacher education and participants' understanding at the programme's conclusion. It is interesting to consider how the prior knowledge that pre-service teachers bring to their studies has been formed—presumably during their preceding secondary schooling—and how, by the end of the programme, this knowledge remains susceptible to change. To examine this, we investigated cohorts of first-year and final-year pre-service chemistry teachers by assessing their use and understanding of PoLs.

To explore final-year students' capacity for continued professional growth at the threshold of their in-service careers, we implemented an eight-week intensive intervention embedded within their classroom practice and subsequently reassessed how they applied PoLs. In the case of first-year students, our aim was to measure their knowledge on the very first day of the programme. Any conceptions they held regarding teaching and learning would, in all likelihood, have originated and developed during their prior experiences in secondary education. However, these experiences may have been different for secondary students who later pursue a career in teaching than those students who are not interested in teaching. To gain some insight into students' conceptions gained during secondary schooling, we compared the knowledge of first-year pre-service teachers with that of peers in the same academic year who had explicitly opted *not* to pursue a teaching career.

What experiences exactly were responsible for any change cannot be determined. It is widely acknowledged that teaching is a very complex endeavour (e.g. Kennedy, 2016; Loughran, 2019) and a wide range of influences may shape beliefs and ideas about teaching and learning (Škėrienė & Augustinienė, 2018).

Research questions

The central research question guiding this study is: How does pre-service chemistry teachers' knowledge of PoLs develop over time? Several studies have examined the differences between novice and expert ideas and beliefs about learning (e.g. Michel, 2013; Lloyd, 2019; Meij et al., 2025). However, we are unaware of studies that have specifically investigated principles of learning from a

conceptual change perspective. In our study the focus is on the development of and the conceptual changes in knowledge of *principles of learning (PoLs)* that occur in everyday science teaching. Three more concrete questions focus on the points in time where we performed our measurements: 'What prior knowledge do pre-service teachers bring from their years in secondary school?", "How does that knowledge develop over the course of 3 years teacher education", and, at the end "What is the influence of intensive training before starting working in the field?".

2. THEORETICAL FRAMEWORK

2.1 Inductive Learning and Korthagen's Three-level model

According to Korthagen (1999; 2010) change and development of knowledge takes place via inductive processes. That is, participants primarily form ideas, concepts and theories through immersion in practice and not through knowledge that is taught. Observations, experiences and prior knowledge gradually evolve into new ideas or make existing ideas, beliefs and knowledge more profound, substantiated, detailed, and closely connected to personal experience. All of this contributes to better understanding.

Both *inductive learning* and *inductive teaching* are terms used in the literature (e.g. Shafto et al., 2014; Hennissen et al., 2017). Inductive teaching generally refers to student-centred approaches, in which *methods* such as inquiry-based learning or project-based learning are employed where learners work on practical context enabling them to derive more abstract concepts (e.g. Duit et al., 2013; Schreurs & Dumbraveanu, 2014). Inductive learning, by contrast, refers to the *process* through which knowledge is constructed in a bottom-up manner: abstract principles, and possibly theories, are formed on the basis of experiences and observations. Inductive teaching may lead to inductive learning, but it is by no means a prerequisite. When people learn informally—that is, outside of formal education—the learning process is most often inductive.

Such inductive learning from experiences was described in the three-level model by Korthagen and Lagerwerf (1996), Korthagen and Kessels (1999) and Korthagen (2010) and was introduced as a possible route to integrate the two visions of how teachers form theoretical models: the cognitive approach where theory is offered and subsequently applied and a more situated learning as in an apprenticeship (Lave and Wenger, 1991).

Figure 1 shows the three-level model graphically. The first level of learning, *Gestalt formation*, is characterised by largely unconscious processes grounded in routines, tacit knowledge, feelings, values, concerns, role conceptions, and prior knowledge.

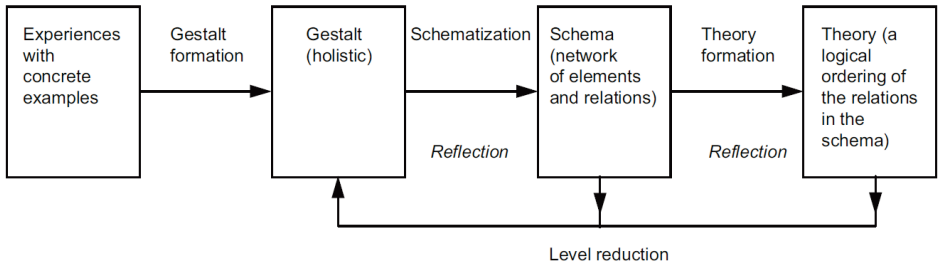


Figure 1 Korthagen's three-level model of knowledge development (1999, p10)

These elements together form a *Gestalt*, a holistic network of experiences which is automatically activated in situations resembling those in which it was acquired, operating primarily at the level of tacit knowledge (Todorovic, 2008). For instance, a pre-service teacher may repeatedly experience that the diversity of pupils' thinking in order to understand a chemical concept makes it very difficult to explain it in one way that would serve them all. At a similar next situation that gestalt may be activated leading to an unpleasant and ambiguous feeling. A gestalt can be an idea or belief that is deeply grounded.

Schematization occurs when the unconscious feeling becomes practical knowledge, that is, when teachers are able to articulate knowledge explicitly. In the example, when asked to reflect on the classroom practice, the pre-service teacher can describe the recurring unpleasant and ambiguous feelings when confronted with pupils' diversity of thinking. Through reflection and discussion with an experienced educator, he/she may adopt another educational form, such as demonstration experiments with questions instead of explaining. This adaptation may improve pupils' engagement because the more individual thinking becomes visible and can be addressed. That results in the development of a new schema by the teacher.

In the third level of learning, *theory building*, different schemas are interconnected leading to a more coherent network of concepts. This level requires a high degree of awareness and knowledge of broader theories operating at a conceptual level. In our example the teacher may have become familiar with more principles of learning like the roles of prior knowledge, images and active thinking and understands how the newly adopted instructional strategies

interconnect and can be applied in other, not identical situations which is high-road transfer (Salomon & Perkins, 1989). Over time, this practical knowledge and theoretical knowledge become intertwined and automatised operating at a more unconscious level and can be considered a new gestalt.

Reflection is a mediating key construct in Korthagen's model (figure 1). A next level is reached when the teacher is able to articulate tacit feelings, ideas, experiences and "knowledge", give words and ask questions to the gestalt or scheme more explicitly, hence, when the content of the gestalt or scheme becomes more conscious. Awareness is key to the development and abstraction of knowledge. When a teacher does not reflect on his or her daily work anymore, knowledge goes to the unconscious and becomes (part of) a gestalt. In other words, every time one reflects on more abstract levels, the gestalt becomes "richer", that is, more abstract ideas, concepts, models and theory are interconnected to the endless experiences, emotions, ideas, images, feelings, notions etc. already experienced. The more abstract elements become part of the concept, the more likely it becomes that the teacher sees the transfer of these elements to other, more or less similar situations.

Korthagen introduced the model as an explanation for the gap between theory and practice experienced in teacher education (Korthagen, 1999; 2007), which remains a main subject of research in teacher education up to the present (e.g. Resch & Schrittesser, 2023). But the model also offers approaches for teaching to overcome the gap. The main point is that teaching is to a large degree a gestalt-driven activity (Korthagen, 2010). As a consequence, the presentation of theory is not sufficient in trying to influence teachers' more perception-driven gestalts. "Although the transfer problem in teacher education is well-known and its causes have been thoroughly researched, it is remarkable that many teacher education programs still reflect the traditional 'application-of-theory model" (Korthagen and Kessels, 1999, p.5). Teacher education should start from student teachers' gestalts, that is, from the experiences, beliefs and convictions they bring from their former school career. In many more recent studies, empirical as well as theoretical, also outside of education, authors have stressed this same important condition to narrow the gap between theory and practice.

As teaching on the basis of experienced situations is always unpredictable, teacher educators need to be well equipped with different models and theories in order to react adequately to what is brought into the discussion while keeping in mind the objective of the lesson which may concern a specific theory or principle. This requires the skill to adapt their teaching behaviour; primarily the ability to skip explaining the theory for a while (Korthagen, 2010).

The model in figure 1 has since been widely used to study cognitive and conceptual learning and professional growth of future teachers (e.g., Kërënxhi & Gjoci, 2015; Westrick & Morris, 2016; Hennisen et al., 2017; Kostiainen et al., 2018; Phung & Michell, 2022; Ergogo et al., 2023; Chen, 2024).

2.2 Conceptual Change

Korthagen's three-level model proposes that initial gestalts emerge unconsciously from experienced perceptions, emotions, and intuitive impressions. Through reflection, these Gestalts gradually develop into more abstract structures, leading to professional growth. This process fits very well with the tenets of conceptual Change Theory (CCT), describing learning as the restructuring and enrichment of prior knowledge, often requiring epistemological shifts (Vosniadou, 2013). Although the important role of prior knowledge in learning was recognised much earlier by Piaget and Ausubel and worked out by van Hiele in the 1970's, Posner et al., (1982) defined conceptual change more precisely as the transition from naïve, scientifically inaccurate conceptions to scientifically valid ones, leading to understanding. They stated that learners are only motivated to change existing conceptions when they recognise these as inadequate, and adopt alternative conceptions when they are considered intelligible, plausible, and useful, the existing ones will change. This suggested an educational approach where teachers should confront learners with numerous experiences that provoke cognitive conflict and stimulate reflection.

Early formulations of CCT assumed that existing conceptions could wholly be replaced, drawing on Piaget's notions of assimilation and accommodation as well as gestalt psychology. However, research into misconceptions soon revealed that such radical replacement was unlikely (e.g., Vosniadou, 2007) and new constructivist ideas from the 1980's shifted the idea of knowledge evolving to knowledge construction (Duit et al., 2013). In response, Strike and Posner revised their 1982 model, describing prior knowledge not as a single coherent structure but as part of a conceptual ecology: an inter-conceptual complex network of anomalies, analogies, metaphors, epistemological and metaphysical beliefs, cross-domain knowledge, language, images, and experiences (Strike & Posner, 1992). Within such an ecology, change is necessarily gradual and time consuming, involving the adjustment of many individual elements rather than wholesale replacement. Learners acquire new experiences and, through *reasoning*, identify small inconsistencies that prompt incremental adaptation. And because of this network-like relationship between concepts, a revision to a concept requires revisions to others.

Moreover, Pintrich et al., (1993) introduced that the affective side of learning with factors such as self-efficacy, motivation, emotions, and control beliefs play a key role in the "cold" cognitive conceptual change learning process and these factors require *intention*, that is, the impetus for change is placed within the learners control as meta-cognitive control over their own learning takes place (Sinatra & Pintrich, 2003). The influence of these motivational, meta-cognitive and affective components of learning on conceptual change has been studied several times under controlled conditions and more recently in a regular classroom (McLure et al., 2020).

The idea of nested network-like structures or frameworks of prior knowledge wherein conceptual change means adapting deeply embedded structures, it was redefined by DiSessa who introduced knowledge-in-pieces (KiP) theory, stating that prior knowledge often is fragmented, incoherent, unstructured, intuitive, and very context-dependent. Contrary to the framework approach, knowledge is not (yet) connected to other concepts and different contexts. DiSessa (1993) named such knowledge pieces phenomenological primitives or p-prims. The fact they are context-dependent and are activated in a particular context means that learners usually do not compare different p-prims in a certain situation. Transfer is then not any more the use of a theory in different contexts but rather a stepwise organization and restructuring of knowledge in other contexts. More understanding develops when p-prims are interconnected across more contexts leading to larger wholes. A more detailed comparison analysis of both strands within CCT was made by Özdemir & Clark (2007) and, focused on teachers' knowledge, by Markauskaite & Goodyear (2014).

The complete process of change occurs consciously when a cognitive conflict is detected. The three-level model of Korthagen resonates with this perspective: abstract theories or scientific concepts cannot be transmitted in a single moment; rather, they must emerge from repeated experiences that gradually merge into a coherent network of meaning by deliberate reflection. CCT comes to that same "conclusion" after researching the psychological mechanism.

Both the framework and p-prims versions of CCT highlight a key factor: inaccurate implicit prior knowledge or misconceptions may *hinder* the shift towards more accurate conceptions, creating resistance to change. Such inaccurate but persistent misconceptions can only be changed by *eliciting* them before learning of new knowledge can start. This is in line with the recommendation that teacher education should start with prior conceptions of learning practice (e.g. Korthagen & Kessels, 1999; Verloop et al., 2001; Markauskaite & Goodyear

2014; Wilcox-Herzog et al., 2015; Shahzad et al., 2017; Kaya et al., 2021; Qiu et al., 2021).

Misconceptions are diverse in nature; they are not just wrong information. Misconceptions are smaller networks bearing *misconceived* knowledge (containing wrong information) or *incommensurate* knowledge (connection to a wrong category) leading to very different (ontological) categories (Chi, 2013). Therefore, eliciting misconceptions requires a sound and profound knowledge of the content being taught by the educator because only if he/she has detailed and rich knowledge of the content, the elicited prior knowledge can be noticed, brought to the conscious, discussed and repaired (Kaya et al., 2021).

Summarizing, conceptual change may be understood as a process in which prior knowledge is progressively enriched with new insights and restructured through the formation of new conceptual linkages. Existing flawed linkages have to be elicited and discussed. In this way, knowledge becomes increasingly coherent, plausible, and therefore more accurately applicable within and across contexts. Achieving such transformations necessitates deliberate and critical analysis of the learner's existing knowledge elements. Above all, this requires time.

Research in CCT has been most prominent in the natural sciences, particularly physics, where concepts are sharply defined. Starting in early childhood, humans construct their own intuitive explanations on the basis of daily experiences with phenomena such as falling, feeling heat, seeing light, hearing sound or dissolving sugar. This body of prior knowledge, termed naïve physics (chemistry, biology), develops in response to curiosity and the human desire to answer "why" questions. Such naïve theories are highly persistent because they are reinforced by extensive lived experiences and embedded within a plentiful conceptual ecology. As a result, they often endure even after years of formal instruction, coexisting with scientifically correct conceptions and continuing to influence reasoning in everyday contexts (Vosniadou, 2007; 2013).

As a note at the outset, we emphasised that this study focuses on the development of knowledge and thus on cognitive learning. However, both Korthagen's three-level model (Korthagen, 2017) and conceptual change theory (Pintrich et al., 1993) emphasised that affective factors such as self-efficacy, motivation, emotions, and control beliefs potently influence cognitive learning . In this light, Korthagen (2017) refers to the 'inconvenient truth' that in teacher education we may place too much emphasis on the cognitive learning of teachers.

2.3 Conceptual Change in Teachers

While early CCT research focused on students' learning, more recent studies have broadened to include (pre-service) teachers. Studies now examine how teachers' conceptions of subject teaching, learning, and knowledge acquisition develop, and to what extent these conceptions can be transformed. Kali et al. (2011) introduced the idea of pedagogical p-prims, drawing on the epistemological p-prims by Hammer and Elby (2003) that are created through experiences with different forms of knowledge and describe how people make sense of what knowledge, knowing and learning are. Pedagogical p-prims, which play a role in pedagogical reasoning, may be regarded as the counterparts of naïve p-prims in the physics domain. They emerge from experiences of being taught or of teaching, and can be considered the foundational elements of 'folk pedagogy' (Kali et al., 2011). Consistent with conceptual change theory, such p-prims, correct or incorrect, are deeply rooted, reinforced by many experiences, resilient to change, and strongly leading in pedagogical reasoning. It may explain why teachers' instructional practices in their later career are sometimes heavily influenced by intuitive reasoning based on their own prior experiences as a learner (e.g. Karavas & Drossou, 2010; Zakaria & Ab. Wahid, 2023). Findings suggest that teachers, much like students, often hold conceptions rooted in personal experiences rather than in disciplinary or pedagogical research (e.g. Basckin et al., 2021; McAfee & Hoffman, 2021).

The concept of pedagogical p-prims has been used widely in studies of teacher education, learning strategies (Glogger-Frey et al., 2018), misconceptions in pedagogy (e.g., McAffee & Hoffman, 2021), intuitions in pedagogy (Markauskaite & Goodyear, 2014), and many studies of subject pedagogy (PCK) in, e.g., physics (Potvin & Cyr, 2017) and chemistry (Dodlek et al., 2024).

Hence, it is important here to acknowledge that to teach and train future teachers in pedagogical reasoning, a teacher educator should bring not students' fragmented pedagogical p-prims to the surface but as well their more complex beliefs how their content is to be taught. In order to accomplish this, teacher educators need thorough knowledge of PoLs, intertwined with content knowledge (Pedagogical Content Knowledge: Shulman, 1986; Kaya et al., 2021).

2.4 A comparison of Korthagen's model and Conceptual Change Theory

Korthagen developed his model with a specific focus on the education and professional development of a teacher (educator). The model is designed as an instrument that can identify distinguishable steps in professional growth, whereas Conceptual Change Theory (CCT) is a broad learning theory aimed at

describing learning and development in general. Nevertheless, when the two frameworks are compared, striking similarities emerge, even though the literature on each never explicitly references the other.

First, both models are fundamentally grounded in the idea of gradual growth in knowledge proceeding through an inductive process. Knowledge is constructed from the concrete to the abstract: observations and experiences give rise to initial structures of coherence that are largely implicit. Korthagen refers to these as *gestalts*. Within CCT they are conceptualized either as discrete phenomenological elements (*p-prims*) or as small nested (sub)frameworks (*naïve theories*) that possess some internal coherence within a larger whole. For both CCT emphasises that these contain too few *connections* with existing knowledge to generate understanding, or include incorrect connections that actually hinder understanding. This inductive growth is considered fundamental, and both models therefore caution against instruction that relies on the deductive transmission of abstract theories and models, as this leads to difficulties in transferring knowledge to other concepts and contexts. The work by Chi (2013) offers a theory on how generally such prior knowledge hinders transfer where Korthagen and Kessels (1999) point concretely to the rapid decisions teachers must make across diverse contexts, in which abstract reasoning is ineffective, and they warn that the model of 'applying newly learned theory to practice' fails for this very reason. (This idea of *high road* and *low-road* transfer was carefully delineated by Salomon & Perkins (1989).

Second, both frameworks place prior knowledge at the centre of learning. Korthagen observes that beginning teachers possess strong preconceptions and that these "have a remarkable resistance to traditional attempts to change them" (Korthagen & Kessels, 1999, p.5). CCT is founded on the assumption that learning *is* the adaptation and enrichment of existing knowledge. When newly introduced knowledge fails to connect with prior knowledge, parallel conceptions emerge or fragmentation occurs.

Third, both perspectives argue that a process of awareness must occur before a genuinely new concept or theory can begin to form. This awareness involves a deliberate slowing down, allowing the learner to view different contexts through the lens of a new abstraction. Here, a distinction becomes apparent between the general learning theory and the model for teacher development. Korthagen places strong emphasis on the act of reflection—consciously pausing to consider practice—which leads to insight and to the establishment of connections across different teaching situations (i.e. transfer). CCT, in more general terms, refers to the *intention* required for conceptual change to occur. Both approach-

es emphasise that the trigger for such awareness must be a personal concern or a concrete problem. Korthagen mentions it the *feed forward problem,* that is, in order to learn anything during teacher education, student teachers must feel disconcerted because of personal concerns about teaching or they must have encountered concrete problems. In CCT this is conceptualised as a cognitive conflict. Such thinking has ramifications for *transfer*. Both theories describe inductive learning as a prerequisite for achieving transfer. Conversely, this implies that a transfer problem, that is when knowledge gained in one context cannot be used in another, can induce a cognitive conflict and thus *trigger* conceptual change: a learner encounters the limits of a personal concept being unable to adequately explain a new situation and (in the words of Posner et al. (1982)) an alternative concept is necessary that is considered intelligible, plausible, and useful. To achieve transfer, a more abstract level of knowledge is necessary that connects contexts and explains what is different about them (Salomon & Perkins, 1989).

Fourth, both frameworks highlight the significant influence of the affective dimension of learning, particularly emotion and motivation (Pintrich et al., 1993; Korthagen 2017).

Finally, when it comes to the term *beliefs*, there is a difference in both theories. It is generally accepted that students entering pre-service teacher training programs bring a host of knowledge, beliefs and assumptions regarding teaching and learning. Prior knowledge is often used as an overarching term for all three; a question in both theories is then 'when is prior knowledge really knowledge and when only a belief or assumption? Korthagen does not explain or mention teacher beliefs within his model, he mentions *preconceptions* that are difficult to change and uses the term *belief* only as a level of reflection in his onion model intended as an auxiliary model for reflection in teacher professional development (e.g. Korthagen, 2017). Prior to the 1990s, in CCT *beliefs* and *knowledge* were often used interchangeably, as were concepts such as *preconceptions*, *naïve knowledge*, *misconceptions*, and *beliefs*. Cognitive psychologists likewise tended to use these terms as labels along a continuum of certainty (Ohlsson, 2009). Pajares (1992) first clearly delineated the distinction between knowledge and beliefs and introduced the concept of a *belief system*. Empirical research in conceptual change (CC) research demonstrated that learners may understand new knowledge but seem hesitant or unable to accept and integrate it into their existing knowledge structures and as a result, beliefs assumed a more prominent role within CCT theory. Motivational and epistemological beliefs were identified and conceptualised as meta-level regulators of conceptual change. The central premise of CCT—that existing knowledge can impede the learning of

new concepts—was also applied to beliefs, which exhibit strong internal coherence across contexts and are closely linked to motivation and even identity (e.g. Pintrich et al., 1992; Sinatra & Mason, 2013). Belief systems are now regarded within CCT as nested with knowledge systems and constitute an active area of research within the educational sciences (e.g. Vosniadou et al., 2020).

2.5 An integrated model

If we try to bring the above together, a circular process can be seen as depicted in figure 2.

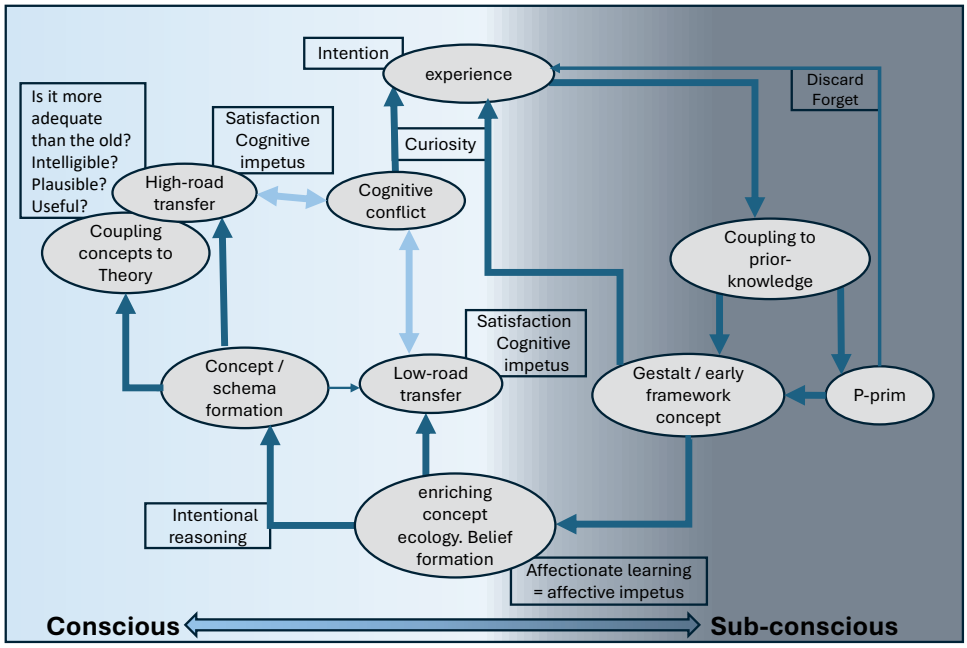


Figure 2 Circular processes of conceptual knowledge development

All cognitive processes originate in immediate experiences and observations, which are instantaneously connected to prior knowledge in long-term memory. Some of these experiences may be retained as isolated and initially meaningless phenomenological primitives (p-prims), while others are perceived as related to earlier experiences, thereby forming the earliest gestalts or concepts. When such processes are repeated, the emerging concept becomes increasingly enriched through exposure to multiple contexts. This enrichment leads to three interrelated outcomes.

First, affective constructs—such as emotions, motivational beliefs, and beliefs about competence—serve to enhance focus and attention, the mechanism that

Chiu (2025) refers to as *affective impetus*. As a result, learners become more consciously aware of the emerging concept, which may initially be recognised only at the level of *'having something to do with'*. This corresponds to low-road transfer (see below).

As the concept becomes fully conscious, intentional reasoning occurs more frequently, leading to the development of a more coherent schema that the learner is able to articulate and explain. New insights, when connected to existing concepts in memory, are now likely to exceed the vague recognition of *'having something to do with'*. Instead, connections are increasingly mediated through the newly formed, more abstract concept, which characterises high-road transfer (see below).

Sustained intentional thinking and deeper conceptual change may ultimately result in theory formation, in which multiple concepts are hierarchically organised into a more abstract and comprehensive theoretical framework capable of explaining and even predicting phenomena. At this stage, the conditions for conceptual change and the acceptance of theory, as described by Posner et al. (1982), become particularly salient.

Within this model, transfer occurs at all stages of development and is always a conscious process. Actively evaluating whether existing contexts align with newly formed concepts—or even deliberately searching for contexts that confirm or falsify them—constitutes the driving force of conceptual change at every level of development. Building on Chiu's notion of *affective impetus* (2025), we propose that transfer functions as the corresponding *cognitive impetus*. The two-way arrows depicted in bright blue in the figure illustrate that transfer is not a discrete step following another process, but rather an ongoing activity of evaluation and adaptation, consistent with the perspective of Bransford et al. (2000, p. 68). Particularly at the level of theory formation, the refinement of theory and high-road transfer are inseparable. The more abstract the theory becomes, the more its construction inherently involves transfer.

In our conceptualisation a cognitive conflict (the central pivot in CCT), is always a consequence of transfer as such conflict arises when existing contexts stored in memory do not align with newly emerging concepts. The occurrence of cognitive conflict therefore presupposes that transfer has already taken place.

Following this line of reasoning, the figure also suggests that presenting learners with a fully developed theory in the absence of relevant contextual experiences would be both ineffective and undesirable. Without contexts, learners

are unlikely to engage in high-road transfer and thus also lack the affective impetus necessary for intentional conceptual change. If a theory is introduced, in our model it should be considered an experience that follows the entire cycle including the possibility that it stays at the p-prim or gestalt level and not the theory level that it was intended for. While this distinction may not be apparent to the learner, it is essential that teachers and teacher educators recognise that the learning cycle begins at this experiential level, with all the attendant implications for instruction and pedagogical guidance.

2.6 Context of this study

This study was conveyed in a teacher education programme of a university of applied sciences in a midsize Dutch city. The four year subject specific programme (here: chemistry) leads to a teaching license in lower levels secondary education. In the curriculum we strive for inductive teaching while paying much attention to students' prior knowledge. This applies not only to subject content knowledge but also to new insights into learning and teaching. The premise is that beginning students have accumulated a wealth of experiences during their secondary school years, leading them to develop general ideas and small theories about learning and teaching. Given the many experiences and emotions supporting these ideas, they may have become ingrained as beliefs. Consequently, this "prior knowledge" must serve as the starting point for the learning process in teacher training. As teacher educators, we face the significant challenge of first eliciting these existing beliefs, making them explicit, prompting reflection, confronting students with misconceptions and subsequently adapting them.

3. METHOD

3.1 Research Design

In this study we examined qualitatively the knowledge and beliefs of three groups of which one was measured twice, as shown in Figure 3. To have an indication of what students learned about teaching and learning in their secondary education, we examined students starting with teacher education, and a comparable group of students still in secondary school who explicitly stated *not* to pursue a teaching career. We assumed that students of both groups have formed ideas about teaching and learning during those years but the students that do not pursue a teachers career would have done so only to a limited extend. That limited extend is not a "zero value" but a difference between the two groups would supply interesting information.

At the same time we examined a group of last year students using the same instrument, conducted an intervention and measured again.

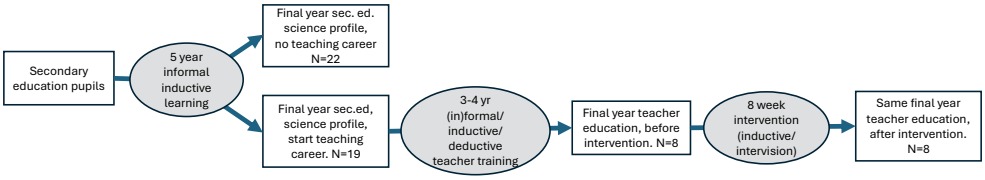


Figure 3 Overview of the learning route of different groups in the research design.

3.2 Participants

In the Netherlands, pupils in the last years of secondary education choose for a profile. A STEM profile consists of physics, chemistry, biology and mathematics besides Dutch language, English and optional subjects. To explore change in beliefs and knowledge about learning and teaching, 41 young adults with a STEM profile were invited.

Twenty two were at the end of secondary education with a STEM profile but explicitly stated that they had *no* interest in education and *no* intention of becoming teachers (below referred to as: starters-NO). This sample was a complete 12th grade science class of a regular secondary school in a midsize Dutch city. It consisted of 14 males and 8 females, average age 17.8 years (sd = 0.64). They were explicitly asked in the survey to state whether they were interested to start a teacher education programme or start studying educational sciences, now or in the future. 21 of them confirmed (definitely) not to; one wrote that becoming a teacher might be an option in future and she was excluded in the data analysis.[2]

Nineteen participants were a first-year class in a science teacher education programme on the very first day of the school year. In the survey they expressed a strong interest in teaching (below: starters-YES). Participants who did any education-related study in the previous year would have been excluded but there were none in the class. The sample consisted of 13 male and 6 female, students average age 19.1 years (sd=1.7).

Eight participants were in the final year of the same science teacher education programme, 4 male and 4 female, average age 22.0 (sd = 2.9). By that time, they had four years of study behind them, including work placements every year, and

2 after the regular analysis her answers were examined separately and showed indeed differences with her classmates revealing more insight in teaching and learning processes, comparable to those of the the startes-YES.

strongly identified with the teaching profession. This group made the test twice, before and after an intervention that consisted of 8 weekly sessions of intensive intervision with joint pedagogical reasoning around video material submitted by themselves from their practice (below: final-BEFORE and final-AFTER).

3.3 Instrument

To ensure comparability of the results, it was necessary to employ a same instrument for both groups of participants. A qualitative methodology was therefore selected, in which participants were asked to reflect on everyday classroom situations that are equally recognizable for all groups. Participants were invited to respond to six vignettes depicting scenarios from everyday science class teaching practices. The vignettes describe authentic chemistry-related situations, drawing on Shulman's model of Pedagogical Content Knowledge (Shulman, 1986), which posits that knowledge of general theories of learning becomes meaningful when situated in specific subject matter. All participants provided written responses to the six vignettes. These responses were qualitatively analysed by open coding to identify differences and similarities in the descriptions, with a focus on learning principles and teaching practices that supported them.

Many authors of theoretical and empirical studies who investigated pedagogical prior knowledge accompanied their conclusions by a firm recommendation that eliciting this prior knowledge and using it as a point of departure for further education offers the most reliable pathway to developing correct knowledge in teachers' minds, thereby maximising the likelihood that they will become more adept at applying that in their everyday classroom practice (e.g. Korthagen & Kessels, 1999; Verloop et al., 2001; Markauskaite & Goodyear 2014; Wilcox-Herzog et al., 2015; Shahzad et al., 2017; Kaya et al., 2021; Qiu et al., 2021). The findings of this study on *change* of such knowledge may either support that view or could suggest rethinking it.

The six vignettes were written by the first author. They all described learning problems in specific chemistry topics in lower secondary education where the students are trained for and do their work placements. Every vignette aimed for a central principle of learning or teaching like transfer, formative testing or classroom management taken from the APA Top 20 principles of learning (APA, 2015), a set of principles derived according to a thorough methodology and captured in a consensus document. The set contains cognitive as well as affective principles.

The situations in the vignettes were richly described so that respondents might connect to more than one principle. To allow the measurement to be repeated

in the same group of participants while striving for maximal consistency of measurement, parallel sets A and B were made describing the same vignettes with slightly different words or another content topic. Every text was followed by two questions: "Why do you think the problem occurs?" and "Which approach do you think would work better?" An English translation of the first vignette in the A-set is supplied in Appendix F.

As a validation step, we ascertained that the vignettes could indeed elicit the intended PoLs. This was done in two rounds. First the two co-authors provided feedback and then versions A and B were sent to two student teachers and two senior teacher educators with the question to highlight specific phrases and connect these to one of the items in a list of provided learning principles. All respondents found the central theme in every vignette, supplemented with several other principles. Three key phrases appeared being interpreted differently than intended. These were discussed with the authors and rewritten in a more unambiguous formulation. The instrument was provided to the participants as a Word-document as well as a pen and paper version.

3.4 Procedure

All participants were given one hour to respond to the vignettes, which proved more than sufficient for everyone. The 12th grade class made the survey at the end of a regular physics lesson in February 2024, a few months before their final exams. As a token of appreciation, they received a small gift afterward. The first-year teacher education students answered on the very first day of their new academic year in September 2024 before any theory had been discussed. The final-year students made the test during the first class of the second semester in March 2024. These students then participated in a peer review intervision (Dutch: *intervisie*) course, a structured form of collaborative reflection among professionals that consists of a weekly one-hour peer review session focused on pedagogical reasoning in their work-placement. Each week, a student brought a 5-10 minutes personal video recording with a chosen *pedagogical content* dilemma linked to science learning (i.e., no classroom management issues) that they experienced in the preceding week. The video was discussed collectively, with the first author (teacher educator) as a moderator posing in-depth questions, if necessary, to keep the focus on learning. After 8 weeks, the students retook the test, with everyone receiving the alternate version from the one they had completed at the start.

3.5 Analysis

The responses on paper were digitised. 17 responses were blank, leaving 325 responses that were loaded in QDA Miner®-software and were given an anony-

mous case code to prevent the coder from being biased. Each case was labelled with three variables: the participant group, A or B set, and the vignette number. The cases were initially close-coded (Babbie, 2013) using the APA top 20 Principles and three supplemented codes for misconceptions, 'I don't know', and formulations that indicated that students were insecure about their answering. This resulted in 669 assigned codes overall. However, during coding it became clear that there was much more detail in the answering than just the APA top 20 principles. Although the principles have in their description more details, many answers could not be coded unambiguously as some answers like for example 'let them work together' could be traced back to different principles. Also new insights became clear, e.g. that answers were sometimes completely focussed on teacher action, rather than on the learning process. Therefore, it was decided to completely recode in a more open inductive approach. During this process 17 additional codes were created, for instance for 'working together'. This resulted in 884 coded phrases.

In a third round an axial approach was conducted where all phrases belonging to one code were reconsidered and compared with each other, especially codes that might overlap, for example 'feedback' and 'formative practices'. This round resulted in recoding of about 10% of the phrases and a few codes were merged. For the final code book see Appendix G.

For inter-rater reliability, the first author made a selection of answers over different groups and vignettes. Coding by the other authors resulted in a Krippendorf α of 0.73 which is considered low bound agreement (Marzi et al., 2024).

After the coding process, descriptive statistics for the codes were transferred from QDA Miner to Excel and were subjected to semi-quantitative analysis, revealing inherent quantitative properties and strengthening the evidential basis of the findings (Maxwell, 2013, p. 128). Outlying frequency of codes and remarkable numeral differences across the groups supplied new perspectives of meaning. The responses labelled with these codes were studied in detail on the words used. Number of words and PoLs used were also counted and although this study is not quantitative, trends in the counts were investigated.

Finally, the detailed results of all 6 vignettes were again brought together to answer the three research questions.

4. RESULTS

In this section some overall descriptives will be reported, followed by an analysis on the three research questions.

4.1 Overall descriptives

Although this study is not quantitative in nature, a counting of the number of words participants wrote and number of PoLs we coded in the answers provided insightful trends. Table 1 shows an overview for the 6 vignettes.

Table 1 Average number of words written and codes assigned per vignette (N=49)

Vignette #/main topic	**Averages per vignette: # words written / # of PoLs coded**			
	Starters-NO N=22	Starters-YES N=19	Finals-before N=8	Finals-after N=8
#1 Transfer, abstract formula to context	69/2,0	98/2,0	306/5,6	256/5,3
#2 Students' belief of self-efficacy	56/1,8	84/2,1	220/4,9	192/4,6
#3 real-world examples in vocational	42/2,0	84/2,2	189/3,9	165/3,8
#4 formative teaching	37/1,5	77/1,9	168/3,8	172/3,9
#5 differentiation in lab work	18/1,0	69/1,8	189/4.0	188/4.0
#6 affective principles in class	53/2.0	83/1.8	258/4.5	193/4.3

These numbers show some clear trends. First, the Starters-YES group provided longer, more elaborate answers than Starters-NO, and although the number of detected PoLs is comparable, final year students used twice as many PoLs in their answers. Second, final-year students provided far longer answers than the starters groups, and also applied more than twice as many PoLs as first-year starters-YES. Third, hardly any change was observed in final-year students' answers before and after 8 weeks of intensive intervision. The number of words written and detected PoLs are related: shorter answers can comprise less codes. Fourth, the average number of words in participants' answers decreased from vignette 1 to 6 for all groups. This may be due to a decrease in focus and/or motivation during the one hour answering session, although it may also have been that later vignettes were less conducive to long answers (order was the same for all participants). Strikingly, quite a few very short 'no idea'-answers were given to vignettes 3, 4 and 5. However, a "revival" was observed in the last vignette that described bad student behaviour, which apparently inspired participants more than other vignettes, possibly because more experiences, knowledge and principles are activated.

In the answers, two more general observations were made in language. Starters used fewer conditional formulations like 'it could be that…', 'maybe' or 'probably' (in 8% of their answers) than final-year students (in 60% of their answers). That might suggest that the final-year students have learned that many situations in teaching cannot be ascribed to a single clear cause or rationale; they do not provide 'the answer' but rather reason from a broader perspective. Starters are more likely to provide *the* reason, which might be a description of a pedagogical p-prim that they harbor.

This is sustained by the second observation that starters responded 32 times with 'no idea' or 'I don't know' or a blank answer, whereas just one final-year student one time did not provide an answer, writing "I find it difficult to properly discern this situation". The starters do not supply a first idea or a little line of reasoning but they "don't know the answer".

4.2 Textual Analysis of the Vignettes

The full text of all vignettes, together with the complete results concerning language use and wording for each vignette, is too extensive to be included in this chapter. Accordingly, an example of Vignette 1 is provided in Appendix F. The overall findings for each research question are summarised below.

RQ1: What ideas about principles of learning do young adults who choose to enrol in a teacher training programme, and those who do not, bring with them?

In the responses of the starters, basic notions regarding the role of principles of learning (PoLs) could generally be identified; however, these were predominantly implicit. Within this implicit mode of responding, the starters often provided surprisingly more insightful answers. For instance, although the term *prior knowledge* was rarely used explicitly, many responses referred to the importance of employing examples and asking questions. Notably, only starter-YES mentioned that teachers should invite *pupils* to provide examples themselves, thereby requiring them to *recall* and *reflect*. This suggests an elementary understanding of the distinction between *learning* and *understanding*, as well as of *transfer*. A similar pattern was evident in references to differentiation, which was articulated as providing 'more or different challenges'.

Clear differences were also apparent in the specific wording used. For example, one starter-YES questioned whether 'the problem is indeed a lack of understanding', whereas a starter-NO stated that 'the student has no comprehension; he still has to develop that'.

Across both groups, all starters generally reasoned from their recent personal experiences of schooling, with an emphasis on teacher behaviour. Many responses began with prescriptive statements, such as 'the teacher should', followed by suggestions including explaining more, investing greater effort, helping the student to study, offering more sincere personal attention, explaining the future relevance of the material, or preparing the class more effectively for tests. Their own recent position as a pupil often seemed their starting point.

Although such responses may also be rooted in implicit beliefs, this was more evident among starters-YES. They appeared to hold certain principles that were largely absent among starters-NO, particularly within the affective domain. Examples include the beliefs that personal perceptions and beliefs about ability influence cognitive learning, and that motivation and cognitive outcomes are interdependent. Overall, starters-YES more frequently framed their responses in terms of motivation and classroom and learning processes, whereas starters-NO tended to focus on goals, rewards and work. When motivation was mentioned by starters-NO, it was often in a normative sense (e.g. 'he is not motivated to do physics'), in contrast to the more exploratory framing used by starters-YES (e.g. 'try to find out what can motivate them for the future').

Although this varied across vignettes, starters-NO more frequently responded with 'I do not know' than starters-YES. Despite having sufficient time to complete the task, they more often appeared unable to relate the situation to prior experiences or insights.

All starters held strong assumptions about pupils in the different educational tracks in the Netherlands. They consistently asserted that pupils in lower-level tracks 'struggle more, have less insight and learn by doing' compared with those in the pre-university track. These assumptions were reflected in their pedagogical recommendations: teach for understanding in higher-level tracks, and teach for facts and memorisation in lower-level tracks.

In the vignette depicting a teacher experiencing difficulties with a class, where affective principles of learning were central, all starters suggested that the teacher should focus on issues such as improving the classroom atmosphere, contacting parents, using rewards and punishments, and altering classroom arrangements or group composition. Surprisingly, nine different starters referred to a more pedagogical approach, for example by suggesting that lessons should be made more challenging so that pupils would have less opportunity to misbehave, or that lessons should be designed in a more positive manner to prevent pupils from being distracted by events outside the classroom.

When it came to misconceptions, we coded all answers that were strange or wrong as misconceptions. Analysis in more detail revealed that the majority had to do with flawed understanding of the terminology and/or bad formulations, e.g. 'They understand the concepts but they don't understand how it works' or 'he is more a mathematician than an abstract thinker'. Only two real misconceptions, in the sense of wrong connections or conceptions that might influence students' future teaching, were found. One, appearing in 6 different formulations by mostly starters-YES, was that a teacher should use *less* examples to speed up understanding: "get it out of those contexts and teach chemistry!" or "don't give exercises with stories, just the pure [chemistry] theory" or "use less contexts so that the pupils have to think". The other misconception was the answer to the formative teaching: 'to measure all those [extra test] results costs a lot of time, better use that to give better lessons' (starter-NO) where formative evaluation apparently is disconnected from its objective of improving the teaching process.

And occasionally, a particularly striking response emerged that reflected a broader conception of learning. One starter-YES, for instance, wrote: "I would change the way of teaching by incorporating more practical work that pupils can do themselves, allowing them to investigate independently. This makes it more interesting: you do more yourself, you have to think more independently, and therefore you study in greater depth."

RQ2: How do students' primary ideas about principles of learning evolve during a teacher education pathway?

Here, we compare the responses of the final-year students prior to their participation in the intervision sessions with the starters discussed above.

The most salient difference is that final-year students referred, overall, to thirteen principles of learning (PoLs), with an average of four PoLs per response—approximately double the number identified in the starters' answers. They tended to perceive the problems presented in the vignettes as more complex and multifaceted, indicating a much broader transfer of PoLs across contexts. This suggests that previously discrete pieces of knowledge had become more integrated. Moreover, final-year students frequently drew on PoLs that extended beyond the primary focus of the vignette. For example, in the cognitively oriented Vignette 1, they referred to the stimulation of inquiry-based learning, described networked learning processes, discussed the role of intrinsic versus extrinsic motivation, highlighted emotional well-being, and proposed corresponding adaptations to teaching activities. One student consistently analysed

each vignette from cognitive, affective and social perspectives. Such breadth of understanding may account for the considerably more elaborate responses produced by this group.

In addition, final-year students tended to express their evaluations in more reflective and abstract terms. Whereas starters wrote statements such as 'this approach is completely wrong', final-year students wrote, for example, 'I do not understand her approach'. This shift indicates the difference between *the* answer and a more questioning attitude, characterised by an ability to generalise across situations and to relate a teacher's actions to underlying principles and theory.

Alongside the increased use of PoLs, final-year students also employed appropriate professional terminology. Terms such as *prior knowledge*, *self-belief*, *fixed mindset*, *constructive alignment*, *intrinsic and extrinsic motivation*, *formative work*, and the *zone of proximal development* were frequently observed.

Final-year students predominantly described what pupils *need* in order to learn, including feedback, structure, examples, self-belief, and opportunities for success in the test. When they referred to the teacher, this was typically framed in terms of what the teacher should do differently because of what did not work, rather than in terms of what the teacher was doing wrong. This, again, reflects a student-centred orientation.

With regard to teaching approaches, final-year students demonstrated a stronger and more explicit focus on the generation of feedback. For example, one student suggested to 'select an exercise [...] to *discuss* with the students'. Six final-year students explicitly stated that teachers should engage in formative practices to identify where students' thinking is going wrong, again pointing to a student-centred perspective in which learning is central. They also recommended the use of active learning strategies, as illustrated by the remark: 'It is especially beneficial for students that the practical is not flawless, so that they can see what they still need to work on.'

Another notable feature of the final-year students' responses was the use of meta-communication. They wrote, for instance, that the teacher should 'make clear what he/she is testing for'. Three students explicitly stated that teachers should (meta-) communicate the objectives of an assignment, both in pedagogical terms and in relation to content.

In the final vignette, which concerned a teacher experiencing difficulties with a class, it became evident that final-year students strongly identified with the situation(s). Several responses included personal experiences and, at times, emotionally charged reactions, such as 'How could he do that?', 'I can relate to this so much', or 'doing a lab session in a class with such an unsafe atmosphere is a complete no-go for me'. Almost all responses foregrounded *safety*, with statements such as 'Unsafe classroom atmosphere!!!' or 'There is a serious lack of a safe learning environment in this class'. This again reflects an initial focus on pupils rather than on the teacher or the instructional approach. The solutions proposed consistently involved suspending chemistry teaching in order to address the situation through a firm and explicit conversation about rules and expectations, rather than, for example, sending pupils to the team manager or altering classroom arrangements.

RQ3: Does a focussed intervention in the final phase of the teacher education programme change final year students' ideas about principles of learning?

Analysing the answers of the final year students after the 8 weeks intervision sessions and comparing them with the answers before showed very little differences, if any. In two vignettes, PoLs appeared to be more coherently connected than before. This might suggest that intervision led to existing knowledge becoming more densely connected, or to richer and more consequent pedagogical reasoning. However, the more coherent connection, can more plausibly be explained by the fact that students practised reasoning during the sessions; in other words, their reasoning skills were better trained. We did not find any indication that their knowledge and beliefs had changed in terms of more in-depth answers.

5. DISCUSSION

The central research question guiding this study was: *How does pre-service chemistry teachers' knowledge of Principles of Learning (PoLs) develop over time?* Overall, analysis of the vignettes leads to three overarching conclusions. First, starters-YES consistently provide richer and more elaborated responses than starters-NO, suggesting that those who actively choose a teaching pathway may already be more aware of classroom processes based on their own school experiences. Second, a clear distinction emerges between starters and final-year students: the latter demonstrate a shift from fragmented, teacher-centred thinking towards more integrated, student-focused pedagogical reasoning. Third, the eight-week focused intervision programme does not appear to result

in a substantive change in the knowledge of final-year students; however, the data suggest that intervision may have contributed to slightly more coherent pedagogical reasoning.

5.1 Starters

With regard to RQ1, the differences between starters-YES and starters-NO are striking. Although all starters are in a comparable position—having completed secondary education with a similar STEM profile and presumably drawing primarily on their own recent educational experiences—substantial differences were observed in the length, richness, and conceptual diversity of their responses. Starters-YES generally use a broader vocabulary and provide descriptions that reflect a more comprehensive perspective on classroom processes.

Moreover, starters-YES more frequently refer to principles of learning that are not directly observable in everyday classroom practice, such as the influence of personal perception and beliefs about ability on cognitive learning and the role of prior knowledge. It is reasonable to assume that initial conditions were broadly comparable for participants from both groups. This study therefore sheds light on factors that may influence the development of students' knowledge and beliefs. Given that participants had not received formal instruction in this domain, these ideas must have emerged through informal, inductive learning processes. Following Korthagen, such ideas can be characterised as being at the level of *gestalts*. The implicit nature of the starters' responses suggests early, largely unconscious connections between observations, with answers being generated by linking new situations to prior experiences without explicit reference to PoLs—what Salomon and Perkins (1989) describe as *low-road transfer*. From the perspective of Conceptual Change Theory (CCT), these may be interpreted as *pedagogical p-prims*, which are either isolated from other contexts or loosely connected within small, unconscious experiential frameworks.

5.2 Consciousness and intention

Nevertheless, some starters demonstrated a deeper level of insight, suggesting the initial development of schemas and, consequently, more conscious thinking. This appears particularly plausible for starters-YES, who may have become aware of their interest in and curiosity about the teaching profession at some point during their school careers. These students may have constructed more abstract concepts relating to educational contexts beyond those they directly observed, which could explain their use of abstract terms such as *prior knowledge* and *self-belief*. In contrast, starters-NO were more frequently unable to provide a substantive response to the vignette problems. Their answers tended to be brief and superficial, often failing to address underlying causes or

mechanisms when compared with those of starters-YES and therefore can be designated as real pedagogical p-prims.

Such conscious reflection and reasoning are central to both theoretical perspectives employed in this study. Within CCT, intentional conceptual change—defined as metacognitive control over one's own learning—is regarded as a key driver of change (Sinatra & Pintrich, 2003) and it encompasses affective dimensions of learning, including self-efficacy, motivation, emotions, and control beliefs (Pintrich et al., 1993; Sinatra & Pintrich, 2003). These are precisely the factors that starters-YES may have experienced, for example positive emotions, growing interest, increased motivation, and a developing sense of competence leading to more conscious observation. This suggests not only a different perception of teachers' actions but also an awareness of their own learning processes and those of their peers, and possibly an early engagement in pedagogical reasoning. That might also explain that starters-YES more frequently propose creative pedagogical strategies, which are rarely mentioned by starters-NO.

Even with respect to motivation, subtle differences can be observed. While motivation is a commonly used term in everyday language and is often invoked in educational contexts as a straightforward explanation for success or failure (e.g. lack of interest or engagement), recognising motivation as a complex construct that interacts with cognitive learning processes reflects a more sophisticated understanding. Although it may seem obvious that learning cannot occur without motivation, appreciating its role within the dynamic interaction between teacher practices and classroom processes represents a deeper level of insight. Some responses from starters-YES indeed demonstrate an emerging awareness of these relationships.

5.3 Misconceptions

This line of reasoning may also explain why the few misconceptions identified in the data occur more frequently among starters-YES than among starters-NO. Misconceptions typically arise when incorrect connections within concepts are formed, often during the early stages of concept development, and require a degree of explicit reasoning. (It remains an open question whether misconceptions can arise at the level of an initial gestalt or p-prim.) Participants must have engaged—albeit briefly and perhaps unconsciously—in intentional sense-making processes, during which flawed connections may have been established. This finding reinforces the importance of eliciting and addressing such beliefs at an early stage of teacher education.

The results further indicate that starters-YES more frequently frame their responses around individual students and their learning, whereas starters-NO tend to focus on teaching actions and what teachers should do differently. Starters-YES thus appear to have a greater capacity to adopt the learner's perspective and consider students' needs. From a CCT perspective, this requires conscious, intentional reflection from a metacognitive standpoint, suggesting the emergence of conceptual or theoretical understanding. However, this interpretation cannot be conclusively established on the basis of the present study, and further research would be required to explore the origins of this difference.

In line with this pattern, starters-NO more often sought answers in changing "what the teacher should do", focusing on e.g. "teach them problem solving skills" or "better teaching", without further elaboration. Their reasoning tended to be more one-dimensional—equating good teaching with clear explanation and skill acquisition—and more outcome-oriented, focusing on task completion and test success. By contrast, starters-YES more frequently articulated responses in terms of student understanding. Whether the former position should be interpreted as a misconception or as an underdeveloped *pedagogical p-prim* remains open to debate. From a conceptual change perspective, development in this area is likely to occur primarily through the enrichment of existing ideas during teacher education, rather than through the complete replacement of existing concepts or beliefs. Nevertheless, an open question remains as to whether a shift towards prioritising pupils' needs over instructional delivery arises solely from conceptual enrichment and experience, or whether more stable personal characteristics also play a role.

5.4 Final-year students

Considering RQ2, about differences between starters and final-year students, the results were somewhat predictable, but the qualitative approach of this study allows for some more explicit description.

First, we observe a significant enrichment of *language*, in the number of words, in the nuances and details. That is in accordance with conceptual change as a result of highly deliberate practice resulting in deeper enrichment of the concepts and schemas for longer time. Moreover, the use of more and correct subject-specific jargon suggests more general abstract principles with new words that have taken root. The principles that are less or not visible to beginners and can only be applied once they have been learned, such as the role of prior knowledge, formative practice and student-centred teaching, seem to be bedrock in many of the fourth-year students' responses. Using these PoLs explicitly within

the answers means that the principles have become indeed general overarching attitudes that demonstrate high-road transfer.

Second, more importantly, there is the use of multiple learning principles per response, indicating that participants have mastered them and, even more so, are able to connect them. Following Korthagen's model, they have integrated multiple schemas into initial, larger wholes allowing transfer to happen via general principles (or even theories), what Salomon and Perkins (1989) depict as high-road transfer.

Third, we see that *learning* has been internalised by all respondents. The paradigm "it doesn't matter what you do, but what your students have learned" apparently has become fundamental to them. 'The role of goals and challenge as motivators that can positively influence cognitive learning' here seems almost self-evident to them. No misconceptions about learning were observed. Such important changes show that not only many daily situations can be connected to PoLs but that a far more abstract idea of teaching and learning has emerged in final-year students which may be so strong and rich and basic that it overarches principles and might be defined as a pedagogical view or even a belief.

5.5 The influence of intervision

Responses of the final-year students were not substantially influenced by the eight-week intervision sessions. Intervision consists of in-depth discussions in which the role of the moderator is minimal or absent. In the present study, this meant that no explicit explanation of PoLs was provided; instead, occasional prompts were introduced, such as 'Can you draw on prior knowledge here?'. Such prompts stimulated silent reflection and further discussion and, hence, may be regarded as practice in more skilful pedagogical reasoning. Although the extent and quality of students' reasoning during their responses to the vignettes cannot be measured, it may be assumed that the recent intervision experience enabled them to perform to the best of their ability at that moment.

The measurements conducted in this study did not reveal an effect on students' overall *knowledge formation.* This does not imply that intervision lacks value. First, it may be possible that students already operated at close to their maximum level of pedagogical reasoning, so that the intervision did not add much. Second, the broad measurement instrument employed in this study may not have been sensitive to subtle conceptual change of e.g. one particular PoL that might have occurred indeed. Such differences would perhaps have become apparent in more in-depth case studies that focus on one or two specific learning principles.

5.6 Schema and theory

Following Korthagen, students can be understood as actively engaging in reasoning processes and as forming coherent schemas and, potentially, theories. The distinction between schema and theory is not sharply defined, and the completeness and accuracy of the theories that may be formed fall beyond the scope of the present study. Korthagen and Kessels (1999) suggest that, at the level of theory, individuals are able to articulate and explain the theory explicitly. It would therefore be of interest to investigate whether students are able to explain learning principles at a more abstract level. Based on our experience with them, we are quite certain that participants in this study are able to explain fundamental principles of learning such as those in the APA Top 20 (APA, 2015), final-year students probably more than starters. This may also apply to other, general principles addressed during their training, such as the neural network memory. However, it would be interesting to examine whether students are also able to articulate in abstract terms principles they acquired primarily through exposure in school placements, such as meta-communication, indicating internalisation at the level of schema or theory.

The findings of this study indicate that no additional principles of learning (other than the ones we prompted for in the vignettes) emerged. The enrichment and intentional knowledge formation that occurred over the course of the programme may have reached a level sufficient for understanding and managing classroom practice. Transfer to other situations appears to have become second nature to the participants. Further development towards theory level, however, requires abstraction, whereby theory itself becomes the object of reflection rather than the concrete context (Korthagen, 2010). This would require a growing interest in theoretical explanation beyond immediate classroom concerns, for example through the study of educational sciences. Nevertheless, the boundary between practice-oriented expertise and explicit theoretical articulation remains fluid, and many highly effective teachers may be deeply engaged with theory without being able to express it explicitly.

5.7 Implicit and explicit responses

An important question concerns whether the responses obtained reflect the explicit and implicit knowledge held by the participants. It is entirely possible that respondents did not draw upon *all* the principles of learning (PoLs) they were familiar with when formulating their answers. The shorter responses provided by the starters-NO do not warrant the conclusion that these participants had nothing further to contribute or lacked the language to express their reasoning. Had the participants been interviewed and prompted to reflect on each principle individually, they might have recognised additional principles, poten-

tially leading to different outcomes. This becomes apparent when considering several responses we initially coded as misconceptions. Statements such as "a practical should be seen as an extra, not as a reward for being restless" or "motivation is always a major issue if students are unwilling to work for it" may indicate a misunderstanding of pedagogical concepts but it is equally plausible that these respondents possessed an adequate understanding but were unable to articulate it precisely. In vignette 5, final-year students explicitly referred to feedback and meta-communication. It is conceivable that, if beginner students had been asked directly about the role of formative assessment as a feedback mechanism, they too might have been able to provide a correct explanation.

On theoretical grounds, we conclude that final-year students are better able to articulate such concepts explicitly because their knowledge structures and beliefs have developed to a point at which they reason in these terms and approach the teaching–learning process from a more abstract, principle-based perspective. This, again, does not justify the conclusion that earlier-stage students do not hold similar conceptions at an implicit level.

A further source of uncertainty regarding implicit and explicit responses concerns the reasoning processes participants employed during the assessment. Our intention was for respondents to record what came to mind first; however, it is possible that final-year students tailored their responses to what they believed was expected of them. This introduces uncertainty regarding the extent to which the written responses accurately reflect their authentic pedagogical reasoning and alignment with classroom practice.

5.8 Chemistry teaching

With regard to subject-specific pedagogy in chemistry, two additional observations merit attention. In the vignette describing a student who struggles with chemistry but excels in physics and mathematics, many participants attributed this difficulty to the fact that reasoning with formulas is relatively straightforward, whereas thinking in terms of particles is more challenging. This suggests that respondents recognise a fundamental epistemic difference between physics and chemistry and are able to relate this difference to conceptual understanding. Starters did not connect this insight to instruction whereas final-year students appear capable to provide adequate teaching approaches to work with these distinct cognitive processes. They clearly demonstrated an understanding of the relationship between the concrete world and abstract representations such as particles and formulas.

Another striking difference concerns the use of examples. Starter-YES participants more frequently suggested providing additional examples, while some starter-NO participants often explicitly said not to. It remains unclear whether the starter-YES group fully understands the fundamental role of contextualisation in the learning process or whether they are merely drawing on their own experiences as learners, recalling that examples were helpful. Final-year students, by contrast, explicitly referred to the function of examples in supporting transfer and the organisation of knowledge.

5.9 Implications for teacher education

These findings give rise to two implications for teacher education. First, as emphasised repeatedly in this paper and supported by a substantial body of literature, the beliefs, ideas, and principles that prospective teachers bring with them at the outset of teacher education programmes should be made explicit, rendered visible, and critically discussed before new theoretical knowledge is introduced (e.g. Korthagen & Kessels, 1999; Verloop et al., 2001; Markauskaite & Goodyear, 2014; Wilcox-Herzog et al., 2015; Shahzad et al., 2017; Kaya et al., 2021; Qiu et al., 2021). Existing pedagogical p-prims or early gestalts constitute powerful beliefs. The present study indicates that, in most cases, these beliefs are not fundamentally incorrect but are underdeveloped and vulnerable to flawed further elaboration. Genuine misconceptions were identified only occasionally, but they do exist. As deeper and more sophisticated understandings of teaching and learning are developed, there is a risk that fragmentation occurs and misconceptions persist as parallel belief systems, continuing to influence pedagogical decision-making throughout teachers' professional careers.

We hypothesised that the findings of this study might challenge the recommendations put forward in the literature or prompt their reconsideration. The trend observed indicates a progression from fragmented, teacher-centred thinking towards integrated, student-focused, and theoretically sound pedagogical reasoning over the course of teacher education. This development appears to result from practical experiences during internships, subsequently integrated with theoretical reflection.

These results therefore support and enrich existing recommendations. We strongly advocate that teacher educators should be both capable of, and well experienced in, engaging students in explicit and conscious pedagogical reasoning, thereby reinforcing and shaping their professional effectiveness.

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CHAPTER 6

Summary, general conclusions, discussion and reflection

1. INTRODUCTION

The starting point of this thesis was my experience that teachers and teacher educators were often unable to explicitly articulate the most general principles of learning or articulate them in their teaching practice (Meij, 2018). Assuming that they are nevertheless competent teachers, my hypothesis was that they do in fact possess such principles, but at a more implicit or unconscious level. My curiosity concerned whether such implicit knowledge and beliefs could be measured and at which stages of teachers' careers they might emerge or disappear. This line of reasoning led to the overarching research question of this thesis:

What is the influence of teachers' explicit and implicit conceptual knowledge and beliefs about the principles of learning on their pedagogical reasoning?

This question was addressed through two sub-questions:

1. What explicit and implicit conceptual knowledge and beliefs about learning do in-service and pre-service teachers hold?
2. How are this knowledge and these beliefs manifested in teachers' pedagogical reasoning?

The literature provided several findings that served as anchor points for this research. It is widely accepted that teacher beliefs and knowledge are not sharply delineated constructs (Fives & Gregoire-Gil, 2015), and that teacher beliefs exert a substantial influence on the didactic decisions teachers make and, consequently, on the ways in which they design their teaching (e.g. Shulman, 1987; Zakaria & Ab Wahid, 2023; McAfee & Hoffman, 2021). With regard to conscious pedagogical reasoning, there is broad consensus, supported by a substantial body of research, that pedagogical reasoning lies at the very heart of the teaching profession; however, after several years of practice, many teachers tend to engage in less profound reasoning, which often reinforces their pre-existing beliefs (e.g. Zeichner & Tabachnik, 1981; Shulman 1986; Lloyd, 2019). Finally, in the field of implicit measurement, there is ongoing debate about the validity and reliability of such research methods (e.g. Forscher et al, 2019; Corneille & Hütter, 2020), although many researchers nevertheless encourage their use to elucidate teachers' beliefs (e.g. Jost, 2019).

2. SUMMARY OF THE MAIN FINDINGS

2.1 First study (Chapter 2)

The first qualitative study was designed to examine how learning theories and principles of learning are addressed within teacher education programmes in the Netherlands. We investigated what is taught, how it is taught, and, above all, why it is taught in that way. The latter question served to clarify the underlying vision and rationale for teaching learning theories to beginning teachers.

What is taught varies considerably across programmes, both for primary and secondary teacher education. Provision ranges from virtually no attention to learning theory to full courses with a dedicated examination. Content is largely dependent on personal choices or individual expertise. How learning theory is taught also varies widely. There is no consensus regarding a certain approach which may be related to the absence of textbooks that explicitly connect learning theory with classroom practice.

All participants were convinced that learning theory has a legitimate place in teacher education and that linking theory and practice constitutes the essence of such programmes. Consequently, they believed that teacher educators should make principles of learning explicitly visible in their own teaching, yet they doubted whether they themselves or their colleagues were capable of doing so. Participants also considered an inductive approach, starting with students' own concrete teaching practice, to be the most effective route. In practice, however, learning theories are often initially presented deductively, although a cautious shift can be observed from 'deductive instruction followed by application' towards more inductive approaches.

The most important finding of this study was that, through their reasoning, participants arrived at the conclusion that their ideals about effective teaching and learning were at odds with the realities of practice, and they openly questioned whether it is feasible for students to consistently link their actions to theory.

2.2 Second study (Chapter 3)

In the second quantitative study, we set out to examine both implicit and explicit beliefs. We developed an instrument comprising three components: a word association task to assess implicit beliefs, an explicit principle endorsement task to measure explicit beliefs, and a classroom statement task intended to capture both. The implicit measures indicated that most teachers' belief systems broadly align with the learning principles under investigation. No significant differences were observed between participant subgroups: novice teachers did

not demonstrate stronger recognition than experienced teachers, nor were differences found across subject domains. Only a weak correlation was identified between response time and age.

Overall, affective principles elicited stronger associations and higher levels of endorsement than cognitive principles. However, the study does not allow conclusions to be drawn regarding the origins of these beliefs—whether they were explicitly taught or whether they form part of a broader belief system extending beyond education and learning.

The principles most strongly recognised concerned the importance of practice and repetition, the use of examples, and the role of motivation. By contrast, the influence of prior knowledge on learning and the difficulty of conceptual change received the lowest scores. Notably, in responses to more concrete classroom scenarios, most principles obtained higher scores than in the explicit endorsement tasks, suggesting that participants recognise principles in contexts but are probably less able to express the principle as an abstract rule. Correlations between implicit and explicit measures were weak or absent. Although the principles were recognised, the study cannot determine the extent to which they are internalised, nor can it make claims about their influence on actual classroom practice.

2.3 Third Study (Chapter 4)

The third study reports the qualitative component of the same instrument developed for Study 2. Teachers were presented with two brief classroom vignettes: one focusing primarily on cognitive principles and the other on affective principles. Participants were again asked to respond rapidly to the question, "What do you think is going on here?". The open-ended responses were analysed qualitatively. As in the previous study, the most notable finding was the limited variation in the frequency with which different principles were invoked by different participant groups. Only the 'use of examples' and 'the role of emotions and motivation' showed statistically significant differences between student teachers, in-service teachers and teacher educators. Only a small proportion of participants across all groups did not refer to any principle, instead providing responses such as "they have forgotten" or prescriptive statements beginning with "The teacher should...", without any underlying principle visible. In addition to the targeted principles, a substantial number of responses fell outside the principles we focussed on; they could be grouped under memory processes, social classroom dynamics, and general considerations about learning.

Significant differences between groups were, however, observed in the language used by student teachers, in-service teachers, and teacher educators. Although a detailed analysis by learning principle lies beyond the scope of this summary, several general patterns can be noted. Students tended to describe principles more implicitly, with a gradual shift towards more explicit articulation among teachers and, in particular, teacher educators. Principles that were more "visible" in daily teaching (these achieved higher scores in the previous study) were associated here with relatively brief responses. For example, the principle that repetition and practice enhance learning was often expressed succinctly, such as "more practice is needed". The use of examples was the most frequently mentioned principle, and a clear progression in theoretical insight was evident across groups: students typically noted that examples are important or that teaching should connect to pupils' lived experiences, whereas teacher educators sometimes explicitly linked the use of context to understanding and transfer.

Responses to the vignette focusing on affective principles were generally shorter, multiple principles of learning were more often combined within a single response, and the wording of answers rarely included conditional formulations suggesting that these principles are easier recognised.

2.4 Fourth Study (Chapter 5)

In the fourth study we tried to shine a light on the origin and development of beliefs and prior knowledge. Last-year secondary school students, half of them pursuing a teaching career, the other half with absolutely no interest, were asked to elaborate on six daily chemistry classroom situations. The same task was performed by final-year pre-service teachers before and after 8 weeks intervision sessions.

Four observations lead to more general conclusions: first, first-year students heading for a teaching career consistently provide richer and more elaborated responses than their peers who do not, suggesting that those who actively choose a teaching pathway may already be more aware of classroom processes based on their own school experiences. Second, a clear distinction emerges between starters and final-year students: the latter demonstrate a shift from fragmented, teacher-centred thinking towards more integrated, student-focused pedagogical reasoning. Third, the eight-week focused intervision programme does not appear to result in a substantive change in the knowledge of final-year students; however, the data suggest that intervision may have contributed to slightly more coherent pedagogical reasoning. Fourth: teacher educators in study 1 considered the use of learning theories and principles essential for

teacher education programmes but were doubtful about the feasibility of students being able to always explicitly underpin their classroom experiences. This study shows that their classroom considerations, even in the very beginning, can be traced back to principles of teaching and learning. More experience and professional jargon lead to an increased ability to explicitly connect practice to concrete principles of learning.

3. OVERALL CONCLUSIONS AND DISCUSSION

The central research question of this thesis was: *What is the influence of teachers' explicit and implicit conceptual knowledge and beliefs about the principles of learning on their pedagogical reasoning?* This question was operationalised through the sub-questions what knowledge and beliefs teachers hold and how these are manifested in pedagogical reasoning. The initial conclusions relating to these questions are first synthesised and subsequently discussed from the perspective of prior knowledge, transfer, motivation and misconceptions.

3.1 RQ1, What explicit and implicit conceptual knowledge and beliefs about learning do in-service and pre-service teachers hold?

Studies 2, 3, and 4 demonstrate that teachers possess both implicit and explicit knowledge and beliefs that can be traced back to the principles of learning we investigated. All three instruments used in these studies showed that general principles of learning were recognised and applied, although some principles were more salient than others (as elaborated below). Studies 2 and 3 further indicate that only a relatively small proportion of participants failed to recognise any principle of learning and study 2 indicated that real misconceptions appear rarely, except for the principle concerning conceptual change. Therefore, the key finding in both quantitative and qualitative results is the limited divergence in the frequency with which teachers in different stages of their careers recognised and applied various principles of learning, although the more detailed study of student teachers (chapter 5) did reveal a substantial difference between starting- and final-year students.

Regarding the explicit measurement, the explicit endorsement test, approximately 85% of all participants explicitly endorsed learning principles and were able to recognise them in classroom situations, with affective principles being acknowledged slightly more often than cognitive ones and only conceptual change scoring significantly lower.

However, the qualitative studies reveal that significant differences emerged in the extent to which these principles were articulated: teacher educators and final-year student teachers were more capable of expressing their knowledge and beliefs in greater detail and with more accurate professional terminology than novice participants who had not yet received formal training.

With regard to (more) implicit knowledge and beliefs, Studies 2, 3, and 4 yielded four key insights. First, in the fully indirect measurement, no distinctions were observed between beginning and experienced teachers; overall, more than 90% demonstrated associations with learning-related words, with affective principles again being more strongly represented than cognitive ones. Second, responses in the context-rich qualitative studies revealed that first-year student teachers implicitly hold principles of learning that guide their pedagogical reasoning. Third, particularly within the affective domain, it became evident that multiple principles were often activated simultaneously within a single situation. This suggests that these principles form part of a broader belief system. However, isolating and measuring such principles within belief systems is a complex matter. The emergence of such initially implicit ideas, integrated into existing knowledge or belief structures without explicit awareness, aligns with general theories of knowledge development (Wilcox-Herzog et al., 2015). Fourth, the principle that *motivation and interest influence learning* here seems to be illustrated, as the development of early ideas about teaching and learning appears to be influenced by the aspiration to become a teacher (and vice versa).

Taken together, these conclusions show that, even though a certain level of knowledge is necessary to appropriately explain classroom processes, certain undeveloped principles of learning are present in all teachers (and even non-teachers) and may be understood as prior-knowledge or pedagogical p-prims (Kali et al., 2011). The notion that such early ideas gradually develop into more complex concepts as prior ideas are enriched through experience, aligns with both Korthagen's three-level model (Korthagen, 2010) as well as conceptual change theory (Vosniadou, 2013).

3.2 RQ2, How is knowledge and beliefs of learning manifested in teachers' pedagogical reasoning?

In the majority of responses in studies 2, 3 and 4, both rapid decision-making and more deliberate reasoning could be traced to underlying learning principles, whether implicit or explicit. However, these studies do not consistently clarify or distinguish whether such principles function as *knowledge of* or *knowledge in* (e.g. Cochran-Smith & Lytle, 1999), a belief (e.g. Fives et al., 2015), a pedagogical p-prim (Kali et al., 2011), or a rule of thumb (Bakshi, 2023). Also, when knowledge

or beliefs remain implicit, this does not necessarily guarantee that a fully developed *principle* is being applied, as principles operate at a more abstract level that enables transfer across contexts. In these studies it was not explicitly examined whether teachers would apply the same principles in comparable situations. By contrast, when reasoning became more explicit and principles were more firmly established, as observed among final-year students and teacher educators, the connection between knowledge, beliefs, and pedagogical reasoning was more explicit and the conclusion more robust. Nonetheless, study 4 shows that secondary education pupils already develop initial ideas and beliefs about teaching and learning through informal learning experiences. Aspirations to pursue a teaching career appear to influence the founding of such learning concepts and therewith probably inspire and encourage their subsequent learning trajectories.

Following the research question, we considered the results of all four studies on teacher education and identified the implications it would bring. As was shown in Study 1, teacher educators regarded learning theories and principles as essential to teacher education programmes. However, they remained doubtful about the most effective approach to integrating them and uncertain about the feasibility of expecting students to consistently ground their classroom experiences in explicit theoretical underpinnings. These studies show that students' classroom considerations can be linked to principles of teaching and learning from the very outset. With growing experience and familiarity with professional terminology, they become increasingly able to connect practice to specific *principles* of learning. This has several significant implications for teacher education that are discussed in the last section of this chapter.

3.3 Principles of learning

Beyond the general conclusions presented above, the studies yielded insights into the use of specific learning principles, either alone or in combination. As the *APA Top 20 Principles of Teaching and Learning* (APA, 2015) served as a consistent point of reference across all studies, it is possible to draw more overarching conclusions regarding the recognition and application of specific principles.

3.3.1 Prior Knowledge affects the Learning Process

This principle was examined, analysed, and reported across all four studies. Three main aspects emerged.

First, in the quantitative studies employing concrete prompts to which participants were required to respond or make associations, high levels of recognition and application were observed across all participant groups. In contrast, the

qualitative studies revealed a clear distinction between implicit and explicit responses in different groups. Whereas novice teachers tended to refer to prior knowledge implicitly, teacher educators explicitly named and discussed the concept of 'prior knowledge'. This pattern suggests that the influence of prior knowledge on learning cannot be succinctly verbalized until it is explicitly taught and formally learned, while the functional connection between existing knowledge and learning processes appears to be established at a much earlier stage, probably in a more implicit way.

Secondly, prior knowledge functions as an overarching construct that has been further differentiated in theoretical models such as those of Korthagen and the CCT framework, which distinguish more specific components, including knowledge, beliefs, gestalts, p-prims, or theories. The studies reported in this thesis were able to distinguish data in these separate components only to a limited extent. Nevertheless, some differences seemed discernible: implicit descriptions seem to be grounded primarily in gestalts or early beliefs, whereas responses as supplied by final-year students referring to multiple learning principles are more indicative of emerging theories (Korthagen, 2010).

Thirdly, if teachers arrive at the theory level it implies that they not only recognise prior knowledge as the starting point for instruction, but also understand that (a) prior knowledge is rooted in concrete experiences, rendering the use of pupils' examples an essential instructional strategy; (b) prior knowledge may be flawed, potentially leading to learning difficulties or the development of parallel concepts. And if teachers possess knowledge of conceptual change, they might even understand that (c) the modification of such flawed knowledge is a time-consuming gradual process requiring repeated exposure and iterative engagement. These insights, taken together, suggest that teachers who hold a more developed understanding of learning also (d) adopt a pedagogical vision in which dialogue takes precedence over explanation and formative approaches are preferred to the correction of incorrect answers. Such rich interconnections between learning principles were observed only occasionaly in the responses of final-year students in study 4, even though the principle that existing knowledge and misconceptions are resistant to change emerged only rarely. This finding aligns with the result that this principle was a negative outlier when it was explicitly examined in the quantitative study.

3.3.2 Learning is based on context, transfer needs to be facilitated.

Transfer in education is defined as the ability to extend what has been learned in one context to different new contexts (Bransford et al., 2000)[3]. Both earlier and contemporary educational theorists have posited that transfer represents the ultimate purpose of education, insofar as it enables learners to connect newly learned knowledge from education with their existing lifeworld. That facilitates an expanded, deeper and more coherent understanding of the world and their lives (e.g. Haskell, 2000, p.xiii). From the perspective of the cognitive learning process, transfer can occur at all stages of learning, even in the initial phase as all learning involves transfer from prior knowledge (Haskell, 2000, p.24). Because learning invariably begins from prior knowledge, such knowledge itself constitutes the context from which transfer occurs. Accordingly, understanding learners' prior knowledge and understanding the specific contexts in which that knowledge has been developed represent two sides of the same coin. The aim of teaching, then, would be to bridge the gap between learners' prior knowledge and new, more abstract concepts enriching understanding with increasingly diverse contexts in order to deepen and widen the overall conceptual framework.

While a small number of students demonstrated understanding of the existence and role of transfer, for most participants prior knowledge was primarily associated with contextualised experiences. Across all studies, the use of examples was mentioned most frequently. How examples were discussed proved informative. First-year students generally stated that the use of examples is important, whereas final-year students more consistently framed examples in relation to the elicitation of prior knowledge, the goal of broader conceptual understanding, and the importance of maintaining pupils' engagement in active thinking. In-service teachers showed both types of answering. Teacher educators sometimes explicitly referred to *transfer*, although not necessarily with greater explanatory depth than that observed in the other groups. The terms abstract or concrete were not observed.

Within the intended meaning of this APA Top-20 principle, *examples* refer more broadly to the concrete experiences that learners already possess. Student teachers indeed articulated this broader idea as "connecting to children's experiential world" (Dutch: *aansluiten bij de belevingswereld van de leerlingen*), which may be understood as connecting to learners' conceptual ecology (Strike & Posner, 1992). Viewed in this way, "giving examples" shifts towards the prac-

3 In both our everyday experience and the participants' responses in these studies we repeatedly observed that transfer is misinterpreted as 'the transmission of knowledge from teacher to student', which does not reflect its intended meaning. Such a limited understanding of the role of transfer in learning might lead to the traditional instructional sequence of introducing new theoretical content followed by provision of an example.

tice of engaging with learners' prior knowledge. This shift foregrounds the challenges that arise when teacher provided examples fail to connect meaningfully with students' existing conceptions.

But exactly this problem, the fact that an example fails to connect with prior knowledge (or just newly taught theory) *is* a cognitive conflict that induces thinking and may lead to conceptual change. The findings of these studies suggest that students demonstrate some awareness of this deeper interpretation of examples. At the same time more experienced teachers and teacher educators noticeably did not. That suggests that, either, it was never taught or learned or that is *washed-out* over the course of professional practice (Mellor, 2021; Zeichner & Tabachnik, 1981) and a teacher returns to intuitive reasoning based on beliefs from personal experiences (Gleeson & Davison, 2016), in this case: 'after explaining the theory I illustrate with an example' as they may have experienced themselves as a learner (Oleson & Hora, 2014; Shahzad et al., 2017; Zakaria & Ab. Wahid, 2023; Kraft et al., 2024). Bråten and Ferguson (2015) support this as they found that student teachers place greater trust in anecdotal, practically derived sources of knowledge than in theory-based accounts of instruction and student learning.

3.3.3 Motivation and the affective principles of learning.

A similar yet complementary pattern is observed in the use and recognition of the affective principles of learning. Where participants gave many concrete descriptions of the use of examples without mentioning the abstract term *transfer*, here the abstract and overarching construct of *motivation* was frequently used as an explanatory framework without using the underlying concepts of it. Motivation is a complex construct, and there remains debate as to whether it functions primarily as a determinant of learning or as a consequence of learning outcomes (Vu et al., 2022). But most participants used it in a rather one-dimensional manner and rarely combined with learning: 'he is not motivated to work'. The *APA Top 20 Principles* distinguishes a cluster of four principles under the heading of motivation grounded in more specific motivational factors: intrinsic versus extrinsic motivation, optimal challenge, teacher expectations and, short-term goal setting. Also, a separate principle describes the influence of emotional well-being on motivation and therewith on learning. The above gives rise to both a conclusion and a critical question concerning the use of affective principles of learning in our studies.

First, the quantitative findings of chapter 3 indicate that affective principles are recognised slightly more quickly and accurately than cognitive principles. The qualitative data corroborate this pattern, demonstrating that participants

across all groups readily refer to motivation and other affective aspects, including fear, confidence, and emotional safety. However, such references tend to be brief, rarely conditional, and seldom explicitly connected to *learning* processes. This pattern suggests that affective principles may be rooted in experience-based belief systems, which is understandable given that these beliefs are likely to have developed throughout everyday life and within the social context, in- and outside of schooling. As a result, participants tend to frame these factors in terms of 'feeling good' rather than connecting them explicitly to cognitive learning.

Mentions of motivation in the qualitative data varied along two axes. The first involves normative or attributive formulations, which are particularly evident among beginning student teachers. These participants tend to explain classroom and learning difficulties in terms of learners' motivation, using statements such as 'they are not motivated' or 'they do not feel like it'. In contrast, experienced teachers and teacher educators more frequently adopt relational or contextual framings. The second mode involves framing affective phenomena as stable pupil characteristics or transient states, rather than as dynamic factors that interact with instructional practices and learning processes.

Altogether, across all groups, explicit links between affective dimensions and cognitive learning outcomes remain relatively uncommon. This discrepancy limits the extent to which affective principles can be effectively employed in reflective pedagogical reasoning.

3.3.4 Misconceptions about teaching and learning

Misconceptions or erroneous prior knowledge in the social sciences are more difficult to define than those in disciplines such as chemistry or physics. This difficulty became particularly apparent during the construction of the research instruments. We identified potential misconceptions in the literature (e.g. Glogger-Frey et al., 2018; McAfee et al., 2021; Menz et al., 2021) and translated these into concise, single-sentence statements. However, during the validation of the instrument, it became clear that although the underlying idea of each proposed misconception was generally understood by all researchers, any specific formulation remained open to interpretation. When responding to the qualitative tasks, participants rarely stated their misconceptions explicitly, for example, by stating that prior knowledge should not influence learning. Instead, flawed reasoning was more often implicit in their responses. Nevertheless, the three studies presented in this thesis together provide some insight into the presence of misconceptions among participants.

In the quantitative study (chapter 3), one component of the test consisted of classroom scenario questions with multiple-choice responses explaining the given situation, one or two of which were deliberately formulated to reflect genuine misconceptions. Two of these items warrant closer attention. The first asked, "Does it help learning to start a new topic with a question-and-answer discussion?" One of the response options stated, "No, because otherwise all the wrong words and explanations will come up, and that should be avoided." This option was selected by six of the 312 participants, all of whom were teachers in secondary or higher education. None were student teachers. Although the number is small, this finding suggests that some teachers either lack this knowledge or are strongly convinced that prior knowledge is unimportant. Given the fundamental nature of this principle, it is plausible that other pedagogical principles may likewise be misunderstood or neglected, or not integrated into pedagogical reasoning at all.

The second notable result—and the most striking outlier in both quantitative and qualitative studies—concerned a fundamental principle from conceptual change theory, addressed in the question, "Is changing someone's existing misconception difficult and time-consuming?" While 158 of the 312 participants across all groups affirmed the principle, 63 selected the deliberately constructed misconception response: "No, it is not difficult; just simply keep reasoning and explaining". These were again predominantly secondary school teachers, but the response was also chosen by a substantial proportion of teacher educators, aligning with earlier findings regarding the use of examples. As noted in the study, these results do not allow us to determine whether participants were unfamiliar with the theory or actively questioned its validity. Nevertheless, it is concerning that a considerable number of teachers appear to adhere to the outdated notion that "the more you explain, the better they understand"—a belief that continues to be widespread within Dutch education.

By contrast, in the first qualitative study (chapter 4), in which the same participants were asked to provide brief explanations of prompted scenarios, very few responses demonstrated clear misconceptions or flawed reasoning. Similarly, in the second qualitative study (chapter 5), where students were asked to engage in more extended pedagogical reasoning, only two responses could be classified as genuine misconceptions: namely, that "a teacher should use fewer examples to speed up understanding" and that "formative teaching takes too much time, which would be better spent on delivering higher-quality lessons". These two observations—that explicit prompting on prior knowledge and conceptual change elicits endorsement of genuine misconceptions, whereas such misconceptions are absent from spontaneous reasoning, lends support to the

idea that participants lack the knowledge of these principles of learning. If one does not have a notion of the role of prior knowledge and the process of conceptual change, the misconception just does not exist and it will not be used in reasoning. Whether the knowledge was never taught or was washed-out cannot be concluded from these studies. Menz et al. (2021) identified several misconceptions from educational psychology and recommend longitudinal research to examine how such misconceptions develop over time, as well as further investigation into their underlying origins (Menz et al., 2023, p. 490). The findings of the present studies may contribute to this discussion. Beliefs and knowledge about learning, both accurate and flawed, appear to originate during secondary education and maybe even before but for the principles examined here, relatively few misconceptions were identified.

A noteworthy finding is that all six endorsements of the misconception concerning prior knowledge were made by practising teachers, as were the majority of endorsements relating to conceptual change. Although no definitive conclusions can be drawn, this pattern suggests that while these principles are addressed during teacher education where explicit reasoning with theoretical integration is required, their use may diminish over time. As a result, such principles may gradually "wash out" (Zeichner & Tabachnik, 1981). This, in turn, suggests that while these principles are mobilised during teacher education because theoretical reasoning is explicitly required, their complexity may result in the diminished use once teachers enter professional practice and such reasoning is no longer externally enforced. The main implication for teacher education is that student teachers, from the first day on, should be taught and trained to focus on pedagogical reasoning.

4. A CRITICAL REFLECTION ON THIS THESIS: LIMITATIONS AND CONSIDERATIONS ON METHODOLOGY AND CONCLUSIONS.

In this section I will discuss some limitations of the conclusions and methodology and reflect on the role of the researcher.

4.1 On the methodology

All four studies presented in this thesis sought to render *implicit knowledge* visible, a task that is methodologically demanding. A first challenge lays in defining implicit knowledge and distinguishing it from related constructs such as unconscious, automated, or belief-based knowledge. Many of these terms are used interchangeably in the literature, and extensive conceptual reviews have

been published on *beliefs* (e.g. Pajares, 1992; Fives & Buehl, 2012), *unconscious* (e.g. Gawronski et al., 2006), and *implicit* (e.g. Corneille & Hütter, 2020).

A second challenge concerns the measurement of implicit knowledge, beliefs, attitudes, or convictions. This endeavour is fraught with difficulty, most notably because probing implicit knowledge inevitably renders it conscious, thereby undermining its implicit nature (Sykes, 2011). Consequently, outcomes can only ever represent reflections or manifestations of underlying knowledge and beliefs, rather than the real contents of memory itself. Nevertheless, several methods and instruments for *indirect measurement*, aimed at eliciting implicit beliefs, have been developed. Indirect measurement is defined as "an inference of a construct without instruction to report it, assuming no introspective awareness of the construct" (Greenwald & Lai, 2020, p. 420).

Within quantitative research, the only validated instrument for this purpose is the *Implicit Association Test (*Greenwald, 1998), which has been in use for approximately three decades. It has been the subject of ongoing debate, with criticism largely focused on issues of validity and reliability (e.g. Corneille & Hütter, 2020). Despite these concerns, the method has been widely employed and has generated important new insights (Greenwald & Lai, 2020). But most research on implicit knowledge and beliefs has relied on qualitative methodologies, such as think-aloud protocols, observational video analysis, stimulated recall, and in-depth interviews, all of which aim to infer knowledge and beliefs from their enactment within specific contexts. It has further been suggested that combining quantitative and qualitative approaches and comparing their results may yield more robust findings, as demonstrated in earlier studies (e.g. Merikle & Reingold, 1991). At the same time, low correlations have been reported between direct and indirect measurements when investigating a single, clearly defined construct (e.g. Nosek, 2007).

Against this background, when we set out to find or develop an instrument, we entered a complex and uncertain methodological domain. We had to balance intellectual curiosity with the methodological constraints in pursuit of maximal validity and reliability. Two considerations underpin and justify the methodological decisions taken.

First, it required that our mindset had to be an *exploratory investigation* of teachers' implicit knowledge and beliefs. This framing does not imply reduced methodological rigour or diminished scholarly value; rather, it acknowledges that the resulting findings are inevitably accompanied by substantial uncertainty. Such an approach nonetheless allowed for the development and use of an instrument

that had not yet been validated, thereby enabling the investigation of the presence of learning principles in teachers' implicit beliefs and knowledge for the first time. Despite the uncertainties, we assumed that the results would raise pertinent questions for teacher education. This position is supported by Jost (2019), who argues that the measurement of implicit attitudes is indispensable despite its inherent uncertainty, and by Denessen et al. (2022), who concluded in their review that indirect measurements remain potentially valuable for understanding teachers' attitudes.

Second, applicability to teacher education practice constituted a central point of departure for all studies. Accordingly, the research design aimed to remain as close as possible to authentic teaching practice and to the ways in which principles of learning manifest themselves in classroom contexts. This led to a primary reliance on qualitative measurements situated within (chemistry) teaching settings. Classroom situations were designed to be recognisable to teachers at different stages of their professional careers, although this broad applicability bears the inherent weakness that it allows for multiple interpretations by participants. Such proximity to practice, combined with the aim of identifying substantive, participant-derived (emic) categories of concepts and beliefs, necessitated an inductive approach employing open coding (Maxwell, 2013, p. 108). Given the considerable influence of language, a lexical approach was adopted (Bolden & Moscarola, 2000), enabling close textual analysis and yielding rich, detailed insights into learning principles as connected to teaching situations. Besides inter-rater reliability, in addition, the substantial qualitative data set was subjected to semi-quantitative analysis (Maxwell, 2013, p. 128), revealing inherent quantitative properties and strengthening evidential basis and reliability of the findings. While these methodological choices enhance validity in relation to the research questions, they simultaneously increase the scope for interpretative variation and limitations on generalisability.

To mitigate uncertainty as much as possible, triangulation was maximised throughout this entire work: three distinct measurements were employed in chapters 3, 4 and 5, all three primarily grounded in the same APA Top-20 Principles (APA, 2015). Data were collected from broad and diverse participant samples. Both qualitative and quantitative research methods were used. In all studies validity sessions were conducted for the instruments and inter-rater reliability was assessed after every round of coding. In different measurements, participants were asked to engage in slow, reflective reasoning, whereas in others they were required to make rapid decisions. The sequence from more indirect to more direct measurements was carefully considered to minimise the risk that principles would become conscious and subsequently influence reasoning and

decision-making. Nevertheless, triangulation does not automatically guarantee increased validity, as different methods may share similar biases and sources of invalidity, thereby creating a false sense of methodological security (Maxwell, 2013). Given the exploratory nature of the present research, such uncertainty is inherent and must be acknowledged.

4.2 On the role of the researcher

The opening sentence of this thesis states, "I am a teacher, through and through." Given this strong professional identity, it must be acknowledged from the outset that personal curiosity and professional experience inevitably influenced instrument development, interviews, the coding process and the subsequent interpretations. Throughout the research period, I continued my regular work as a chemistry teacher educator, engaging with students on issues related to chemistry teaching and learning. The mutual influence between professional practice and research activity should therefore be regarded as inherent. The central question is whether this influence constitutes bias that should be banned, or subjectivity that is valuable in its own right.

A complicating factor in interpreting qualitative data is the considerable variation in participants' ability to articulate their ideas, provide detailed explanations, and employ appropriate disciplinary terminology. For the current studies this observation introduces uncertainty in two respects: first, in how participants might have interpreted the statements and vignettes we formulated in the research instruments; and second, in how their responses were interpreted by the researcher. This issue is particularly salient in the lexical approach, where nuanced differences in wording are central to interpretation.

In this context, the researcher's pedagogical content knowledge can be considered in two ways: it may enable deeper understanding of the meaning of words, while simultaneously risking the imposition of preconceived interpretations. Within classical qualitative methodology, the latter is recognised as a source of potential bias. However, Roulston and Shelton (2015) argue that such "bias" should not be treated solely as a source of error, but rather reconceptualised as an inherent and potentially productive aspect of subjectivity.

Nevertheless, this linguistic mediation between researcher and participant, inescapable as it is, may have influenced the findings. In recognition of this, all research texts, instruments and publications, were shared with a wide range of students, teachers, and researchers. To minimise one-sided interpretations, conditional rules were formulated when new codes were developed, and multiple sessions were held with fellow researchers in which the possible meanings

of words were discussed. Where possible, outcomes were shared with participants for member checking and confirmation.

4.3 on the conclusions

Having these critical remarks in mind, some of the conclusions may have to be reconsidered.

The principal conclusion is that nearly all participants possess some level of principles of learning, whether in the form of beliefs or knowledge. Genuine misconceptions appear to be rare. These conclusions are strongly supported by the findings of all three studies. However, these studies do not supply evidence that the principles steer pedagogical reasoning or decision-making. And, although the results of the two qualitative studies with fast decision-making and slower reasoning showed comparable results, the samples were not identical which limits the strength of direct comparisons.

Two findings raise questions about the relationship between beliefs, knowledge, and daily practice. First, there is only a weak correlation between the structured quantitative assessments and the open ended qualitative questions in chapter 3. Second, misconceptions that participants endorsed when explicitly prompted for did not surface in their explanations of classroom situations. Together, these findings suggest a gap between the knowledge and beliefs that teachers express in structured assessments and how they reason in practice-based contexts (practice). This gap has been subject of research and discussion for a long time (e.g., de Corte, 2000; Korthagen, 2007; Broekkamp & van Hout-Wolters, 2008; Resh & Schrittesser, 2023). First it should be acknowledged that the language used in the research instruments influences the outcomes. Participants' beliefs and knowledge are more accurately captured when questions or statements are formulated as concretely as possible.

The finding that differences between novices and experienced teachers are sometimes small, is not in line with Nosek (2007). He suggested that correlations between implicit and explicit measurements, ranging from very weak to strong, are influenced by moderating factors from the social and mental context. One of these factors, namely, the extent of personal experience with a particular domain and how richly developed that domain is in one's thinking, may apply to our measurements. According Nosek's reasoning, more experience and richly developed thinking means that knowledge becomes more readily accessible and correlations between explicit and implicit measurements become stronger. Applied to our study this would predict systematic differences between novice and experienced teachers since experienced teachers have presumably

reflected on these issues more often. However, this is not what we observed. This supports the general idea that, outside teacher education, over time many teaching principles become more implicit. It might be explained by differences in levels of abstraction (e.g. as conceptualised in Korthagen's model, 2010) or by the existence of parallel concepts (e.g. Vosniadou, 2013). Nevertheless, drawing on the findings of the qualitative studies reported in this thesis, a more likely explanation for the incongruence between implicit and explicit measures may lie in the availability of appropriate professional language. Such language cannot be assumed to be readily available and may influence the extent to which knowledge and beliefs can be expressed explicitly.

Korthagen called the gap between theory and practice a "perrenial problem" (Korthagen, 2007). The results of these studies raise the question whether it is a *problem*. Study 1 shows the mostly deductive approach of general theories in teacher education in the Netherlands. Study 2 and 3 show that teachers in all stages of careers hold principles of learning and study 4 shows that this knowledge, at least for STEM students, evolves over the course of a few years to more integrated and student-centred ideas about teaching. The weak correlations between indirect and direct measurements suggests that teachers are quite able to use PoLs in explaining *concrete* learning situations. Abstraction to more general ideas arrives later, all in line with the Korthagen's three-level model (1996; 2010). Could the gap therefore be understood not so much as a problem, but rather as a natural stage in the process of development? Everyone holds theories of varying sophistication that gradually develop as existing concepts are enriched. What can be articulated reflects the depth, richness, and interconnectedness of those concepts. From this perspective, the problem is not the gap, but rather the standards we have defined for the level of theoretical proficiency that students must meet in the Netherlands. That suggests rethinking for teacher education.

The frequent and superficial mentions of motivation in reaction to the vignettes raise doubt about the depth of understanding of this concept, especially among pre-service teachers. The Top 20 principles of learning describe motivation as a complex construct that consists of several factors (intrinsic motivation, goal setting, emotion). This complexity was seldom expressed by participants. Given the profound impact of motivation on both teaching and learning, dedicated research would be necessary into the concept (pre-)service teachers have of motivation and the influence of this concept on student learning.

Participants' answers in our studies, therefore, are likely based more on routine and implicit beliefs than on deliberate theoretical reflection. For our purpose,

this is a positive outcome, as we sought to elicit both explicit and implicit knowledge.

5. RECOMMENDATIONS FOR EDUCATION

This thesis originated from a concrete observation and a subsequent curiosity within the field of chemistry teacher education. The findings are now brought back to educational practice, with particular attention to the persistent gap between theory and practice.

5.1 On the principal findings

The findings of this study suggest several recommendations for education. Before describing these recommendations, I will briefly summarize the results from our research that inform them. First, teachers at all stages of their careers hold ideas about teaching and learning. Even on their very first day in teacher education, students already possess notions of fundamental learning principles. Only a small proportion of teachers demonstrate an absence of such knowledge or beliefs. Second, despite their limited experience, many beginning students are already capable of reflecting on educational issues when confronted with concrete classroom situations within their specific subject domain. Third, only a few misconceptions were identified in these studies, but we do not know if undetected misconceptions may persist and develop into persistent parallel conceptions when left unaddressed. Fourth, exploration of the prior knowledge of both novice and experienced teachers reveals that their underlying learning principles are often not markedly different, although beginning students may lack the deeper understanding or conceptual language required to articulate them. Fifth, especially explicit knowledge of PoLs about the role of prior knowledge and changing existing knowledge and beliefs seems to be scarce. Finally, teacher educators (in the Netherlands) consistently acknowledge the difficulty of teaching learning theories in educational practice and actively seek effective methods for teaching them.

These findings lead to the following recommendations. First, teacher educators need to be aware that students are likely to *share*, at least implicitly, many of their own ideas about learning. Consequently, educators should be willing to slow the pace of instruction, postpone the explanation of seemingly "new" theory, and devote time to exploring shared foundational ideas. Working with teachers of all ages, experience levels, and subject areas should begin by making implicit experiences explicit, thereby moving from unconscious to conscious understanding.

Second, teacher educators require both theoretical knowledge and a rich repertoire of subject-specific practical examples illustrating how emerging learning principles can be identified and how they operate within particular content areas. This enables them to recognise students' primary ideas, also ones that are poorly articulated and underdeveloped, and to connect these in meaningful ways to established scientific theory. If such prior ideas are to be effectively connected to scientific theory in a way that allows students to recognise their own thinking within a broader conceptual framework, it is plausible that this process is more readily achieved through clearly defined, specific learning *principles* rather than through broad learning *theories* (such as behaviourism or constructivism).

All of the above requires students to demonstrate a genuine and sustained focus on the *learning* process, which may motivate them to continue reflecting on and exploring new pedagogical approaches.

5.2 Affective and Cognitive Principles

The studies in chapters 3 and 4 indicate that affective learning principles are more readily recognised and applied than cognitive principles, with the importance of motivation being particularly prominent. As discussed earlier, this may stem from the fact that motivation is a widely and easily used, intuitively understood concept in everyday life, resulting in a rich network of experiences and informal theories. Consequently, motivation is employed frequently and broadly as an explanatory concept, though not necessarily as a principle that shapes learning processes.

The challenge lies in bringing this deeply embedded component of teachers' belief systems, intuitively recognised but insufficiently articulated, into conscious awareness, so that teachers can understand its influence on cognitive learning. Teacher education would benefit from explicitly connecting everyday understandings of motivation to cognitive learning processes and demonstrating that motivation is not merely a normative judgement (e.g. "he simply does not feel like it"), but rather the outcome of distinguishable underlying constructs such as teacher beliefs, goal orientation, and emotions. Rather than focusing on correcting misconceptions, greater emphasis seems warranted on helping teachers recognise the role of affective principles in cognitive knowledge construction and their value as a dimension of pedagogical reasoning that may guide and shape both instruction and learning. The implication for teacher education is to integrate affective principles systematically into pedagogical reasoning and practice, ideally through explicit modelling by teacher educators.

5.3 Inductive and Deductive Learning

In everyday life, the acquisition of new knowledge typically follows an inductive pathway, whereby implicit insights are formed through endless experiences (Korthagen en Kessels, 1999). In line with numerous scholars (e.g. Korthagen & Kessels, 1999; Verloop et al., 2001; Markauskaite & Goodyear 2014; Wilcox-Herzog et al., 2015; Shahzad et al., 2017; Kaya et al., 2021; Qiu et al., 2021), this thesis repeatedly emphasised that learning of teacher practice is fundamentally an inductive process and should therefore begin with eliciting learners' concrete prior knowledge. Although this applies equally to the teaching of, for instance, chemistry, history, or research methodology, it is of particular importance for teacher education because (a) prior knowledge of learning is largely derived from experience, and (b) in teacher education, learning theories are taught solely with the aim of applying them in practice. Presenting learning theories or principles in isolation from meaningful content is unlikely to connect with teachers' prior knowledge. Such knowledge may be understood at a surface level but not internalised; it may be reproduced, but not necessarily applied. Rather than bridging the gap between theory and practice this approach may inadvertently widen it.

However, certain abstract concepts—such as prior knowledge, transfer, and network-like memory structures—are not easily inferred from experience alone. Although rudimentary ideas may already exist, these concepts require explicit instruction. Teacher educators can therefore benefit from identifying how transfer between diverse experiences can be connected through the introduction of such abstract concepts. These concepts can serve as organising principles that give structure and meaning to what teachers already know. At this point, inductive and deductive learning processes intersect. However, as these concepts may fade from active use, they need to be regularly reintroduced and embedded in everyday professional language. When abstract terms remain consciously present in practice, they can catalyse reflection, foster theory formation, and thereby contribute to ongoing professional development.

5.4 Reflection

Throughout teacher education programmes, students are required to engage in conscious reasoning. Lesson preparation, reflective assignments, and discussions with mentors during teaching placements continually prompt students to make their experiences explicit and to connect them with theory. This process, however, often diminishes once graduates enter professional practice. Both the literature and the findings of this thesis suggest that unconscious learning does not cease at this point. On the contrary, professional experiences—particularly

during the early years of teaching—continue to induce the formation of new gestalts or to elevate existing ones to higher theoretical levels.

The first study revealed that learning theory is commonly taught at the beginning of teacher education programmes to equip students with theoretical knowledge prior to classroom practice. However, teacher educators expressed doubts about the appropriateness of this timing, given students' limited pedagogical experience at this stage. They suggested that learning theory might be more effectively taught towards the end of the programme, or even after graduation, when teachers demonstrate greater motivation to reflect, richer discussions, and a stronger willingness to investigate and apply theory in their own practice.

Taken together, these findings support the recommendation that continued conscious reflection—whether guided or unguided—is essential for sustained professional development, particularly during the first years of teaching.

5.5 Mandatory Theoretical Underpinning of Practice in Teacher Education

A further concern identified in the first study relates to the requirement that students justify pedagogical decisions with learning theories, a principle widely regarded as bedrock within higher education, including teacher education. In chapter 2, however, teacher educators mentioned the observation that such theoretical justification is rarely authentic. To address this issue, this section draws on my findings but also extends beyond them to outline my perspective on how this situation in teacher education might be addressed.

The findings of this thesis indicate that students' reasoning about learning can be more effectively inferred from concrete PoLs, which provide anchors that connect to practice, rather than from abstract learning theories, particularly in the later stages of their programmes. Recognising this leads to four key recommendations for teacher education.

First, given the complexity of the teaching profession, connecting any given experience to theory requires extensive and readily accessible knowledge of a wide range of theories and models. Chapters 3, 4 and 5 show that all participants hold basic beliefs and knowledge that can be traced back to a limited number of PoLs. Moreover, principles are being applied in variable levels in pedagogical reasoning and decision-making. As some teacher educators in chapter 2 already suggested, we think that for understanding *learning,* offering students a concise set of clearly defined learning principles that they can readily recall or

consult through a limited number of sources, would prevail over teaching learning theories.

Secondly, in light of cognitive development of students, the higher education requirement to underpin practice experiences with literature, needs training in the first year of study. "Literature" then could be narrowed to a focus on one or two principles, preferably those for which students already possessed prior knowledge. The initial aim here then is to foster *awareness* of whether, and how, these principles operate within students' own practice contexts and, ideally, to cultivate a positive disposition towards their *usefulness*, before progressively broadening the theoretical repertoire over time. With learning principles such an approach can be realised whereas with learning theories reduction is difficult.

Third, the expectation that practical classroom problems encountered in work placements should *subsequently* be linked to theory—based on the assumption that "the literature" will provide solutions to problematic teaching situations, seems largely ineffective and does not reflect authentic daily teaching practice according to the teacher educators in study 1. That might be because in this situation the theoretical principles do not become part of the concrete, often inductive learning process. If the goal is to connect theory and practice, it is more logical for student teachers to link theory to their *learning goals, prior* to the teaching process. Being aware of a learning principle when entering practice might substantiate pedagogical reasoning and making choices based on knowledge. Afterwards problems then can be brought back to that theory and forces to critically reflect on theory *and* practice.

Finally, students would ideally be exposed to numerous concrete examples of learning principles visible in action. That preferably starts in university through teacher educators' meta-communication about learning principles at work during their own teaching, as well as through explicit discussion of learning principles during joint reflection with the coach in teaching placements.

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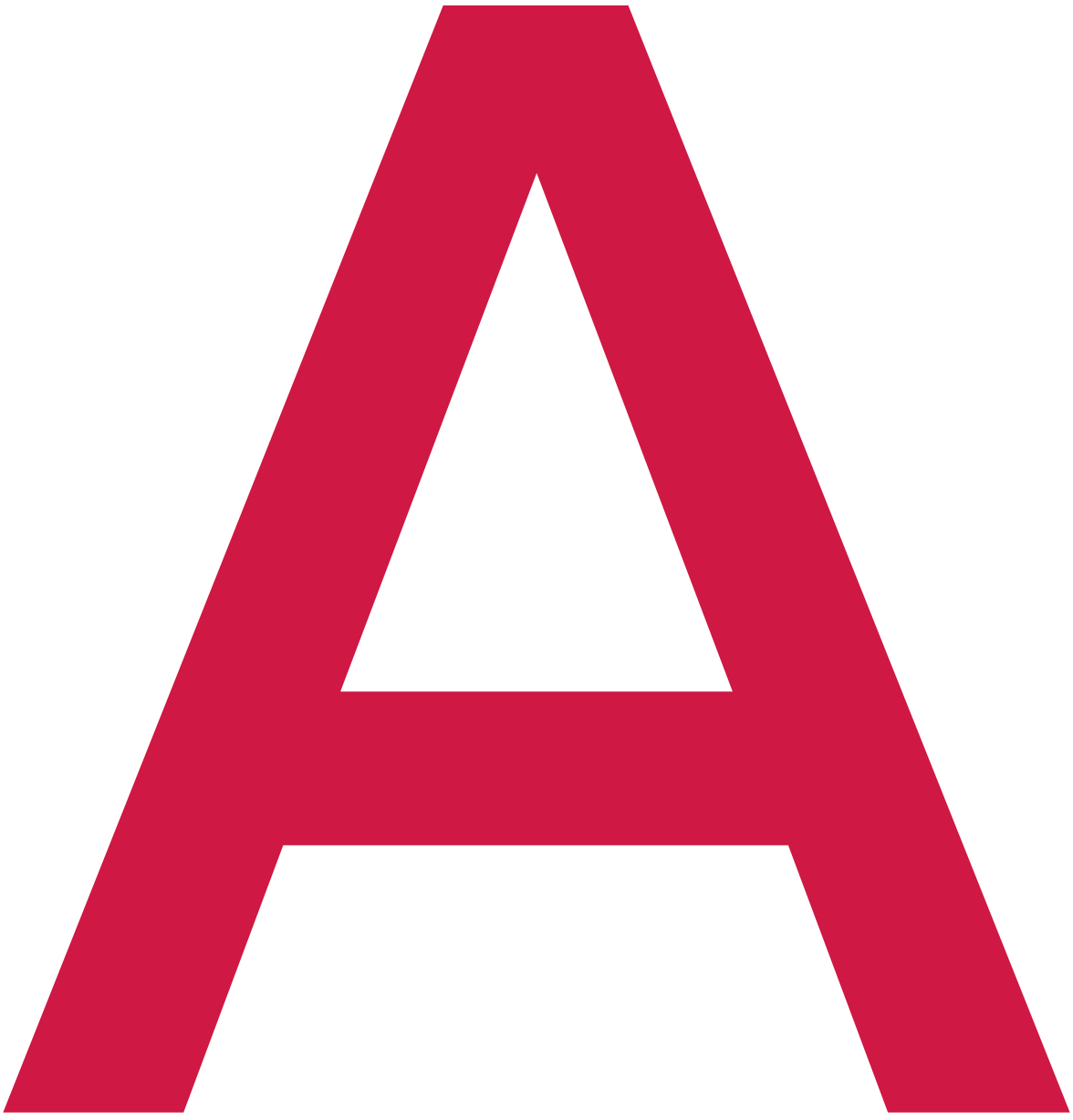
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APPENDICES

Appendix A	Interview protocol study 1	page 193
Appendix B	Code book study 1	page 195
Appendix C	Questions of the three components of online test in study 2	page 197
Appendix D	Vignettes for fast response study 3	page 202
Appendix E	Code book study 3	page 203
Appendix F	Example of one vignette study 4	page 205
Appendix G	Code book study 4	page 207

APPENDIX A: INTERVIEW PROTOCOL (TRANSLATED FROM DUTCH)

(questions in italics were added after three interviews had been done)

1. What is your function in your university and how many years of experience do you have as a teacher educator?

2. Can you explain to me how, in your university, curriculum development takes place?
- Who is/are responsible for the curriculum?
- What is your role in the decisions about curriculum design and development?
- Are teachers of the content (e.g., chemistry, history..) involved in the curriculum design, or just educational scientists and/or management?
- *Would you characterise the process of curriculum design as more top-down or more as bottom-up?*

3. Can you tell me what theories about learning is offered in your curriculum?
- What theories and/or principles are offered?
- What books, documents or other sources are used?
- Where in the program are LTs offered? Only once or more times?

If so, repeatedly or concentrically?
- How is knowledge of LTs assessed?

4. Can you explain what the role of LTs is in your teacher education program?
- Are theories of learning discussed in regular lessons (chemistry, history...)? If so, can you describe how? Do you think LTs are used by your colleagues?
- How are LTs used in internships? Do you ask students to use them? Do students have to refer to LTs in their daily work? Do you have experience with how they are actually used in internships?

5. Can you describe your personal vision of the role that LTs could play in teacher education and in education in general?
- What would the teacher education curriculum ideally look like, when you focus on learning?
- Should knowledge of learning ideally be taught inductively or deductively, according to you?

Then APA Top 20 Principles from Psychology for PreK-12 Teaching and Learning were presented.

- What would be more effective, according to you: to teach theories (e.g., constructivism) or concrete principles? Can you elaborate on that?
- Can someone become a good teacher without theory?
- What is the role of educational scientific research in a teacher's daily practice, according to you? (Maybe you have a metaphor?)
- *What do you think of offering LTs after the teacher education program, say, five years later?*

APPENDIX B: CODEBOOK STUDY 1

CATEGORY / RQ	CODE	DESCRIPTION	EXAMPLE (quote from interview transcript)
What is offered?			
	#what	Plain explanation of content	LTs and memory functions are superficially offered at the same time.
	#where / when	when or where in the curriculum the content is placed	In the first semester the focus is on designing lessons, in the second semester on learning.
	#literature	what literature/sources are used	We used to have Woolfolk but that was too abstract; now we work with the book by Chinn.
	#boundaries	remarks on the choice of content considering boundary conditions	It depends a little on the educational science people we have [available] in the house. Our program is quite short. You can do LTs but there are so many things to do. We have masters of philosophy among the students. You'll have to adapt the level and literature then.
	#assessment	assessment of LTs somehow, and if so, how it is done	LTs are assessed by a multiple-choice knowledge test which is controversial.
How are LTs offered?			
	#how	educational choices made on how LTs are offered	We work inductively; we have a fully [student] concerns-steered program.
Role/function of LTs			
	#awareness learning	becoming aware of the role of learning in education / having a richer vision of learning	If fostering of learning is your craft, your profession, I think you should know a lot about that.
	#validate pedagogical choices	substantiating pedagogical reasoning in daily practice, e.g., in lesson design	For designing a digital course or a regular one you need all of that [LTs] and of course for designing a good lesson.

CATEGORY / RQ	CODE	DESCRIPTION	EXAMPLE (quote from interview transcript)
	#aware theory	becoming aware of what a theory is and the role of theories in education	Sometimes you have to explain that it is theory, we *think* that it works that way.
	#link theory practice	making a link between theory and practice in assessments for internships	The function of LTs [...] in internships... if it was all more explicit, we might refer to it from both sides.
	#teacher education	improving teacher education quality	Teach as you preach! Yes, exactly. Making it all [your pedagogical choices] as a teacher educator visible all the time and repeat doing that.
Respondents' vision of LTs in education			
	#forming a vision	should help students to develop a vision on education and learning	LT is a very important way of looking at education but it's never theory alone; you have to have a vision and a goal what you want to achieve.
	#enrichment	should enrich students' educational practice	In present-day education, teachers have to design and develop more and more and then you have a need for underlying theory.
	#when	should be offered during or after teacher education program	If you look at students' concerns during the program, you see that they are mainly busy with "how will I survive in class".
	#secondary education	should help increase the quality in secondary education	You can integrate educational science with the content, but much better with the practice in internships.
	#professional attitude	Should help to become a real professional teacher (behaviour)	Our profession is a very complex one and I think that with [L]Ts you can learn it faster and more profoundly.
	#criticisms / doubts	participants express explicitly their doubts about the role of LTs	It's a very interesting question if all this *meta meta* thinking actually works. The transfer to their own classroom will always be questionable.

APPENDIX C: CONTENTS OF THE THREE TEST COMPONENTS USED FOR STUDY 2

All content here is translated from Dutch to English except for the literature statements. Especially the words of the implicit word association task are best translations which leads sometimes to ambiguity in English that is not the case in the original language.

Notice that the classroom statements are formulated in informal language in order to reach a maximum of participants recognising them.

Principles 1-5 are about cognitive learning, 6 -10 about affective.

APA numbers refer to APA Top-20 principles of learning (APA, 2015). For more details, please see the publication.

Principle of learning as mentioned in text	***Principle from literature in test component 4***	***Words offered in test component 1***	***Classroom statement in test component 3***	***MC-answers in test component 3***
1 pre-knowledge	What students already know affects their learning. (APA, nr.2)	prior-knowledge experiences	When introducing a new topic, it helps for learning if you first ask students questions about what they already know about it. (correct)	Does it help for learning to start a new topic with a Q&A-session (Dutch: onderwijsleergesprek)? Yes, because learning begins with the prior knowledge and experiences students already have Yes, because then as a teacher you get a better picture of which students are stronger or weaker No, because then you lose time and attention, it's better to get straight to the point No, otherwise all the wrong words and explanations will come up and you don't want that
2 repeating	Acquiring long-term knowledge and skill is largely dependent on practice (APA, nr.5)	to repeat to practice	Regular repetition of the subject matter has hardly impact on learning. (incorrect)	Does repeating the subject matter affect learning? Yes, repeating each time gives structure to the lesson and therefore confidence Yes, repetition makes connections in memory stronger which makes it more permanently stored No, repetition makes pupils bored or irritated which actually hinders learning No, repetition does not work with learning, repetition only works with skills training
3 Context	Learning is based on context, so generalizing learning to new contexts is not spontaneous but instead needs to be facilitated (APA, nr.4)	context examples	Bringing examples to new topics is nice for illustration but does not lead to better learning. (incorrect)	With new material, are examples nice only for illustration and not for understanding? Yes, students get a bit more motivated but it doesn't lead to better understanding Yes, it makes the subject matter more cheerful but not necessarily clearer No, it leads to better understanding because there is a link between school and daily experience. No, it leads to better understanding because you can reason better with an example

Principle of learning as mentioned in text	*Principle from literature in test component 4*	*Words offered in test component 1*	*Classroom statement in test component 3*	*MC-answers in test component 3*
4 CCT	Learning requires substantial change of exisiting concepts which happens slowly and stepwise (Vosniadou, 2013)	resistance to adapt	If you want to correct wrong explanations (misconceptions) that students have, it is laborious and takes a a lot of time and repetition (correct)	Is correcting misconceptions that students have laborious and slow? Yes, it is difficult because they themselves do not see that their explanation is wrong Yes, it is difficult because their misconception is based on many personal experiences throughout their lives No, it is not difficult as long as you provide enough other examples that support the correct explanation No, it is not difficult as long as you explain correctly and reason clearly
5 dual coding	Cognition involves verbal and non-verbal information that reinforce each other.	language images	If you explain a topic with a powerpoint, you should put pictures in it and minimum words (correct)	Should you put pictures and minimum words in a powerpoint when explaining a topic? Yes, the spoken words and powerpoint images reinforce each other, leading to better understanding Yes, because the memory is very good at processing the spoken text and the written words at the same time No, you have to put the text you tell right on the powerpoint, then they can read along for better understanding No, you shouldn't put pictures in the powerpoint when telling a story. The pictures interfere with listening.

Principle of learning as mentioned in text	***Principle from literature in test component 4***	***Words offered in test component 1***	***Classroom statement in test component 3***	***MC-answers in test component 3***
6 beliefs	Students' beliefs or perceptions about intelligence and ability affect their cognitive functioning and learning (APA, nr.1)	convictions self-confidence	Give weak students a simple task and then extra compliments on the grade achieved; that eventually leads to better learning (incorrect)	Should you give weak students a simple task with extra compliments on the grade? Yes, every extra compliment gives confidence and ultimately leads to better learning. Yes, it's all about the grades after all so a compliment on that is a reward that leads to better learning. No, you should compliment <u>all students</u> on good grades No, you should compliment all students but on effort, not grades
7 motivation	Students tend to enjoy learning and perform better when they are more intrinsically than extrinsically motivated to achieve (APA, nr.9)	motivation interest	If someone does not make sense of the material in your lesson or does not realise what it is for, it makes learning less effective (correct).	Is it true that 'not liking the material' or 'not seeing what for' makes learning less effective? Yes, because there should always be a positive atmosphere in class Yes, because some intrinsic motivation is important for learning No, as long as it is clear what the test means at the end, learning will take place. No, because you can always set a nice reward, then learning will take place.
8 goals	Setting goals that are short term (proximal), specific, and moderately challenging enhances motivation more than establishing goals that are long term (distal), general, and overly challenging. (APA, nr.12)	expectations goals	Stating an achievable goal for a lesson positively influences learning (correct)	Does naming an achievable learning goal positively influence learning? Yes because working with goals creates students' expectations and this encourages them to learn Yes because stating goals reflects expectations that the teacher has and that motivates No, goal setting is a tool for teachers in their lesson preparation, not for students to learn No, students are busy enough with the content; thinking about goals as well makes it complex

Principle of learning as mentioned in text	*Principle from literature in test component 4*	*Words offered in test component 1*	*Classroom statement in test component 3*	*MC-answers in test component 3*
9 emotions	Emotional well-being influences educational performance, learning, and development (APA, nr, 15)	well-being emotion	Regularly laughing together in class has a positive impact on the learning process (correct)	Does laughing together regularly have a positive impact on learning? Yes, because laughing gives a sense of belonging and that influences the learning process Yes, because positive emotions in class make you feel comfortable and that positively influences the learning process No, laughing together creates a nice atmosphere for a while at most, but that has no influence on the learning process No, because laughing distracts from thinking and has a negative influence on the learning process
10 social	Learning is situated within multiple social contexts (APA, nr.13)	cooperation social	Getting pupils to work together in a deliberate way promotes social skills and thus the learning process (correct)	Does working together help the learning process? Yes, because then learners are more likely to hear the right answer in the language of peers and that promotes the learning process. Yes, because besides the content, it promotes social skills and thinking and thus learning No, because many ideas and half right answers from different students confuses the learning process. No, you don't train these kinds of skills in your class because not every teacher can do that so there are other classes for that

Twenty "school-words" (school related but not specifically to learning): board chalk, school bell, microscope, answering sheet, smart-board, pencil, parents council, projector, classroom, mentor, laptop, gym, copier, bicycle parking, schoolyard, school principal, detention, correcting, computer screen, books.
Twenty "nonsense-words" (not related to school nor learning): chicken, fever, daisy, ironing board, ditch, blue, grass, brick, snow, injection, sailing, air, sawing, wing, car door, animal, valve, tower block, jogging, tunnel.
All words are best translations from Dutch which leads sometimes to ambiguity in English that is not the case in the original language

APPENDIX D : VIGNETTES FOR FAST RESPONSE STUDY 3

Two cases were designed, each clearly incorporating several PoLs. Vignette 1 predominantly features three cognitive PoLs, while Vignette 2 focuses more on affective PoLs, although all can be recognised in both cases. Both vignettes were presented in Dutch, and for this paper have been translated into English.

Vignette 1 is based on prior knowledge, practice and repeating, and context:

A teacher explains the concept of democracy. The book gives a definition and some "conditions for a healthy democracy". The teacher has the definition copied and illustrates the conditions with some examples.

Two months later there is an event in the news questioning democracy in our country. The teacher shows the news report and a fierce discussion immediately ensues. Then he asks the students what conditions from the earlier lesson are at issue here.

The classroom falls silent; none of the students has an answer. When he points out the conditions in the book again, there are a few very brief questionable responses.

Vignette 2 is based on student's own beliefs, motivation and emotion:

A teacher puts a sum on the board and asks who can explain the right approach to the solution. She gives someone a turn and says very invitingly, "Tell me, how do you think you should approach this?" The student replies, "Ooh, no idea. I can't do math, you know that, right?"

The teacher gives a few hints and keeps smiling kindly inviting the student to make a first move, but she just looks unhappy and insists she has no idea.

In both cases the question was "What do you think is going on here?" What is your diagnosis of this vignette? Rather than tell what the teacher should do, say what you think is going on.

APPENDIX E CODE BOOK STUDY 3

CATEGORY	CODE	DESCRIPTION	EXAMPLE QUOTE
Explicit			
	#prior	Answer contains: bringing prior knowledge or ideas	Pupils view it from their prior knowledge rather than with the new information
	#repeating	Answers containing: repeating or practising	learners just copied the definition but there was no repeating.
	#context	Answers containing: connection theory/practise or application of example	not worked and linked from the experiential world, is therefore not learned sustainably
	#belief	Answers containing: belief/ self-confidence/ doesn't dare / mind-set	as long as the student keeps the mindset that he/she cannot do math then that thought blocks
	#motivation	explicit statement containing motivation or interest	Pupils are just not interested in this subject
	#emotion	Answers containing: emotion / fear/dare/afraid/ unsure/unsafe	Doesn't dare in front of class
Implicit			
	#prior	Explicit words not used but it is visible that a connection to prior knowledge misses	There was no "entrance" [for the pupil] to solve this sum, the step is too big
	#repeating	Explicit words not used but it is suggested that there should have been more repetition	Too much time between the first lesson and the lesson with the situation
	#context	Explicit words not used but a form of transfer is visible	The concept of democracy has not come to life for the students.
	#belief	Explicit words not used but is visible that lack of belief is present	It is demotivating and counter-productive to challenge someone against their will to do something they think they cannot do.
	#motivation	Answers not containing motivation but word like interest or like in a less direct way	Students would like to give their own opinions but don't know what's in the book anymore.

CATEGORY	CODE	DESCRIPTION	EXAMPLE QUOTE
	#emotion	Answers not containing emotions but the feeling or behaviour of the pupil	the pupil is put under pressure and immediately shuts down.
Other			
	#memory	Short and long answers containing: memory, forgotten, remember, not stuck, in mind, lost, ingrained, recollect, faded	The only thing they've done is copy over. None of these teaching methods stick for very long.
	#classroom	Answers referring to the situation in the classroom and/or factors influencing that.	The class dynamic inhibits showing what she knows. The atmosphere in the classroom can hinder demonstrating your feeling to be allowed to fail.
	#learning	Answers that reveal that participant has a focus on learning, either using that word or more implicit	It was worked through too quickly instead of students actively thinking about it in class.

APPENDIX F EXAMPLE OF A VIGNETTE STUDY 4

All texts are translated from Dutch to English by ChatGPT. Every text was followed by two questions: "Why do you think the problem occurs?" and "Which approach do you think would work better?"

Series A, Vignette 1

Jantien teaches science to Year 9 (GCSE Foundation level) students. The topic is density.

Three days ago, she introduced the topic by explaining mass, volume, and density using a PowerPoint presentation. She then mentioned two examples from the textbook: wood floating on water and warm air rising from a volcano. After that, she wrote the formula $\rho = m/V$ on the board, and together, they worked through a simple calculation.

For this lesson, she starts by capturing the students' curiosity with a small block of a "very special material"—platinum. The students get to hold it briefly; it feels very heavy. One student immediately exclaims, "The density is really heavy!" while another says, "It's much heavier than iron." Jantien corrects them, explaining that they should no longer describe density as "heavy." "Make sure to remember this for the test!" she says, before continuing, "We learned how to calculate the density of a block like this. Who remembers how to do it?"

Silence...

She asks, "What did we do last lesson?" Someone mentions "volcano," but no other answers follow. When she asks for the formula, one student hesitantly responds, "Yeah, with that weird symbol. V divided by m... right?"

Jantien sighs, writes the correct formula on the board, and holds up the block. "Okay, how do we use this formula to calculate the density of this block?" The students remember that they had to weigh and measure it with a ruler but struggle to recall how to apply this in the formula. Jantien goes through the process again: she measures and weighs the block, writes the numbers in the formula on the board, and calculates the density. The answer is 21, and when she asks whether the block is lighter or heavier than an iron block of the same size (with a density of 8), most students guess that "iron is lighter" because 8 is a smaller number.

During a practical session, the students determine the density of several different material blocks themselves.

Problem:
In the next lesson, Jantien gives a formative test. The standard density calculations go well, but calculating m or V when given the other two values still frequently goes wrong. Questions requiring students to predict whether a block of iron or platinum would float on mercury (using density values from a table) or what happens to warm air from a radiator in a living room still need to be explained. Therefore Jantien decides to create a worksheet with more practice exercises for students to complete at home. The test results show two students scoring 7 and one an 8, but the remaining 19 students are around a grade 5 or lower.

APPENDIX G CODE BOOK STUDY 4

APA numbers refer to the APA Top 20 principles of learning (APA, 2015).

Not all the codes represent a real principle of learning, some codes were added to in order to distinguish different types of answering (e.g. #transfer and #examples that both are part of APA principle 4).

All codes , descriptions and example quotes were translated from Dutch to English. Quotes were translated by ChatGPT with the particular prompt to stay as close as possible to the meaning.

CATEGORY	CODE	SHORT DESCRIPTION	EXAMPLE QUOTE
Cognitive			
	#belief	APA principle 1: belief or perception about own intelligence affects learning	The student has already accepted that he is less good at chemistry than at physics.
	#prior	APA 2: what students already know affects learning	Jantien did not base the practice exercises on the needs and shortcomings of the students.
	#ZPD	zone of proximal development	You can guide this student using scaffolding by asking a slightly more difficult question each time.
	#practice	use practice of the future profession in teaching	Especially in vocational education, you have many opportunities to make "vague" physics clearer by linking it to practical situations.
	#transfer	Actual clear examples of transfer where new contexts are explicitly mentioned	The teacher explains specific situations instead of explaining the concept. Students can only apply the "trick" to cases they have already encountered, and cannot reason independently in new situations.
	#examples	Just the use of examples	The students have seen and worked on too few different examples from their own world of experience.
	#rehearse	APA 5: acquiring long term knowledge depends on practice	The students have practiced too little with the formula themselves; as a result, they don't yet have a solid grasp of it.

CATEGORY	CODE	SHORT DESCRIPTION	EXAMPLE QUOTE
	#feedback	clear, explanatory and timely feedback is important for learning	By discussing answers as a class, students hear each other's responses and therefore think about them again.
	#selfregulate	APA 7: Students' self regulation assists learning	If that doesn't work, you should consider whether a different approach to the learning itself or to the explanation would be effective.
	#inquirybase	Use inquiry based learning as a teaching tool	I think students in VWO want to do more themselves. Just give them a mixture of four substances and say: I only want substance X, figure it out!
	#cooperate	Students working together	Have the student work together with students who do understand it, and provide extra tutoring if needed.
	#think	cognitive learning only takes place when people actively think.	The students don't really think for themselves and copy everything directly from the book. They don't understand questions that require genuine reasoning.
	#dualcode	combine language and images	It would work better if he drew it out on the board, with a clear explanation of why certain substances react to form completely new substances. In this way, the students can better understand, the drawing gives them a visual representation.
	#networklearn	any description where respondent shows a clear notion of concepts in a network memory	This means that the students cannot apply the learned concepts, and therefore that the concepts are not well integrated into the students' knowledge network.
Affective			
	#challenge	APA 10: students persist in the face of challenging tasks	It doesn't work to make practica easy, because students need a challenge so that they can better see the relevance of the subject.
	#differentiate	differentiate to different levels of understanding to keep pupils challenged	The practicum should in any case be adjusted to the level. What may be difficult for TL can indeed be boring and therefore too simple for VWO.

CATEGORY	CODE	SHORT DESCRIPTION	EXAMPLE QUOTE
	#proxgoals	APA 12: setting goals that are short term (proximal) more enhances motivation	It's good that she has a yearly goal, but for a student a year is a very long time. Goals step by step.
	#teacherexpect	APA 11: teacher expectations about their students affects motivation	She could potentially stimulate the students by expressing their competence. This way, students receive a small compliment, which can foster intrinsic motivation.
	#motivate	APA 9: students tend to enjoy learning when intrinsically motivated	Rewarding the person who finishes the assignments first only affects the students' extrinsic motivation and not their intrinsic motivation.
	#relationsafe	APA 14: Interpersonal relationships and communication are critical to the learning process.	As a teacher, you want to maintain a safe classroom climate, which at the moment is not working.
	#emotion	APA 15: Emotional wellbeing influences educational performance and learning	That may cause panic among the students during the test, causing them to think less effectively.
	#behaviour	APA 16: Expectations for classroom conduct can be learned/proven principles of behaviour	Julian does not set his boundaries clearly or consistently enough with the dominant boys. As a result, they continue to display this challenging behaviour. Such dominant behaviour is a cry for clear boundaries.
	#classmanage	APA 17: Effective classroom management is based on high expectations, positive relationships, and a high level of student support.	To seat these students spread out across the classroom so they can no longer cling to each other and therefore have to connect with the rest of the class. This should then be discussed with the mentor so that this is the case in every lesson.
	#formative	APA 18: formative and summative are both important. Also all responses on formative action/ approach.	The online assignments are not a means of improving poor test scores, but rather a way to check whether they have understood the material BEFORE they take the test.

CATEGORY	CODE	SHORT DESCRIPTION	EXAMPLE QUOTE
	#attention	All responses that state that the teacher should provide more personal attention to the student in order to find out what is on their mind.	Try to find out whether she really is a "language person" and don't just assume that. Look for ways in which it might work and she discovers that she may actually be more of a STEM-oriented person.
	#affectcogn	responses in which affective factors are explicitly linked to cognitive learning.	The approach described is ineffective. The foundation—namely the classroom relationship—is not in order. He may implement good didactics in the form of a practical/lab activity, but honestly, this will not lead to more learning.
other			
	#misconcept	clear misconceptions about teaching and learning or strange reasoning that doesn't make sense	It also takes a lot of time to measure how everyone has performed; that time could be better spent on giving better lessons.
	#no idea	Respondents state they have no idea what happens or what to do	
	#construct	All responses that state constructive alignment is not in order	There are hardly any insight-based questions in the modules, yet they are still assessed on the test.
	#metacomm	meta-communicate beyond the content; clarify the learning process	More explanation WHY it is necessary to learn all this
	#teachtolearn	responses that state that you should teach the pupils how to learn	She could let the pupils solve a problem with a systematic problem-solving approach
	#teacherbehave	All responses that only describe what a teacher should do without any connection to learning	Make more funny lessons
	#pedreason	Clear examples of pedagogical reasoning	A practical exam is a very valuable instrument. However, I would consider, for each level, what is feasible and useful to assess.

CATEGORY	CODE	SHORT DESCRIPTION	EXAMPLE QUOTE
	#conditional	All formulations starting with constructions like 'It might be that...' or words like maybe or probably	
	#remarkable	Remarkable responses that needed more analysis or discussion with the team	



DANKWOORD

DANKWOORD

Dat was een hele lange ontdekkingsreis! En zoals het is met ontdekkingsreizen, je hebt een richting en een onbekend doel waar je *hoopt* iets te vinden. Maar je moet wel zin hebben in die *reis* want jouw Ithaka is vaag, onzeker en kan zomaar tegenvallen.

Ik ben al van jongs af aan gefascineerd door het aanleggen van een spoorlijn in een onbekend, ruig en bergachtig landschap om zo een nieuw punt te ontsluiten. Wat je uiteindelijk bereikt, is een nieuwe verbinding tussen het oude bekende en iets nieuws. De foto op de voorzijde laat dat zien. En dat is de metafoor: ik heb een nieuwe verbinding aangelegd. Maar ook niet meer dan dat; het landschap links en rechts van de nieuwe route blijft onbekend gebied en schreeuwt nu om meer exploratie. Mijn nieuwe verbinding is maar één lijntje in het netwerk. Maar die tunnels en bruggen zijn mooi en stevig en daar ben ik trots op.

Het was een een uitdaging die 7 jaar geleden begon. Het had allemaal sneller gekund, misschien, maar op zo'n lange reis kan van alles tegen zitten. Ik koos soms voor zorg voor mijn naasten en moest dit project dan even stil leggen. Er is zoveel gebeurd in 7 jaar. Maar het staat me nog wel helder voor ogen hoe het begon. Met mijn masterthese waarvoor Martijn mijn begeleider was en waaruit opmerkelijke resultaten kwamen waarop hij mij aanspoorde om hier promotie-onderzoek van te maken. Dat was weliswaar een oude wens maar ik dacht dat ik er inmiddels te oud voor was. Maar het thema fascineerde me (en nog steeds), en een NWO promotiebeurs voor leraren moest haalbaar zijn mits er wel tijd beschikbaar was op Windesheim.

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onze gesprekjes missen. En je bezit een hoog oplossend vermogen voor zwarte gaten in, en beren op de wetenschappelijke weg; je hebt altijd een positief perspectief of een creatieve uitweg wat me meer dan eens hielp anders te kijken en zo verder te komen. Ik ben je zeer dankbaar!

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Hoe heerlijk is het om nu in een trein te zitten en een nieuw landschap aan je voorbij te zien trekken. In gedachte rijd ik het traject nog eens, geniet van de bouwwerken en de uitzichten op het onbekende onderweg en rol dan het gloednieuwe station in. Vanaf hier zijn nog geen verdere lijnen...



NEDERLANDSE SAMENVATTING

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Inleiding

Het uitgangspunt van dit proefschrift was de ervaring dat leraren en lerarenopleiders vaak niet in staat waren om de meest algemene principes van leren expliciet te verwoorden of deze in hun onderwijspraktijk te articuleren. Uitgaande van de veronderstelling dat zij desondanks competente docenten zijn, was mijn hypothese dat zij dergelijke principes wel degelijk bezitten, zij het op een meer impliciet of onbewust niveau. Mijn nieuwsgierigheid richtte zich op de vraag of dergelijke impliciete kennis en overtuigingen meetbaar zijn en in welke fasen van de loopbaan van leraren deze ontstaan of juist verdwijnen. Deze redenering leidde tot de overkoepelende onderzoeksvraag van dit proefschrift:

Wat is de invloed van expliciete en impliciete conceptuele kennis en overtuigingen van leraren over principes van leren op hun didactisch redeneren?

Deze vraag werd uitgewerkt in twee deelvragen:

1. Welke expliciete en impliciete conceptuele kennis en overtuigingen over leren bezitten leraren in opleiding en bevoegde leraren?
2. Hoe manifesteren deze kennis en overtuigingen zich in het didactisch redeneren van leraren?

De literatuur bood verschillende bevindingen die als ankerpunten dienden voor dit onderzoek. Ten eerste wordt algemeen geaccepteerd dat overtuigingen en kennis van leraren geen scherp afgebakende constructen zijn en dat overtuigingen van leraren een substantiële invloed uitoefenen op de didactische beslissingen die zij nemen en daaruit de wijze waarop zij hun onderwijs vormgeven. Ten tweede, met betrekking tot bewust didactisch redeneren bestaat brede consensus, ondersteund door omvangrijk onderzoek, dat didactisch redeneren de kern vormt van het leraarschap. Tegelijkertijd blijkt dat veel leraren na enkele jaren praktijkervaring minder diepgaand redeneren, waardoor bestaande overtuigingen eerder worden bevestigd dan bevraagd. Ten derde ‘indirecte metingen’, daarover bestaat een voortdurende discussie over de validiteit en betrouwbaarheid van dergelijke onderzoeksmethoden, hoewel veel onderzoekers desalniettemin pleiten voor het gebruik ervan om overtuigingen van leraren beter te kunnen verklaren.

Eerste studie (Hoofdstuk 2)

De eerste kwalitatieve studie is opgezet om te onderzoeken hoe leertheorieën en leerprincipes aan bod komen binnen Nederlandse lerarenopleidingen. Wij onderzochten wat er wordt onderwezen, hoe dit gebeurt en vooral waarom dit op die manier gebeurt. Die laatste vraag diende om de onderliggende visie en rationale voor het onderwijzen van leertheorieën aan beginnende leraren te verduidelijken.

Wat wordt onderwezen varieert aanzienlijk tussen opleidingen, zowel binnen de opleidingen voor primair als voor voortgezet onderwijs. Het aanbod loopt uiteen van vrijwel geen aandacht voor leertheorie tot volledige cursussen met een afzonderlijke toetsing. De inhoud blijkt grotendeels afhankelijk van persoonlijke keuzes of individuele expertise. Ook de wijze waarop leertheorie wordt onderwezen verschilt sterk. Er bestaat geen consensus over een bepaalde aanpak, wat mogelijk samenhangt met het ontbreken van leerboeken die leertheorie expliciet verbinden met de onderwijspraktijk.

Alle deelnemers waren ervan overtuigd dat leertheorie een legitieme plaats inneemt binnen de lerarenopleiding en dat de koppeling tussen theorie en praktijk de essentie van dergelijke opleidingen vormt. Daarom waren zij van mening dat lerarenopleiders leerprincipes expliciet zichtbaar zouden moeten maken in hun eigen onderwijs, hoewel zij betwijfelden of zijzelf of hun collega's daartoe daadwerkelijk in staat zijn. Deelnemers beschouwden bovendien een inductieve aanpak, waarbij wordt uitgegaan van de concrete onderwijspraktijk van studenten, als de meest effectieve route. In de praktijk worden leertheorieën echter vaak aanvankelijk deductief aangeboden, al lijkt voorzichtig een verschuiving zichtbaar van 'deductieve instructie gevolgd door toepassing' naar meer inductieve benaderingen.

De belangrijkste bevinding van deze studie was dat deelnemers via hun redeneringen tot de conclusie kwamen dat hun idealen over effectief onderwijzen en leren soms op gespannen voet stonden met de realiteit van de praktijk, en dat zij openlijk de vraag stelden of het haalbaar is dat studenten hun handelen consequent expliciet aan theorie verbinden.

Tweede studie (Hoofdstuk 3)

In de tweede, kwantitatieve studie onderzochten wij zowel impliciete als expliciete overtuigingen. Hiervoor ontwikkelden wij een instrument bestaande uit drie onderdelen: een woord-associatietaak om impliciete overtuigingen te meten, een expliciete taak rond het onderschrijven van principes om expliciete overtuigingen te meten, en een klassensituatietaak die bedoeld was om

beide dimensies in kaart te brengen. De impliciete metingen toonden aan dat de overtuigingen van de meeste leraren in grote lijnen overeenkomen met de onderzochte leerprincipes. Er werden nauwelijks significante verschillen gevonden tussen subgroepen van deelnemers: beginnende leraren vertoonden geen sterkere herkenning dan ervaren leraren, noch werden verschillen vastgesteld tussen vakdomeinen.

Over het geheel genomen riepen affectieve principes sterkere associaties en hogere niveaus van onderschrijving op dan cognitieve principes. De studie laat echter niet toe conclusies te trekken over de oorsprong van deze overtuigingen: of zij expliciet werden onderwezen dan wel deel uitmaken van een breder overtuigingssysteem dat verder reikt dan onderwijs en leren.

De principes die het sterkst werden herkend, betroffen het belang van oefening en herhaling voor leren, het gebruik van voorbeelden en de rol van motivatie. Daarentegen scoorden de invloed van voorkennis op leren en de moeilijkheid van conceptuele verandering het laagst. Opvallend was bovendien dat de meeste principes in reacties op concretere klassensituaties hogere scores behaalden dan wanneer men het expliciet geformuleerde principe moest beoordelen. Dit suggereert dat deelnemers principes herkennen binnen contexten, maar waarschijnlijk minder goed in staat zijn om deze principes als abstracte regels te herkennen. De correlaties tussen impliciete en expliciete metingen waren zwak of afwezig. Hoewel de principes werden herkend, kon de studie niet vaststellen in welke mate zij daadwerkelijk geïnternaliseerd waren, noch uitspraken doen over hun invloed op het feitelijke handelen in de klas.

Derde studie (Hoofdstuk 4)

De derde studie beschrijft het kwalitatieve onderdeel van hetzelfde instrument dat in studie 2 werd ontwikkeld. Leraren kregen twee korte klassensituaties voorgelegd: één gericht op cognitieve principes en één op affectieve principes. Deelnemers werd opnieuw gevraagd snel te reageren op de vraag: "Wat denkt u dat hier aan de hand is?" De open antwoorden werden kwalitatief geanalyseerd.

Net als in de voorgaande studie was de meest opvallende bevinding de beperkte variatie in de frequentie waarmee verschillende principes door verschillende groepen deelnemers werden aangehaald. Alleen het 'gebruik van voorbeelden' en 'de rol van emoties en motivatie' vertoonden statistisch significante verschillen tussen leraren in opleiding, bevoegde leraren en lerarenopleiders. Slechts een klein deel van de deelnemers verwees niet naar een leerprincipe, maar gaf antwoorden zoals "ze zijn het vergeten" of normatieve uitspraken die begonnen

met "De docent zou moeten...", zonder dat een onderliggend principe zichtbaar werd.

Naast de beoogde principes viel een aanzienlijk aantal reacties buiten de principes waarop wij ons richtten; deze konden worden gegroepeerd onder geheugenprocessen, sociale klassendynamiek en algemene overwegingen over leren.

Wel werden significante verschillen tussen groepen vastgesteld in het taalgebruik van leraren in opleiding, bevoegde leraren en lerarenopleiders. Twee meer algemene patronen werden zichtbaar. Ten eerste, studenten beschreven principes doorgaans in meer impliciete bewoording, terwijl bij leraren en in het bijzonder lerarenopleiders een geleidelijke verschuiving zichtbaar werd naar explicietere formuleringen. Ten tweede, principes die in het dagelijkse onderwijs duidelijker 'zichtbaar' zijn — en die in de vorige studie hogere scores behaalden — gingen hier gepaard met relatief korte reacties. Zo werd het principe dat herhaling en oefening leren bevorderen vaak bondig verwoord, bijvoorbeeld als "er is meer oefening nodig".

Het gebruik van voorbeelden was het meest genoemde principe, waarbij een duidelijke ontwikkeling in theoretisch inzicht zichtbaar werd tussen de groepen: studenten merkten doorgaans op dat voorbeelden belangrijk zijn of dat onderwijs moet aansluiten bij de leefwereld van leerlingen, terwijl lerarenopleiders soms expliciet de relatie legden tussen contextgebruik, begrip en transfer.

Reacties op de situatie gericht op affectieve principes waren over het algemeen korter, meerdere leerprincipes werden vaker gecombineerd binnen één reactie en de formulering van antwoorden bevatte zelden conditionele constructies. Dit suggereert dat deze principes gemakkelijker worden herkend.

Vierde studie (Hoofdstuk 5)

In de vierde studie probeerden wij de oorsprong en ontwikkeling van overtuigingen en voorkennis op te helderen. Leerlingen uit het laatste jaar van het voortgezet onderwijs, waarvan de helft een loopbaan in het onderwijs ambieerde en de andere helft absoluut geen interesse had in het leraarschap, werden gevraagd zes alledaagse klassensituaties uit een scheikundeles nader toe te lichten. Dezelfde taak werd uitgevoerd door laatstejaarsstudenten van de lerarenopleiding, vóór en na een intervisietraject van acht weken.

Vier observaties leiden tot meer algemene conclusies. Ten eerste geven eerstejaarsstudenten die een onderwijsloopbaan ambiëren consequent rijkere en meer uitgewerkte reacties dan hun leeftijdsgenoten zonder interesse in het

leraarschap. Dit suggereert dat degenen die bewust kiezen voor een onderwijsopleiding reeds meer oog hebben voor klasprocessen op basis van hun eigen schoolervaringen.

Ten tweede ontstaat een groot onderscheid tussen beginnende en afstuderende studenten: de laatste groep vertoont een verschuiving van gefragmenteerd en docentgericht denken naar duidelijk meer geïntegreerd en leerlinggericht didactisch redeneren.

Ten derde lijkt het gerichte intervisieprogramma van acht weken niet te leiden tot substantiële veranderingen in de kennis van afstuderende studenten; de gegevens suggereren hoogstens dat intervisie mogelijk heeft bijgedragen aan iets meer coherent pedagogisch redeneren.

Ten vierde, lerarenopleiders in studie 1 beschouwden het gebruik van leertheorieën en leerprincipes als essentieel voor lerarenopleidingen, maar twijfelden zij aan de haalbaarheid van studenten om hun klaservaringen steeds expliciet theoretisch te onderbouwen. Deze studie laat zien dat hun kennis en overtuigingen die ten grondslag liggen aan hun overwegingen over klassensituaties, zelfs in een zeer vroeg stadium, reeds terug te voeren zijn op principes van onderwijzen en leren. Meer ervaring en een groeiende beheersing van professioneel jargon zal leiden tot een groter vermogen om de praktijk expliciet te verbinden met concrete leerprincipes.

Conclusies bij onderzoeksvraag 1:

De vraag is: Welke expliciete en impliciete conceptuele kennis en overtuigingen over leren bezitten leraren in opleiding en bevoegde leraren?

De studies 2, 3 en 4 tonen aan dat leraren beschikken over zowel impliciete als expliciete kennis en overtuigingen die kunnen worden teruggevoerd op de leerprincipes die wij onderzochten. Algemene leerprincipes werden herkend en toegepast, hoewel sommige principes sterker naar voren kwamen dan andere; vooral expliciete kennis van leerprincipes met betrekking tot de rol van voorkennis en het veranderen van bestaande kennis en opvattingen blijken beperkt aanwezig. Slechts een relatief klein deel van de deelnemers herkende geen enkel leerprincipe en echte misconcepties kwamen zelden voor, met uitzondering van het principe betreffende conceptual change. De belangrijkste bevinding in zowel de kwantitatieve als kwalitatieve resultaten is daarom de beperkte divergentie in de frequentie waarmee leraren in verschillende fasen van hun loopbaan diverse leerprincipes herkenden en toepasten, hoewel de meer gedetailleerde

studie naar leraren in opleiding (Hoofdstuk 5) wel een aanzienlijk verschil liet zien tussen beginnende en afstuderende studenten.

De kwalitatieve studies laten echter zien dat significante verschillen optraden in de mate waarin deze principes werden verwoord: lerarenopleiders en afstuderende studenten waren beter in staat hun kennis en overtuigingen gedetailleerder en met accurater professioneel jargon te formuleren dan beginnende deelnemers zonder formele opleiding.

Gezamenlijk tonen de studies aan dat bepaalde, nog onontwikkelde leerprincipes aanwezig zijn bij alle leraren (en zelfs niet-leraren) en kunnen worden begrepen als voorkennis. Het idee dat dergelijke vroege overtuigingen zich geleidelijk ontwikkelen tot complexere concepten naarmate eerdere ideeën worden verrijkt door ervaring, sluit aan bij zowel het drie-niveaumodel van Korthagen als bij de *conceptual change theory.*

Conclusies bij onderzoeksvraag 2

De vraag is: Hoe manifesteren deze kennis en overtuigingen zich in het didactisch redeneren van leraren?

Allereerst konden in het merendeel van de reacties in studies 2, 3 en 4 zowel snelle besluitvorming als meer weloverwogen redeneringen worden teruggevoerd op onderliggende leerprincipes, ongeacht of deze impliciet dan wel expliciet waren. Deze studies maken echter niet consequent duidelijk of dergelijke principes functioneren als kennis of overtuiging. Bovendien garandeert impliciete kennis of impliciete overtuigingen niet noodzakelijk dat een volledig ontwikkeld principe wordt toegepast, aangezien een principes op een abstracter niveau toepassen betekent dat transfer tussen contexten mogelijk is.

Wanneer redeneringen explicieter werden en principes steviger verankerd waren, zoals werd waargenomen bij afstuderende studenten en lerarenopleiders, werd de relatie tussen kennis, overtuigingen en didactisch redeneren echter duidelijker zichtbaar. Niettemin laat studie 4 zien dat leerlingen in het voortgezet onderwijs reeds via informele leerervaringen initiële ideeën en overtuigingen ontwikkelen over onderwijzen en leren. Aspiraties om een onderwijsloopbaan te volgen lijken daarbij de vorming van dergelijke leerconcepten te beïnvloeden en daarmee waarschijnlijk hun verdere leertrajecten te inspireren en te stimuleren.

Ten tweede werden in deze studies slechts weinig misconcepties vastgesteld, maar het blijft van belang deze te verkennen omdat niet-gedetecteerde mis-

concepties kunnen voortbestaan en zich ontwikkelen tot hardnekkige parallelle concepties.

Ten derde laat de verkenning van de voorkennis van zowel beginnende als ervaren leraren zien dat hun onderliggende leerprincipes vaak niet wezenlijk van elkaar verschillen. Hoewel beginnende studenten mogelijk het diepere begrip of de conceptuele taal missen die nodig is om deze principes expliciet te verwoorden, werden al wel waargenomen dat zij een principe in meerdere situaties toepaste.

Ten slotte erkennen lerarenopleiders (in Nederland) consequent de moeilijkheid van het onderwijzen van leertheorieën voor toepassing in de onderwijspraktijk.

Implicaties voor de lerarenopleiding.

Allereerst wordt duidelijk dat aankomende en zittende leraren in alle fasen van hun loopbaan kennis en overtuigingen over onderwijzen en leren hebben. Zelfs op hun eerste dag binnen de lerarenopleiding bezitten studenten reeds opvattingen over fundamentele leerprincipes; slechts enkelen vertonen een afwezigheid van dergelijke kennis of overtuigingen. Bovendien laten zij zien dat ze al in staat zijn te reflecteren op onderwijskundige vragen, zij het beperkt door de afwezigheid van vaktermen. Dat betekent dat lerarenopleiders zich ervan bewust moeten zijn dat studenten waarschijnlijk, althans impliciet, veel van hun ideeën over leren *delen*. Lerarenopleiders zouden daarom bereid moeten zijn het tempo van instructie te vertragen, de uitleg van ogenschijnlijk "nieuwe" theorie uit te stellen en tijd vrij te maken voor het verkennen van gedeelde fundamentele ideeën. Het werken met leraren, ongeacht leeftijd, ervaringsniveau en vakgebied, zou moeten beginnen bij het expliciteren van impliciete ervaringen, zodat een overgang mogelijk wordt van onbewust naar bewust begrip.

Ten tweede laat deze studie zien dat studenten didactisch kunnen redeneren in situaties met concrete *vakinhoud*. Om nu te voorkomen dat leren en onderwijzen los komen te staan van die vakinhoud, zouden lerarenopleiders, naast theoretische kennis, een rijk repertoire aan *vakspecifieke* praktijkvoorbeelden nodig hebben die illustreren hoe zich ontwikkelende leerprincipes binnen specifieke vakinhouden kunnen worden herkend en hoe deze functioneren. Dit stelt hen tevens in staat primaire ideeën van studenten te herkennen, ook wanneer deze nog beperkt gearticuleerd of onderontwikkeld zijn, en deze op betekenisvolle wijze te verbinden met bestaande wetenschappelijke theorie.

Ten derde, indien dergelijke voorkennis effectief verbonden moet worden met wetenschappelijke theorie op een wijze die studenten in staat stelt hun eigen

denken te herkennen binnen een breder conceptueel kader, dan lijkt het aannemelijk dat dit proces gemakkelijker gerealiseerd wordt via duidelijk afgebakende en specifieke leerprincipes dan via brede leertheorieën, zoals behaviorisme of constructivisme. Daarbij laat deze studie zien dat met name het leerprincipe 'voorkennis beïnvloedt het leerproces' en de basale rol die voorkennis speelt in meerdere andere principes, aandacht moet krijgen.

Overigens, al het bovenstaande vereist allereerst dat studenten een oprechte en duurzame focus op het *leerproces* ontwikkelen en niet alleen op didactische en onderwijskundige handelingen. Goed geïnternaliseerde principes waarmee leren kan worden herkend, kunnen motiveren om ook later nieuwe didactische benaderingen te blijven onderzoeken en erop te reflecteren.

Affectieve en cognitieve principes

De studies in hoofdstukken 3 en 4 laten zien dat affectieve leerprincipes gemakkelijker worden herkend en toegepast dan cognitieve principes, waarbij vooral het belang van motivatie sterk naar voren komt. Dit kan voortkomen uit het feit dat motivatie een breed gebruikt en intuïtief begrepen concept is in het dagelijks leven, waardoor een rijk netwerk van ervaringen en informele theorieën ontstaat. Motivatie wordt daardoor frequent en breed ingezet als verklarend concept, maar niet noodzakelijk als principe dat leerprocessen structureert. De lerarenopleiding zou baat hebben bij het expliciet verbinden van alledaagse opvattingen over motivatie aan cognitieve leerprocessen en bij het inzichtelijk maken dat motivatie niet louter een (normatief) verschijnsel aan de rand is (bijvoorbeeld: "hij heeft er gewoon geen zin in"), maar eerder het resultaat van onderliggende constructen zoals opvattingen van leraren, doeloriëntatie en emoties, zodat leraren het effect ervan op cognitief leren gaan begrijpen. De implicatie voor de lerarenopleiding is dat affectieve principes systematisch geïntegreerd dienen te worden in pedagogische redeneringen en onderwijspraktijken, bij voorkeur via expliciete modellering door lerarenopleiders.

Inductief en deductief leren

In het dagelijks leven verloopt de verwerving van nieuwe kennis doorgaans via een inductief proces, waarbij impliciete inzichten ontstaan door een opeenstapeling van ervaringen. In lijn met talrijke onderzoekers benadrukt dit proefschrift herhaaldelijk dat het leren van de complexe onderwijspraktijk fundamenteel *inductief* van aard is en daarom zou moeten beginnen met het expliciteren van concrete voorkennis van leraren in opleiding.

Hoewel dit eveneens geldt voor het onderwijzen van, bijvoorbeeld scheikunde, psychologie of onderzoeksmethodologie, is dit van bijzonder belang voor de

lerarenopleiding omdat (a) de studies in deze these laten zien dat voorkennis over leren voortkomt uit ervaring en (b) leertheorieën binnen de lerarenopleiding uitsluitend worden onderwezen met het oog op toepassing in de praktijk.

Het presenteren van leertheorieën of leerprincipes los van betekenisvolle inhoud zal waarschijnlijk onvoldoende aansluiten bij de voorkennis van leraren. Dergelijke kennis kan op oppervlakkig niveau worden begrepen, maar niet geïnternaliseerd; zij kan worden gereproduceerd, maar niet noodzakelijk toegepast. In plaats van de kloof tussen theorie en praktijk te overbruggen, kan deze benadering die kloof onbedoeld juist vergroten.

Echter, bepaalde abstracte concepten zoals voorkennis, transfer en netwerkachtige geheugenstructuren kunnen echter niet uitsluitend uit ervaring worden afgeleid. Hoewel rudimentaire ideeën hierover mogelijk reeds aanwezig zijn, vereisen deze concepten expliciete instructie. Lerarenopleiders kunnen daarbij profiteren van het identificeren van manieren waarop transfer tussen uiteenlopende ervaringen verbonden kan worden via de introductie van dergelijke abstracte concepten. Deze concepten kunnen fungeren als organiserende principes die structuur en betekenis geven aan wat leraren reeds weten.

Op dit punt kruisen inductieve en deductieve leerprocessen elkaar. Omdat dergelijke abstracte concepten zonder regelmatige verbinding met de praktijk echter uit het actieve gebruik kunnen verdwijnen, dienen zij regelmatig opnieuw geïntroduceerd en ingebed te worden in het alledaagse professionele taalgebruik. Wanneer abstracte begrippen bewust aanwezig blijven binnen de praktijk, kunnen zij reflectie stimuleren, theorievorming bevorderen en zo bijdragen aan voortdurende professionele ontwikkeling.

Reflectie

Gedurende lerarenopleidingen worden studenten voortdurend aangespoord tot bewust pedagogisch redeneren. Lesvoorbereidingen, reflectieopdrachten en gesprekken met begeleiders tijdens stages stimuleren studenten continu om hun ervaringen expliciet te maken en deze te verbinden met theorie.

Dit proces neemt echter vaak af zodra afgestudeerden de beroepspraktijk betreden. Maar zowel de literatuur als de bevindingen van dit proefschrift suggereren dat inductief leren op dat moment niet ophoudt. Integendeel, professionele ervaringen, vooral tijdens de eerste jaren van het leraarschap, blijven leiden tot de vorming van nieuwe gestalts of tot het verheffen van bestaande gestalts naar hogere theoretische niveaus. Wat vaak ontbreekt is de expliciete en bewuste reflectie op die nieuwe inzichten.

De eerste studie liet zien dat leertheorie doorgaans aan het begin van lerarenopleidingen wordt aangeboden om studenten theoretische kennis mee te geven voorafgaand aan de praktijkervaring in de klas. De deelnemende lerarenopleiders uitten echter twijfels over de geschiktheid van deze timing, gezien de beperkte didactische ervaring van studenten in deze fase. Zij suggereerden dat leertheorie mogelijk effectiever onderwezen kan worden aan het einde van de opleiding, of zelfs na afstuderen, wanneer leraren rijkere discussies kunnen voeren en daarmee meer gemotiveerd zijn om theorie in hun eigen praktijk te onderzoeken, daarop te reflecteren en toe te passen.

Gezamenlijk ondersteunen deze bevindingen de aanbeveling dat voortdurende, bewuste reflectie, zowel begeleid als onbegeleid, essentieel is voor duurzame professionele ontwikkeling, in het bijzonder gedurende de eerste jaren van het leraarschap.

Verplichte theoretische onderbouwing van praktijk in de lerarenopleiding

Een aanvullende zorg die in de eerste studie naar voren kwam, betreft de eis dat studenten didactische beslissingen theoretisch onderbouwen met leertheorieën, een principe dat binnen het hoger onderwijs, inclusief de lerarenopleiding, algemeen als fundamenteel wordt beschouwd. In hoofdstuk 2 merkten lerarenopleiders echter op dat dergelijke theoretische onderbouwingen zelden authentiek zijn. Om deze problematiek te adresseren, bouwt deze paragraaf voort op de bevindingen van deze studies, maar gaat zij tevens verder door mijn visie uiteen te zetten op mogelijke manieren om dit binnen de lerarenopleiding te verbeteren.

De bevindingen van dit proefschrift suggereren dat de redeneringen van studenten over leren, effectiever kunnen worden afgeleid uit concrete leerprincipes, die aanknopingspunten bieden voor de praktijk, dan uit abstracte leertheorieën, met name in de latere fasen van hun opleiding. Vanuit dit inzicht kunnen vier aanbevelingen voor de lerarenopleiding worden afgeleid.

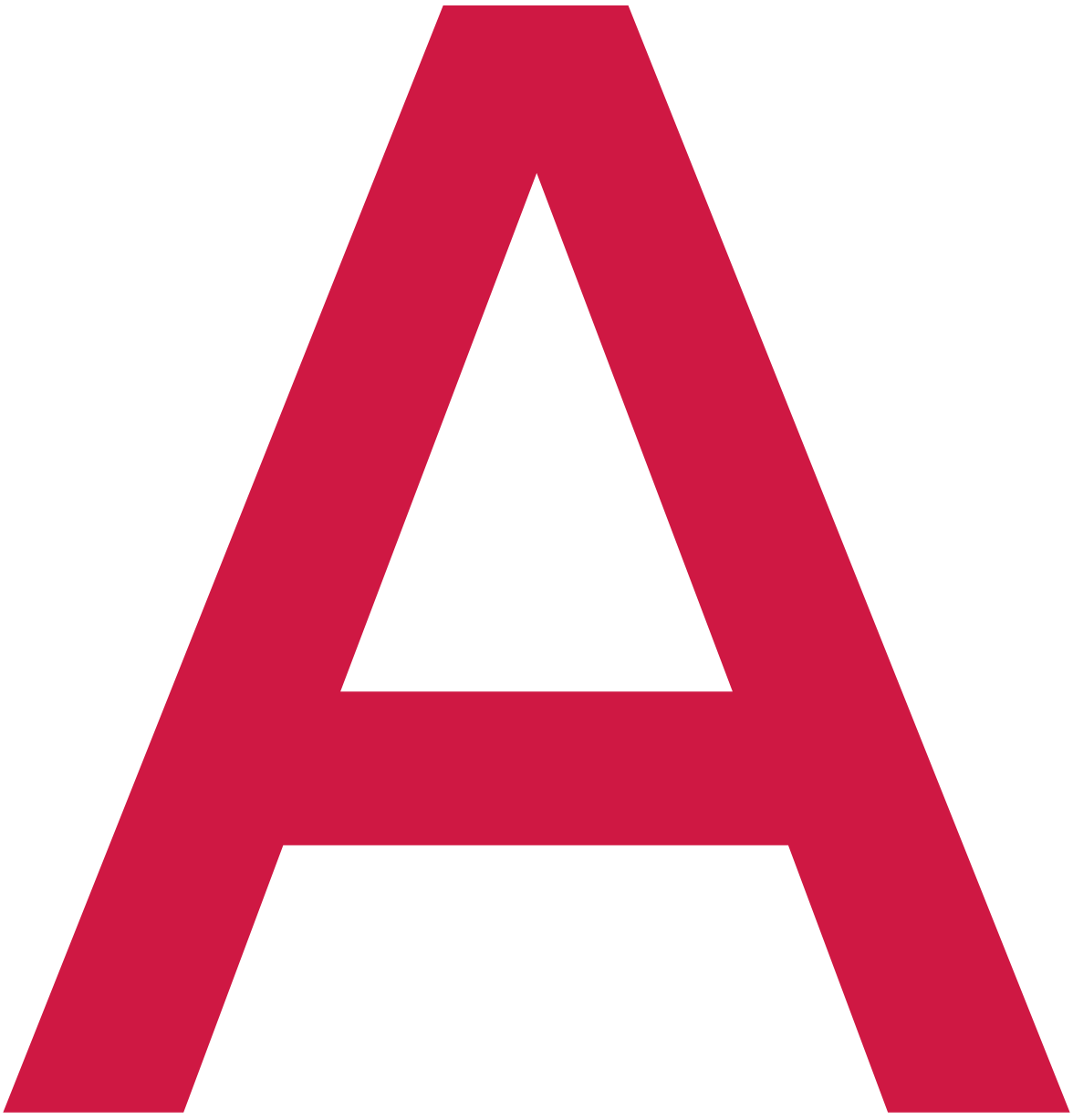
Ten eerste, gezien de complexiteit van het beroep van docent, vereist het verbinden van ervaringen aan theorie kennis van een breed scala aan theorieën en modellen. De hoofdstukken 3, 4 en 5 tonen aan dat alle deelnemers beschikken over basale opvattingen en kennis die terug te voeren zijn op een beperkt aantal leerprincipes die in wisselende mate toegepast in didactisch redeneren en beslissen. Zoals enkele lerarenopleiders in hoofdstuk 2 reeds suggereerden, menen wij daarom dat het aanbieden van een beknopte set duidelijk gedefinieerde leerprincipes die studenten gemakkelijk kunnen onthouden of raadplegen via

een beperkt aantal bronnen, effectiever is voor het zien en begrijpen van leren in de dagelijkse context dan het onderwijzen van brede en omvangrijke leertheorieën.

Ten tweede vereist de verplichting binnen het hoger onderwijs om praktijkervaringen theoretisch te onderbouwen reeds training vanaf het eerste studiejaar. "Literatuur" zou daarbij in eerste instantie beperkt kunnen worden tot één of twee principes, bij voorkeur principes waarvoor studenten reeds over voorkennis beschikken. Het initiële doel is dan om *bewustzijn* te ontwikkelen van de vraag óf en hóe deze principes functioneren binnen de eigen praktijkcontext van studenten. Dat zou idealiter leiden tot een positieve houding ten aanzien van de bruikbaarheid van leerprincipes, waarna het theoretisch repertoire geleidelijk wordt uitgebreid. Met leerprincipes is een dergelijke benadering realiseerbaar, terwijl reductie bij leertheorieën aanzienlijk moeilijker blijkt of zo algemeen blijft dat de betekenis niet wordt gezien.

Ten derde lijkt de verwachting dat praktijkproblemen uit stages achteraf gekoppeld moeten worden aan theorie, vanuit de aanname dat "de literatuur" oplossingen zal bieden voor problematische onderwijssituaties, grotendeels ineffectief en weinig representatief voor de authentieke dagelijkse onderwijspraktijk, althans volgens de lerarenopleiders uit Studie 1. Dit kan ermee samenhangen dat theoretische principes in deze situatie geen onderdeel worden van het *inductieve* leerproces. Indien het doel is theorie en praktijk daadwerkelijk te verbinden, ligt het meer voor de hand dat studenten theorie koppelen aan hun didactisch redeneren en opstellen van leerdoelen *voorafgaand* aan het onderwijsproces. Bewustzijn van een leerprincipe voorafgaand aan de praktijk vergroot de kans dat het wordt herkend, didactisch redeneren ondersteunt en het maken van keuzes op basis van kennis versterkt. Problemen die zich in latere situaties voordoen, kunnen vervolgens opnieuw aan die theorie worden gekoppeld en zo aanleiding geven tot kritische reflectie op zowel theorie als praktijk. De opbouw van kennis via een inductief proces wordt zo beter ondersteund.

Ten slotte zouden studenten idealiter regelmatig worden gewezen op concrete voorbeelden waarin leerprincipes zichtbaar in werking zijn. Dit begint bij voorkeur reeds binnen de opleiding zelf, via de meta-communicatie van lerarenopleiders over leerprincipes die zichtbaar worden in hun eigen onderwijs, evenals via expliciete bespreking van leerprincipes tijdens gezamenlijke reflectie met begeleiders gedurende stages.



OVER DE AUTEUR

OVER DE AUTEUR

Erik Meij (1965) groeide op in Vianen (Ut). Na het behalen van het havo diploma aan het Cals College in Nieuwegein, volgde hij de laboratoriumopleiding aan de toenmalige Haagse Analistenschool en studeerde scheikunde aan de universiteit Utrecht. Hij trad in 1987 in dienst bij DSM Resins in Zwolle waar hij 15 jaar in verschillende rollen onderzoek deed aan thermohardende polymeren voor constructies, drukinkt en UV-hardende systemen. In die tijd deed hij een lerarenopleiding met het vooruitzicht ooit het onderwijs in te stappen. In 2000 verliet hij het bedrijfsleven, ontwikkelde een aantal dansprojecten en werkte drie jaar in de jeugdhulpverlening.

In 2002 kwam hij terecht op de tweedegraads lerarenopleiding van de hogeschool Windesheim in Zwolle als lerarenopleider. Daar verzorgt hij nog steeds onderwijs in chemie en didactiek en begeleidt studenten in hun ontwikkeling naar leraarschap. In 2014 volgde hij een master in onderwijskunde aan de VU Amsterdam en in 2019 kreeg hij een NWO promotiebeurs voor leraren waarmee dit promotieonderzoek tot stand kwam.

About the Author

Erik Meij (1965) grew up in Vianen (Ut). After obtaining his HAVO diploma from Cals College, he completed laboratory training at the former Haagse Analistenschool and subsequently studied Chemistry at Utrecht University. In 1987, he joined DSM Resins in Zwolle, where for fifteen years he conducted research in various roles on thermosetting polymers for construction applications, printing inks, and UV-curing systems. During this period, he also completed a teacher training programme with the intention of eventually entering the field of education. In 2000, he left industry, developed several dance projects, and worked for three years in youth care services.

In 2002, he joined the teacher education programme for lower-secondary education at Windesheim University of Applied Sciences as a teacher educator. There, he still teaches chemistry and subject pedagogy and supervises student teachers in their professional development towards becoming teachers. In 2014, he completed a Master's degree in Educational Sciences at Vrije Universiteit Amsterdam and in 2019, he was awarded an NWO doctoral scholarship for teachers, through which the present doctoral research was undertaken.

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