Educational Research and Innovation

Pedagogical Knowledge and the Changing Nature of the Teaching Profession

Edited by Sonia Guerriero

Centre for Educational Research and Innovation

OECD

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Foreword

Highly qualified and competent teachers are the key for excellent education systems. This has been a constant message resulting from the Organisation for Economic Co-operation and Development (OECD) work on education through programmes such as the Programme for International Student Assessment (PISA) and the Teaching and Learning International Survey (TALIS). In a knowledge society, teachers are also increasingly seen as knowledge professionals, working at the frontline of one of society's most important knowledge creation and transfer systems: education. But what does that mean when we qualify teachers as knowledge professionals? This has been the fundamental question for the Centre for Educational Research and Innovation (CERI) to embark on the Innovative Teaching for Effective Learning *(ITEL) project.*

Teachers are expected to process and evaluate new knowledge relevant to their core professional practice and to regularly update their profession's knowledge base. This challenge is situated in a rapidly changing educational system, which is expected to deliver on "21st century skills" in increasingly more diverse classrooms, and conditioned by expanding research-based scientific knowledge base on teaching and learning. This process of continuous renewal of teachers' professional knowledge is an important part, maybe the most important, of teachers' professionalisation. These new demands and opportunities might require teachers to update their teaching methods, employ innovative teaching practices and mobilise various sources of knowledge. For some countries, this might entail a re-skilling of the current teaching workforce and upgrading of the profession's knowledge base within teacher education institutions and through professional communities. Understanding what the current knowledge base looks like will help determine whether and to what extent upgrading teachers' skills is required.

The idea for this book came about as a result of a symposium held in June 2014 that was organised by the CERI in collaboration with the Flemish Department of Education and Training. The purpose of the symposium was to bring together a group of leading experts to support the conceptual development of the ITEL project. Its purpose is to better understand the pedagogical core of the teaching profession, namely, teachers' pedagogical knowledge, and how it relates to teachers' professional competences and student learning.

In order to contextualise the current landscape in the field, the symposium entitled "Teachers as Learning Specialists – Implications for Teachers' Pedagogical Knowledge and Professionalism" was developed to explore the pedagogical knowledge base of the teaching profession and investigate to what extent that knowledge is up-to-date. In particular, the Symposium aimed to provide insight into conceptual and empirical research regarding the following questions:

1. *What is the nature of the pedagogical knowledge base of the teaching profession?*
   - *How is teachers' general pedagogical knowledge conceptualised? Is it multi-dimensional, and if so, what are the various cognitive dimensions and can these be measured?*
   - *How do teachers' motivations and beliefs about teaching relate to their pedagogical knowledge and how can these relationships be measured?*

- *How does teachers' pedagogical knowledge impact student learning outcomes?*
- *What is the relationship between pedagogical knowledge and teachers' overall professional competence, and how can it be measured?*

2. *Is the pedagogical knowledge of the teaching profession up-to-date?*
   - *Does the knowledge base of teachers sufficiently incorporate the latest scientific research on learning? Can scientific research inform teachers about how to create effective teaching-learning environments?*
   - *Does the current state of teachers' pedagogical knowledge meet the expectations for teaching and learning "21st century skills"?*

This publication is the first of two volumes produced as part of the ITEL project. The objective is to frame the conceptual basis for the development of an instrument to assess teachers' pedagogical knowledge. The second volume will summarise the results of a pilot study in which the instrument was developed and show its analytical potential in exploring teachers' professional competence, in particular, their general pedagogical knowledge.

This publication was edited by Sonia Guerriero of the Centre for Educational Research and Innovation (CERI). Within the OECD Secretariat Francesca Gottschalk, Emily Heppner, Matthew Gill, Rachel Linden and Nóra Révai provided valuable editorial support.

Dirk Van Damme
Head of the Innovation and Measuring Progress Division
Directorate for Education and Skills

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Secondly we would like to express our gratitude to the authors who contributed to this publication (in order of their chapters): Karolina Deligiannidi, Diana Toledo-Figueroa, Sigrid Blömeke, Kathleen Stürmer, Tina Seidel, Johannes König, Fani Lauermann, Daniel Ansari, Marilyn Leask, Tracey Tokuhama-Espinosa and James W. Pellegrino.

Other contributors we would like to thank include Francesca Gottschalk, who developed text boxes for Chapter 9 as well as contributing considerably to editing. Emily Heppner, Rachel Linden, Nóra Révai and Matthew Gill - who combined have contributed to both editing and the preparation for publication.

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Last but not least, we would like to thank the members of the CERI Governing Board who have provided various comments and input throughout the different phases of this publication.

Sonia Guerriero,
Editor

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Executive summary

Teachers possess highly-specialised knowledge that continually transforms as new knowledge emerges from practice and research or is shared through professional communities. Pedagogical knowledge, that is, knowledge of teaching and learning, refers to the specialised body of knowledge of teachers for creating effective teaching and learning environments for their students. There is agreement that competence in teaching requires a high level of pedagogical knowledge, but there is still the need to assess teacher knowledge as an outcome of teacher education systems and as a predictor of effective teaching and student achievement. These questions are important for OECD countries to improve the policies of the teaching workforce, including initial teacher education, induction and mentoring, and professional development. This publication therefore aims to summarise and synthesise conceptual and empirical work that can contribute to policy development in this area.

Pedagogical Knowledge and the Changing Nature of the Teaching Profession is based on an OECD/Centre for Educational Research and Innovation (CERI) Symposium on "Teachers as Learning Specialists – Implications for Teachers' Pedagogical Knowledge and Professionalism" held in June 2014 in collaboration with the Flemish Department of Education and Training. It brings together research from the OECD Secretariat and papers by leading experts to examine the current status of teachers' knowledge base and implications for the instructional process. It is structured in three parts as follows.

Teacher knowledge and the teaching profession

Knowledge dynamics may be viewed as a complex system, in which multiple actors interact to shape teachers' knowledge. This includes the importance of empowering teacher educators and teachers themselves to take charge of teachers knowledge base.

Part I provides a broad contextual view on teachers' knowledge by investigating the knowledge dynamics in the profession and how teachers' knowledge is described in some key documents.

The introductory chapter by **Sonia Guerriero** and **Karolina Deligiannidi** presents a contextual overview of the teaching profession and the rationale for investigating teachers' pedagogical knowledge.

The chapter by **Nóra Révai** and **Sonia Guerriero** reviews the literature on knowledge dynamics in the teaching profession and proposes a framework of analysis consisting of structural, functional and social dimensions. The authors argue that targeting the improvement of teacher learning, with a special focus on strengthening the links between the agents of teacher learning, is an approach that has potential to facilitate the dynamics of teachers' knowledge.

Diana Toledo-Figueroa, **Nóra Révai** and **Sonia Guerriero's** chapter explores how teachers' professionalism and pedagogical knowledge are manifested through qualifications frameworks and professional standards. Using the metaphor of a "knowledge wall", the authors illustrate how the two frameworks relate to each other and examine how different types of knowledge components are described in five professional standards.

Measuring teacher knowledge and professional competence: Challenges and opportunities

General pedagogical knowledge is relevant for high quality instruction, but teachers' affective-motivational characteristics also matter.

Part II explores conceptual and empirical work on teachers' pedagogical knowledge and how to measure pedagogical knowledge as an indicator of teacher quality.

First, **Sonia Guerriero's** chapter reviews the empirical literature on teachers' pedagogical knowledge. The review includes the teaching and learning process, teacher knowledge and its relationship to student learning outcomes, how teachers apply their knowledge in decision-making and how pedagogical knowledge is learned and developed. The author concludes by summarising implications for teacher education.

Sigrid Blömeke's chapter proposes a multidimensional model of teacher competence that includes both cognitive and affective-motivational facets. Blömeke models teacher competence as a continuum that includes perception, interpretation and decision-making skills as mediating processes in the transformation of knowledge into performance. The author presents empirical studies that measure teacher competence. In particular she draws the attention to the various challenges of assessing situation-specific teacher skills.

In the next chapter, **Kathleen Stürmer** and **Tina Seidel** introduce the concept of "professional vision" to show how teachers draw on their generic pedagogical knowledge about effective teaching and learning to notice and interpret relevant features of classroom situations. The authors present a tool with which future teachers' professional vision can be assessed. Their findings reveal that both formal and informal opportunities to learn are related to higher levels of professional vision.

In this chapter, **Johannes König** explores the relationship between motivations for teaching and the general pedagogical knowledge of teachers to further examine the underlying motivational factors that drive expert teaching. The empirical studies presented suggest that teaching motivations influence knowledge acquisition during initial teacher education. The author recommends further exploring the relationship between motivation and teaching in future research.

Finally, **Fani Lauermann** describes different theory-driven conceptualisations of teacher motivation, and explores teachers' "self-responsibility" as a motivational construct to understand how teachers perceive their professional responsibilities. The author argues that besides knowledge and skills, teachers' motivational characteristics, such as their beliefs about their teaching abilities, expectancies and values and perceived responsibilities are necessary ingredients of teacher professionalism. She also highlights some methodological and theoretical challenges to be addressed in future work.

21st Century Demands on Teacher Knowledge

Emerging evidence has the potential to broaden teachers' pedagogical knowledge about student learning however more is required to be able to improve pedagogy, teacher education and professional development of teachers.

Part III is designed to be forward-looking and explores the impact of 21st century demands on teachers' knowledge and the teaching profession.

Daniel Ansari, Johannes König, Marilyn Leask and **Tracey Tokuhama-Espinosa** make a case for teachers to incorporate findings from the "Science of Learning" into their knowledge base. Ansari and his colleagues argue that teachers play a key role in shaping the brains of their students. Teachers who understand basic neuroscience concepts and the mechanisms that underlie learning can enhance the cognitive engagement of their students and help realise the potential for each and every student to learn.

James Pellegrino's chapter is based on a review on definitional issues regarding 21st century skills and terms like 'deep learning' and 'transfer of knowledge.' The author reviews the state of empirical evidence showing that these various competencies matter for success in endeavours such as education, work and other aspects of adult life, but that there are challenges in teaching for transfer and assessment.

Bringing together the work in this volume, the last chapter by **Sonia Guerriero** and **Nóra Révai** presents a new conceptual framework of teachers' professional competence. It formulates three interconnected challenges regarding pedagogy, teacher learning and the teaching profession. Finally, the chapter proposes a study that would contribute to filling the evidence gaps and addressing the challenges highlighted in this volume.

PART I

Teachers' knowledge and the teaching profession

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Chapter 1

The teaching profession and its knowledge base

by
Sonia Guerriero and Karolina Deligiannidi
OECD

This chapter outlines the context for investigating teacher knowledge by providing a brief overview of the teaching profession. First, we summarise some of the sociological literature on professions, including how professions have been conceptualised, what their main attributes are and how teaching is seen within these approaches. Second, we review the main factors that have exerted influence on the status of the teaching profession such as autonomy, governance, self-regulation and teacher education. These reflections prompt questions on teachers' scientific knowledge base, their professional competence and how the two are related. Questions raised in this introduction provide the rationale for this publication: the need to derive evidence-informed suggestions for educational policy and future research by examining the current state of teachers' pedagogical knowledge and implications for the instructional process.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

To introduce the major policy and research issues concerning teachers and knowledge, this chapter provides the reader with a contextual overview of the teaching profession. Scholars from different fields have been trying to operationalise what a profession is and what its attributes are. The status of teaching as a profession has been largely debated. This chapter is not meant to provide an extensive review of literature; rather it introduces some of the arguments in this debated field and thus serves as a rationale for investigating teachers' pedagogical knowledge as a component of professional competence.

Contextualising the teaching profession

In recent decades the teaching profession has been on the policy agenda of most OECD countries and partner economies. Some of the key issues include how to attract motivated and high-achieving candidates to the profession, how to retain quality teachers and how to improve initial teacher education and professional development. The teacher clearly contributes to student learning and achievement, and the empirical research base showing the value of high quality teachers in learning outcomes is growing. For example, even after accounting for prior student learning and family background characteristics, several studies indicate that teacher quality is an important factor in determining gains in student achievement (Darling-Hammond, 2000; Hanushek, Kain and Rivkin, 1998; Muñoz, Prather and Stronge, 2011; Wright, Horn and Sanders, 1997).

Often, the status of the profession has been implicated in the recent challenge in recruiting and retaining good teachers. The teaching profession is perceived to have a lower status than other professions such as medicine, law or engineering (Ingersoll and Merill, 2011). However, defining what is meant by the status of a profession in general, and the status of the teaching profession in particular has long been debated. In 1966, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Labour Organisation (ILO) addressed the importance of the status of the teaching profession. The publication "The ILO/UNESCO Recommendation concerning the Status of Teachers" states that:

> "*the expression 'status' as used in relation to teachers means both the standing or regard accorded them, as evidenced by the level of appreciation of the importance of their function and of their competence in performing it, and the working conditions, remuneration and other material benefits accorded them relative to other professional groups.*" (UNESCO/ILO, 2008: 21).

Commonly, the word "status" is used as a generic term to indicate social standing. Scholars, however, have proposed to operationalise the concept by decomposing it. For example, Hoyle (1995a; 2001) proposes to distinguish occupational status from occupational prestige and esteem. According to Hoyle (2001), occupational status is the category to which knowledgeable groups (e.g. politicians, sociologists) allocate an occupation. On the other hand, occupational prestige is "the public perception of the relative position of an occupation in a hierarchy of occupations" (Hoyle, 2001: 139), whereas occupational esteem is "the regard in

which an occupation is held by the general public by virtue of the personal qualities which members are perceived as bringing to their core task" (Hoyle, 2001: 147). In their usage of the word, UNESCO/ILO appear to be referring to the concepts of prestige and esteem.

Status is a relative concept and shows cross-cultural variation (Hargreaves, 2009). In the review which follows, we show that the status of the teaching profession is closely linked to whether teaching is (or is not) acknowledged as a profession. Sociologists have been interested in the study of professions for a long time, and we briefly review some of this debate as it relates to teaching, before returning to discussing the status of the teaching profession specifically.

What is a profession?

There are different approaches to characterising professions and those that are based on determining criteria may emphasise different elements. Many scholars have written about the distinction between professions and semi-professions, and for one reason or another, some have characterised teaching as a semi-profession (e.g. Hoyle, 2001; Howsam et al., 1985; Krejsler, 2005; Ingersoll and Merrill, 2011). For example, Howsam et al. (1985), who use a taxonomic approach to defining professions, conclude that teaching is a semi-profession because it does not have all the characteristics of a profession, as illustrated in Box 1.1.

Professions and semi professions

Howsam et al. (1985) classify teaching as a semi-profession because it lacks one of the main identifying characteristics of a full profession: professional expertise. They argue that teaching lacks a common body of knowledge, practices and skills that constitute the basis for professional expertise and decision-making. This is a consequence of the practice of teaching not being founded upon validated principles and theories. In their view, few teachers use existing scientific knowledge, nor do they contribute to building a scientific knowledge base through the development of principles, concepts and theories or to validating practices. As a consequence, there are no agreed-upon performance standards for evaluating teachers to continue in the profession. Importantly, the quality of the preparation of teachers and induction into the profession is poor as a consequence of the absence of a common body of scientific knowledge underpinning professional expertise and transmitted via teacher educators during initial teacher education.

Likewise, Hoyle (1995b) argues that teaching satisfies some but not all criteria of a profession. His defining criteria, also within a taxonomic perspective, are somewhat different from those of Howsam et al., but there are some important similarities. For example, in characterising full professions, Hoyle (1995b: 12) argues that "although knowledge gained through experience is important, this recipe-type knowledge is insufficient to meet professional demands and the practitioner has to draw on a body of systematic knowledge". Furthermore, in the case of professions, the acquisition of knowledge and development of specific skills requires a lengthy period of higher education and training, during which the practitioner undergoes a process of socialisation to the professional values, centred on the client's interests and made explicit through a code of ethics. Like Howsam et al., Hoyle considers decision-making to be an important characteristic of professions because professions require the practice of skills in situations that are not routine and where professional judgement, based on a systematised body of knowledge, will need to be exercised when encountering new problems. Both scholars stress the importance of

autonomy over professional judgement regarding daily practice, as well as autonomy over control of regulating the profession, such as the setting of admissions criteria, performance standards and licensing.

Box 1.1. **Characteristics of a profession**

1. Professions are occupationally related social institutions established and maintained as a means of providing essential services to the individual and society.
2. Each profession is concerned with an identified area of need or function (e.g. maintenance of physical and emotional health, preservation of rights and freedom, enhancing the opportunity to learn).
3. Collectively and individually the profession possesses a body of knowledge and a repertoire of behaviours and skills (professional culture) needed in the practice of the profession; such knowledge, behaviour and skills normally are not possessed by the non-professional.
4. The members of the profession are involved in decision making in the service of the client, the decisions being made in accordance with the most valid knowledge available, against a background of principles and theories, and within the context of possible impact on other related conditions or decisions.
5. The profession is based on one or more underlying disciplines from which it draws basic insights and upon which it builds its own applied knowledge and skills.
6. The profession is organised into one or more professional associations which, within broad limits of social accountability, are granted autonomy in control of the actual work of the profession and the conditions which surround it (admissions, educational standards, examination and licensing, career line, ethical and performance standards, professional discipline).
7. The profession has agreed-upon performance standards for admission to the profession and for continuance within it.
8. Preparation for and induction to the profession is provided through a protracted preparation programme, usually in a professional school on a college or university campus.
9. There is a high level of public trust and confidence in the profession and in individual practitioners, based upon the profession's demonstrated capacity to provide service markedly beyond that which would otherwise be available.
10. Individual practitioners are characterised by a strong service motivation and lifetime commitment to competence.
11. Authority to practice in any individual case derives from the client or the employing organisation; accountability for the competence of professional practice within the particular case is to the profession itself.
12. There is relative freedom from direct on-the-job supervision and from direct public evaluation of the individual practitioner. The professional accepts responsibility in the name of his or her profession and is accountable through his or her profession to the society.

Source: Howsam, R. B., et al. (1985), "Educating a profession", http://eric.ed.gov/?id=ED270430.

A semi-profession meets some, but not all, of the criteria for professions. For example, Etzioni (1969) describes semi-professions as occupations where training is shorter, status tends to be less legitimated, there is a less established right to privileged communication, a less specialised body of knowledge and less autonomy from supervision or societal control than professions. In some cases, semi-professions are occupations that are in the process of becoming professions through a process known as "professionalisation". This process refers to achieving the status of a profession (Evetts, 2012), or "the degree to which occupations exhibit the structural or sociological attributes, characteristics and criteria identified with the professional model" (Ingersoll and Merrill, 2011: 186). Box 1.2 illustrates the characteristics of semi-professions as proposed by Howsam et al. who compiled the characteristics from various sources.

Box 1.2. **Characteristics of a semi-profession**

1. Lower in occupational status.
2. Shorter training periods.
3. Lack of societal acceptance that the nature of the service and/or the level of expertise justifies the autonomy which is granted to the professions.
4. A less specialised and less highly developed body of knowledge and skills.
5. Markedly less emphasis on theoretical and conceptual bases for practice.
6. A tendency for the professional to identify with the employment institution more and with the profession less. (This difference is not due to the condition of employment, but to the identity of the practitioners.)
7. More subject to administrative and supervisory surveillance and control.
8. Less autonomy in professional decision-making with accountability to superiors rather than to the profession.
9. Management of organisations within which semi-professions are employed by persons who have themselves been prepared and served in that semi-profession.
10. Absence of the right of privileged communication between client and professional.

Source: Howsam, R. B., et al. (1985), "Educating a profession", http://eric.ed.gov/?id=ED270430

The concept of professionalism

Defining when an occupation is or is not a profession is closely related to the discourse of professionalism. For example, Freidson (2001) names two basic assumptions underlying the professionalism of an occupation: (1) unique and specialised tasks that can only be performed by members of the occupation who have the required formal training and experience and (2) work that cannot be standardised, rationalised or commodified. Freidson (2001: 2) defines professionalism as a "set of interconnected institutions providing economic support and social organisation that sustains the occupational control of [the] work". Professionalism exists "when the organized occupation gains the power to determine who is qualified to perform a defined set of tasks, to prevent all others from performing that work, and to control the criteria by which to evaluate performance" (Freidson, 2001: 12). The ideal elements of professionalism as proposed by Freidson are illustrated in Box 1.3.

Box 1.3. **Elements of professionalism**

1. Specialised work in the officially recognised economy that is believed to be grounded in a body of theoretically based, discretionary knowledge and skill and that is accordingly given special status in the labour force
2. exclusive jurisdiction in a particular division of labour created and controlled by occupational negotiation
3. a sheltered position in both external and internal labour markets that is based on qualifying credentials created by the occupation
4. a formal training programme lying outside the labour market that produces the qualifying credentials, which is controlled by the occupation and associated with higher education
5. an ideology that asserts greater commitment to doing good work than to economic gain and to the quality rather than the economic efficiency of work.

Source: Freidson, E, (2001), *Professionalism, the Third Logic*, Polity, Cambridge.

The concept of professionalism can also be used to describe the attitudes and psychological attributes of members of a profession or of those aspiring to be professionals (Ingersoll and Merrill, 2011). Pratte and Rury (1991, as cited in Shon, 2006: 4) define professionalism as "an ideal to which individuals and occupational groups aspire in order to distinguish themselves from other workers". Thus, professionalism could be perceived as an occupational value.

Hargreaves (2000) investigated the historical processes underlying the development of teacher professionalism among several different countries and identified four phases: the pre-professional age, the age of the autonomous professional, the age of the collegial professional and the age of the post-professional or postmodern professional. Teaching in the pre-professional era was considered to be "technically simple". It employed the transmission method of teaching, and training occurred through apprenticeships by observing more experienced teachers. Beginning in the 1960s, during the age of the autonomous professional, teacher salaries increased and teacher education was increasingly based on university courses. Teaching practice and classroom pedagogy became subjects of inquiry. During the age of the collegial professional, beginning in the 1980s, teachers became members of professional communities. Teachers participated in professional collaborations and teacher education was moved to universities. However, the 1980s also saw the introduction of educational reforms and increasing complexity in education governance. By consequence, teachers' roles and responsibilities began to change. The current post-professional age is being influenced by economics, globalisation and digital communication, and these changes are bringing further uncertainty to teachers' professionalism. As a consequence, the status of the teaching profession, as it relates both to its prestige as well as to its governance, is being influenced by various factors, including sociological, political, cultural and economic ones.

The status of the teaching profession

The above review suggests that one reason the status, or social standing, of the teaching profession is difficult to define could be due to teaching being placed more along the lines of a semi-profession than a profession. There are several interrelated core characteristics of professions which are not necessarily apparent in the teaching profession: (1) a profession-specific, systematised and scientific body of knowledge that informs the daily activities of practitioners; (2) a lengthy period of higher education training and induction,

and continuous professional development and (3) autonomy, both in connection with the right to exercise professional judgement and decision-making in practice and in governance over the profession. These three characteristics are at the heart of a profession. At the same time, new scientific knowledge is continuously incorporated into the profession often by practitioners themselves, as they have the expertise for evaluating the applicability of new research for practice. Due to their specialised knowledge and lengthy training, the practitioner is granted the freedom, autonomy and trust to decide on the most appropriate course of action by members of society, as well as self-regulation and autonomy over governance. Governance and self-regulation seem to be closely associated with professional autonomy, and it can be argued that a profession that does not have control over itself is by consequence less prestigious.

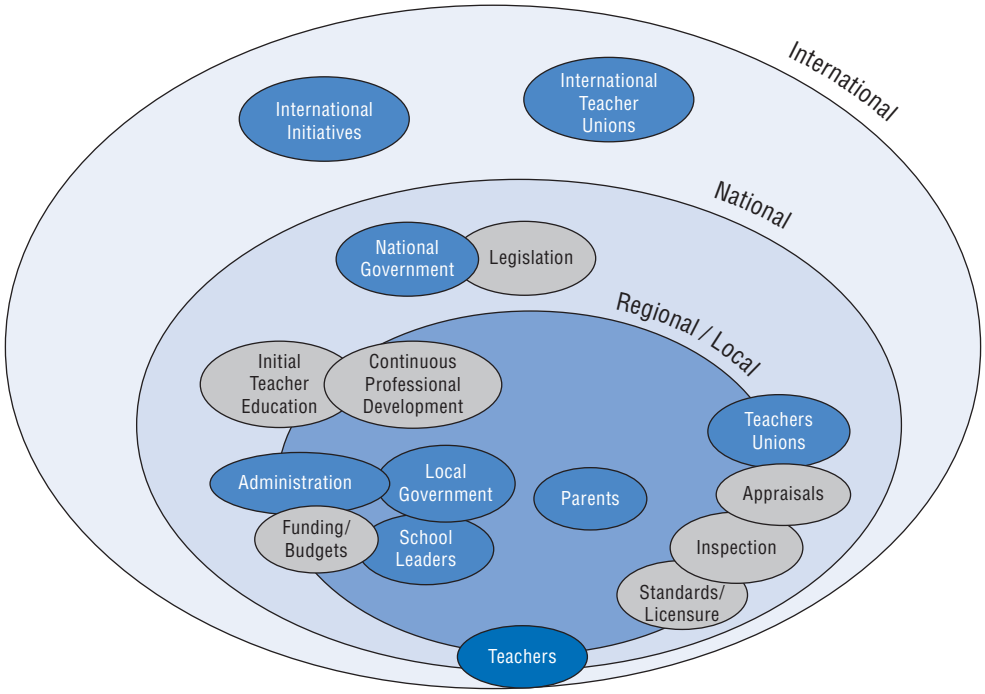
Teaching governance and autonomy

Indeed, issues of governance and self-regulation are two factors that have exerted a strong (often negative) influence on the status of the teaching profession in recent years. Hargreaves (2000) argues that, up until the collegial era, the occupational changes in teaching had been moving toward increasing teacher autonomy and by consequence teacher professionalism. However, since then and continuing today, the intensification of educational reforms and governance structures that are becoming increasingly more complex are eroding teachers' autonomy, resulting in a path towards the de-professionalisation of teaching. Some argue that teachers have lost whatever autonomy they might have had in decision-making over pedagogical theory and their classrooms and have become functionaries or employees of hierarchical organisations (Lortie, 1975 in Biddle, 1995). Performance-based compensation schemes are an example of how teachers are perceived as employees who are expected to achieve certain outcomes in order to earn their salaries. Other evidence suggests, to the contrary, that recent decentralisation trends increase schools' autonomy and also enlarges professional autonomy of teachers (Burns and Köster, 2016). Regardless of these arguments, a number of scholars have similarly argued that autonomy is one of the basic elements of teacher professionalism (Whitty, 2008; OECD, 2016a) and one of the key identifying characteristics of a profession (e.g. Etzioni, 1969; Hoyle, 1995b; Howsam et al., 1985; Reagan, 2010).

The extent of autonomy in the teaching profession is context dependent and varies both between and within countries. Within each context, the extent of autonomy granted to teachers will be the result of how the profession is governed at local or regional, national and international levels, and in the case of the teaching profession, its governance is dependent on the governance of education as whole. To illustrate the complexity involved in the governance of the teaching profession, Figure 1.1 displays some of the major factors (and this is not an exhaustive set) that come into play in the governance of the profession – much of them having to do with the increase in accountability of education systems in recent decades. For example, the extent of decision-making power that teachers have over factors such as school inspections, teacher appraisal, performance standards, credentialing and licensure, will determine the degree of autonomy teachers have over their profession in their context. According to Hargreaves and Flutter (2013), the increasing emphasis on accountability through national or international tests of student performance is likely to influence the status of the profession. This is related to issues of trust in the profession; whether teachers are considered responsible for what they do and how they can affect the extent to which they are trusted, and by consequence whether their profession as a whole is trusted.

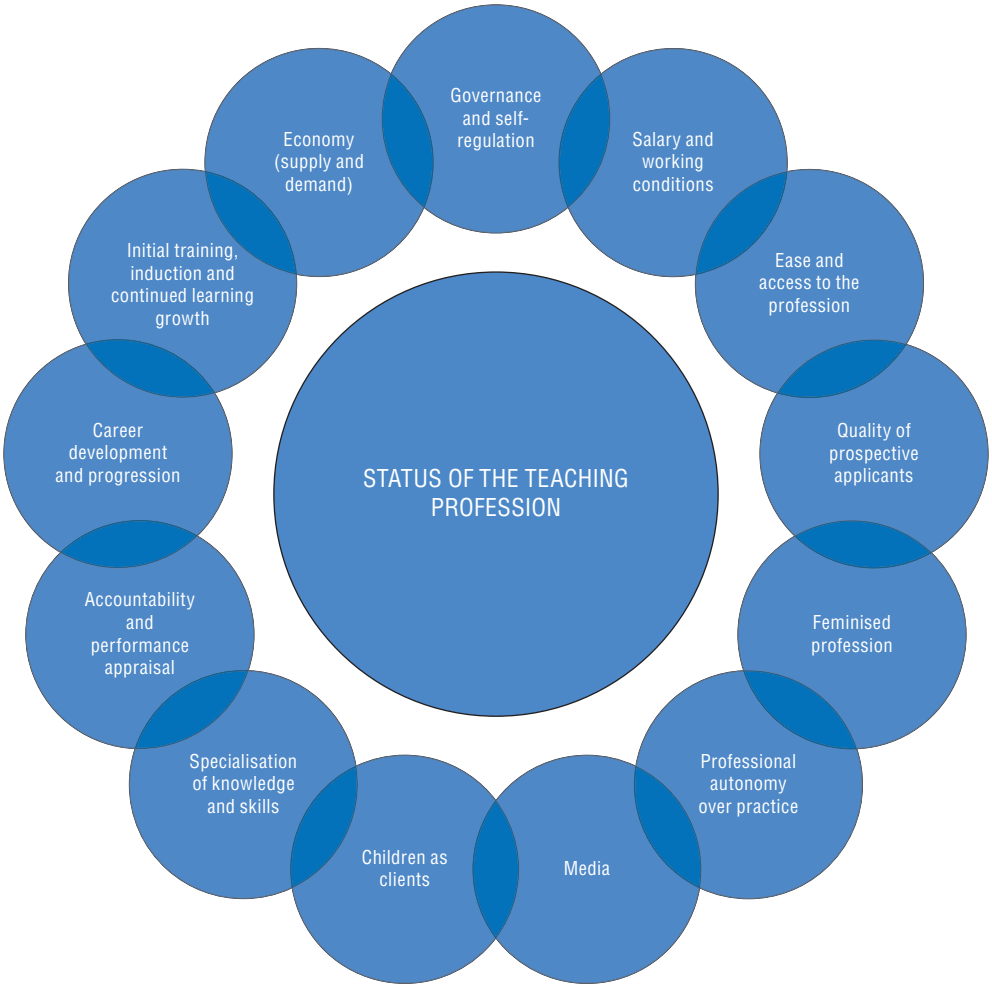
The less decision-making power granted to teachers within this complex system, the less autonomous the profession. By consequence, the profession is perceived as less prestigious. Indeed, empirical data exist to support this relationship. The Teaching and Learning International Survey (TALIS), which collects teachers' self-reported perceptions about the learning environment and working conditions in their schools, shows a strong positive association between the extent that teachers participate in decision-making and the likelihood that society values teaching as a profession (OECD, 2014a). In countries where teachers are not included as decision-makers, the teaching profession is less likely to be valued in society.

Figure 1.1. **Factors affecting the governance of the teaching profession**



Governance and autonomy are just two of the factors that are frequently debated in the literature related to their influence over the status of the teaching profession. There are a range of other factors which in combination interact in complex ways to determine the resulting status, as illustrated in Figure 1.2 (in no particular order). Two that have been debated at length by policy makers and economists alike are salary and working conditions. In writings related to the sociology of professions, Hoyle (1995b) identified one noteworthy characteristic of full professions that does not appear in the list of Howsam et al. (1985). According to Hoyle (1995b: 13), "lengthy training, responsibility, and client-centeredness are necessarily rewarded by high prestige and a high level of remuneration". Likewise, in the UNESCO/ILO (2008: 21) recommendation, the word "status" is used to refer to "the working conditions, remuneration, and other material benefits accorded them [teachers] relative to other professional groups".

Figure 1.2. **Possible determinants of the status of the teaching profession**



Indeed, salary and working conditions are often implemented as policy levers for improving the profession's prestige. This is because in most OECD countries and partner economies teacher salaries are lower compared to occupations requiring equivalent levels of education, and the salary difference is often cited as one of the primary reasons for the perception of the profession's lower status. For example, OECD data indicate that across OECD countries primary-school teachers earn on average 81% of the salary of a tertiary-educated 25-64 year-old full-time, full-year worker; lower-secondary teachers are paid 85% of that benchmark; and upper-secondary teachers are paid 89% of that benchmark salary (OECD, 2016b). In terms of working conditions, factors often cited as negatively impacting the profession's status include large class sizes, long teaching hours, excessive workloads, poor job security, lack of instructional resources, poor school safety, little or no access to professional development opportunities and excessive administrative duties (Leitwood, 2006). Some policy initiatives have tried to improve one or more aspects of teachers' working conditions for raising the status of the profession with varying degrees of success (Hargreaves et al., 2007).

Public perceptions of the teaching profession

One factor that might play a role in shaping the public's perception of the teaching profession is the media (Cameron, 2003). Media sources can portray a negative image of teaching, usually through film, but often via news reports, for example, when there are contract disputes between the government and teacher unions (Hargreaves et al., 2007). Others have written about how the importance of the "clients" of a profession affect its prestige (Eraut, 1994). In the case of teaching, the clients are children, and because children have a lower social standing than adults, by consequence the profession is lower in social status. Also, patriarchal attitudes in societies may contribute to the devaluation of teaching due to the high proportion of women in the profession (Hoyle, 1995a).

Indeed, teaching is predominantly a women's profession. According to recent OECD data (2016b), women make up 97% of teachers at the pre-primary level, 82% at the primary level, 68% at the lower secondary level, 58% at the upper secondary level, and only 43% at the tertiary level. Additionally, recent international reports indicate that the proportion of female teachers is increasing (Commonwealth Secretariat and UNESCO, 2011). Interestingly, "a preponderance of women" is argued to be a characteristic of semi-professions identified by Howsam et al. (1985: 18). Often referred to as the "feminisation" of the teaching profession, the overrepresentation of female teachers has been argued to have a detrimental effect on its occupational status (Hoyle, 1995a).

Some have argued that the overrepresentation of female teachers may partly be the result of the profession attracting individuals (irrespective of gender) who value predictable work hours and long summer vacations because this corresponds well to the schedules of families with children (Podgursky, 2003, 2011). Because of issues such as family responsibilities and structural barriers such as limited opportunities for promotion, teaching is often perceived to be "career-less" (Lortie, 2002). OECD data indicate that, in most countries, opportunities for promotion and new responsibilities are generally limited for teachers who want to stay in the classroom (Schleicher, 2011). Even when upward mobility is an option, salaries are still smaller in relation to other hierarchical organisations. Poor career prospects and limited opportunities for continued learning and professional growth contribute to lowering the profession's prestige (Hargreaves, 2009).

Accessibility

The teaching profession is generally viewed as easily accessible. When compared to other professional occupations such as medicine or law, selection into initial teacher education is not competitive. Factors such as the quality of prospective applicants into initial teacher education programmes and minimum entry requirements are highly related to occupational prestige. For example, it has been argued that those who enter teaching are generally of lower academic achievement than those who enter other professional occupations such as medicine or law (Hoyle, 1995a, 2001), and many scholars and policy makers have advocated for raising entry standards (Darling-Hammond, 2005; Carlo et al., 2013; Eurydice, 2015). To add to this, the rise of alternative entry routes might affect the profession's prestige (Hargreaves and Flutter, 2013). Alternative entry routes and the private tutoring industry are often accused by teachers and teacher unions of contributing to the continued de-professionalisation of teaching (Finn and Petrilli, 2007). In some contexts, the rise of alternative entry routes has necessitated reducing the duration or scope of initial teacher preparation thereby impacting the depth of knowledge and skills to be acquired by graduates, or by restricting teacher education to the learning of routine-like, prescriptive

practices, leading to further claims of de-professionalisation. On the other hand, alternative routes can also be effective (Humphrey et al, 2008). For example an evaluation of teachers in the U.S. trained through different routes to certification revealed no statistical difference between traditional preparation and alternative routes in terms of their impact on student achievement (Constantine et al, 2009).

Often, however, ease of accessibility has to do with market drivers affecting supply and demand, which are often out of the control of the profession itself. For example, opening up the profession through alternative entry routes or the lowering of entry requirements are usually the result of policies aiming to fill teacher shortages, either due to changing demographics, challenges in recruiting new teacher candidates, or teacher attrition. It is often suggested that there is a high attrition rate for novice teachers leaving the profession. For example, in the USA it has been reported that almost 50 percent of those who enter teaching leave before their fifth year of practice (Ingersoll and Perda, 2012; Perda 2013 as cited in Ingersoll and Merill, 2013). However, there is some variation between countries. For example in Israel 32% of upper secondary teachers leave the profession within their first 5 years, in England 27% and in the Netherlands 22.5% (OECD, 2014b). Hence, Hargreaves and Flutter (2013) introduce elements such as recruitment and retention as factors influencing teaching's status.

At the same time, challenges in teacher recruitment and retention have been argued to be the result (rather than determinant) of the poor status of teaching. For instance, despite high demand for teachers or ease of access into the profession, many OECD countries and partner economies face challenges in recruiting new, particularly high-ability candidates and retaining quality teachers in the workforce. This is related to another approach to exploring the status of the teaching profession having to do with whether teaching is an attractive career choice (Everton et al, 2007; Carlo et al., 2013; Eurydice, 2015). A recent study investigating the career expectations of secondary school students in countries participating in the Programme for International Student Assessment (PISA) in 2006, reported that, on average across countries, only 5% of students indicated that they planned to work in the teaching profession (OECD, 2015). Whether challenges in recruitment and retention or the quality of prospective applicants are the result or the cause of the profession's poor status remains an open question.

Teachers' pedagogical knowledge and the teaching profession

According to the consensus of scholars as reviewed above, the knowledge, skills and expertise required by practitioners of full professions are the result of a lengthy period of specialised training and continuous professional development. The more specialised the knowledge and skills, the lengthier and more challenging the training. In the case of teaching, as discussed previously, it has been argued that the knowledge and skills required by teachers are often considered to be less sophisticated than those required in other major professions (Hoyle, 1995b). Related to this is the notion that teaching can be learned simply through observation, and because most adults have experienced at least some type of formal schooling, teaching is therefore perceived as something that is easy to master and routine (Hoyle, 1995a, 2001). Indeed, for almost two hundred years those who were responsible for teaching in schools were not subject to any form of specific preparation or training (Lortie, 2002). Those who entered the teaching profession tended to have varied qualifications, and the occupation was unregulated (Lortie, 2002).

The lack of a profession-specific knowledge base and the absence of any specialised pedagogical training are important factors implicated in the lower prestige of the teaching profession, and likewise, in characterising teaching as a semi-profession. Others who argue that teaching is not a profession, or that it is rather a semi-profession, have similarly pointed to the absence of a profession-specific or specialised knowledge base derived from scientific processes (e.g. Ingersoll and Merrill, 2011; Thomas, 1998). For Hoyle (1995a), specialisation is linked to a higher professional status and this may help explain why secondary teachers, who are specialised in the content they teach, are considered to have a higher status than those in primary education, who are generalists. Hoyle (1995a) further argues that another reason the teaching profession has been unable to enhance its status is the uncertain relationship between educational and pedagogic theory, pedagogic practice and learning outcomes, and points to the frequency with which teachers themselves appear to criticise educational theory as irrelevant to their everyday practice (Hoyle, 1995b). In such a way, it is argued, teachers cast doubt on their own professional knowledge.

And this is the rationale for our book on teachers' pedagogical knowledge and the teaching profession: What is the nature of teachers' pedagogical knowledge? Is the current state of teachers' pedagogical knowledge evidence-based and grounded in current scientific understanding about learning? Is teaching practice informed by research? To date, this is still not clear. Furthermore, there is more to competent teaching than a scientifically-informed knowledge base. How does teachers' pedagogical knowledge relate to overall professional teaching competence? And how do these relate to the professionalisation of teaching? We argue that raising the status of the teaching profession can be achieved by making teaching and learning more scientific and evidence-based.

The empirical study of teaching and learning has been going on for centuries and, especially in recent decades, there is a growing body of scientific literature investigating teaching and the effects of various teaching practices on student learning. One prominent example is the work of Hattie (2009) who conducted a synthesis of educational research studies looking at which teaching practices had the most influence on student learning. Are teachers familiar with this and related research or do they continue to use practices that have been shown not to work? Another example comes from the interdisciplinary field of the "Science of Learning", which includes the foundation fields of cognitive science, neuroscience and developmental psychology. This new field of research has made huge progress in understanding how the human brain processes, encodes and retrieves information, and how these biological processes interact with aspects of the social learning environment. Understanding how the brain works and how the brain is affected by social interactions with parents, peers and teachers, and how learning is hindered by environmental factors such as poverty or trauma, can inform teachers' pedagogical practice. Such an understanding can help teachers adapt lessons to individual students' prior knowledge, motivation and ability levels, for example, or help teachers to design and structure lessons to enable deep, rather than surface, learning.

Thus, teachers' pedagogical knowledge base is not static. New knowledge emerges from research or is shared through professional communities, and this knowledge needs to be accessed, processed and evaluated, and transformed into knowledge for practice. As professionals, teachers are expected to process and evaluate new knowledge relevant for their core professional practice and to regularly update their profession's knowledge base. Indeed, one of Hargreaves's (2000) recommendations for re-professionalising teaching is for teachers to implement a rigorous knowledge base that supports their professionalism

through a critical assessment of the scientific basis of effective teaching before applying it to practice. Similarly, Buchberger (2000) argues that professionalisation of teaching can be achieved by adopting scientifically-validated knowledge and practices. Importantly, as proposed by Helsby and McCulloh (1996 in Whitty, 2008), having control over how their knowledge is developed, negotiated and used in the classroom is a key factor underlying teachers' autonomy. As we have argued in the previous section, professional autonomy is an important determinant of a profession's prestige.

The nature of teachers' pedagogical knowledge and how new knowledge is incorporated into the profession is an especially relevant issue for policy makers. The learning environments of today's classrooms are becoming more diverse and teachers are expected to teach "21st century skills" that are the new priority among OECD countries and partner economies. In our increasingly complex, knowledge-based and interconnected digital societies, the labour market requires a new set of skills previously of little significance for seeking employment. Today, skills such as creativity, critical thinking, problem-solving, collaboration, communication, among others, are necessary to succeed in the labour market. These new demands require teachers to deviate from traditional teaching methods and to employ innovative, evidence-based teaching practices. For some countries, this might entail a re-skilling of the current teaching workforce and upgrading of the profession's knowledge base within teacher education institutions and through professional communities. Therefore, understanding what the current knowledge base looks like will help determine whether and to what extent re-skilling is required.

Thus, there is a need to derive evidence-based suggestions for educational policy and future research by examining the current state of teachers' pedagogical knowledge and implications for the instructional process. Although new research is suggesting that a high level of pedagogical knowledge is part of competent teaching, there is still the need to assess teacher knowledge as a learning outcome of teacher education systems and as a predictor of effective teaching and student achievement. These questions are important for making policy improvements across the spectrum of the teaching workforce, from policies directed to pre-service teachers and teacher educators in initial teacher education, through to novice teachers undergoing induction and mentoring, and to in-service teachers participating in professional development.

This volume

With the above considerations in mind, the OECD Centre for Educational Research and Innovation (CERI) Symposium on "Teachers as Learning Specialists – Implications for Teachers' Pedagogical Knowledge and Professionalism" (Brussels, 18 June 2014) brought together leading experts in the field to begin explore two overarching questions: (1) What is the nature of the pedagogical knowledge base of the teaching profession, and (2) is the pedagogical knowledge of the teaching profession up-to-date?

Part I of this book provides a broad contextual overview of teacher's knowledge and the teaching profession. We explore the dynamics of knowledge in the teaching profession from a structural, functional and social perspective and what complexity theory can offer to understanding the governance of teachers' knowledge. Next we look at how teachers' professionalism and pedagogical knowledge is manifested through instruments such as qualification frameworks and professional standards. Part II and III bring together the set of papers contributed by experts at the symposium.

The purpose of Part II is to explore current conceptual and empirical work on teachers' pedagogical knowledge, and how pedagogical knowledge can be measured as an indicator of teacher quality. It investigates the following:

- How is teachers' general pedagogical knowledge conceptualised? Is it multi-dimensional, and if so, what are the various cognitive dimensions and can these be measured?
- How do teachers' motivations and beliefs about teaching relate to their pedagogical knowledge and how can these relationships be measured?
- How does teachers' pedagogical knowledge impact student learning outcomes?
- What is the relationship between pedagogical knowledge and teachers' overall professional competence, and how can it be measured?

Chapters 4 - 8 synthesise literature on teachers' pedagogical knowledge, propose various models and concepts to better understand the complex nature of teacher competence, including both cognitive and affective-motivational facets. They also underline how teachers draw on their pedagogical knowledge in the classroom and investigate the motivational factors that drive expert teaching.

Part III is designed to be forward-looking and explores the impact of 21st century demands on teachers' knowledge and the teaching profession through the following questions:

- Does the knowledge base of teachers sufficiently incorporate the latest scientific research on learning? Can scientific research inform teachers about how to create effective teaching-learning environments?
- Does the current state of teachers' pedagogical knowledge meet the expectations for teaching and learning "21st century skills"?

Chapter 9 investigates whether and how incorporating findings from the Science of Learning into teachers' knowledge base could enhance teaching and learning. The authors argue that teachers who understand the mechanisms that underlie learning can enhance the cognitive engagement of their students and help to realise the potential for each and every student to learn. Chapter 10 reviews the definition of "21st century skills" and terms like "deep learning" and "transfer of knowledge". It provides a state of the art of the empirical evidence on how these various competencies matter for success in education, work and other aspects of adult life, and underlines the challenges in assessment and in teaching for transfer.

We conclude with a summary of the work presented in this volume and discuss implications for the teaching profession. The argument that will emerge is that teaching should become a more evidence-based practice, and importantly, be informed by scientific research on teaching and learning. We argue that grounding the practice of teaching in a scientific knowledge base will address the challenges that are giving the profession a low status. Doing so would address the argument made previously that teachers do not generally use scientific knowledge in their practice, or that they do not contribute to building a pedagogical knowledge base founded on scientific principles.

Of course, this would require considerable reforms to how teachers are trained, the duration of training, and correspondingly, reforms to the roles and responsibilities of teacher educators. As a consequence of such reforms, we would expect corresponding changes to minimum standards for entry into teacher education programmes, and likewise, for

certification and licensing. More stringent entry requirements, a lengthier training period, and practice grounded in a scientific knowledge base typically leads to the profession being granted autonomy and trust over daily practice and governance, and consequently, a higher prestige.

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Chapter 2

Knowledge dynamics in the teaching profession

by
Nóra Révai and Sonia Guerriero
OECD

This chapter explores the structural, functional and social dimensions of knowledge dynamics in the teaching profession. Knowledge dynamics refers to the characteristics of knowledge that transform, change and evolve as a result of various processes and influences. First, we provide an overview of the structural aspects that relate to the dynamics between teachers' explicit and tacit knowledge. Second, we analyse the different functions of knowledge – its production, mediation and use – and explore how these functions interact and influence each other. We also look at evidence about how functional dynamics relate to solidification of teachers' knowledge. Third, we study how teachers' knowledge is affected by a range of complex social processes such as interactions among different actors and other elements of the social-professional field. Lastly, we explore the different possibilities that complexity theory can offer to understanding knowledge dynamics and the consequences that this analytical perspective can have on governing teachers' knowledge.

Introduction

Knowledge is dynamic; it is changed and shaped by learning, experience and various other processes. This is true whether we consider the individual knowledge of a person, the collective knowledge of a group of people, or the underlying knowledge base of a profession. Like other professions, the knowledge base of the teaching profession is also dynamic and constantly changing. For example, new knowledge emerges from research or is created by and shared through professional communities. In some cases, new curricular demands from policymakers may require teachers to learn new pedagogies, such as the teaching of social and emotional skills. As professionals, teachers are expected to process and evaluate new knowledge that is relevant to their core professional practice and to regularly update their profession's knowledge base. Investigating the "knowledge dynamics" in the teaching profession is one way to measure how knowledge flows within, and also in and out of the profession, and especially how new knowledge is incorporated into the profession through processes such as initial teacher education, professional development, or networking, as well as how it is created by the profession itself.

The purpose of this chapter is to better understand the dynamics of knowledge, and in particular, the knowledge dynamics in the teaching profession. Some critics have argued that the knowledge base of the teaching profession has not kept up-to-date with new pedagogical and learning research (Dumont, Istance and Benavides, 2010). This will be covered in more detail later. Doctors and engineers are either required or expected to update their practice based on new advances in their fields. For example, doctors can more effectively treat cancers thanks to new findings in DNA sequencing; engineers use advances in materials science to build better bridges and taller buildings. On the other hand, arguments, such as that the knowledge upon which the teaching profession is based has remained the same since the writings of Vygotsky and Piaget, are not uncommon in discussions about teaching. For instance, teacher education institutions continue to train new teachers based on Vygotsky's theory of the "zone of proximal development" and Piaget's theory of cognitive development. While it is important for new entrants to a profession to learn about the historical foundations upon which their profession is based, it is just as important, if not more so, to also learn about contemporary perspectives on teaching and learning (Anderson et al., 1995; Sawyer, 2006). For example, new research in the fields of cognitive science and developmental psychology has shown that the theories of Vygotsky and Piaget are not fully supported by empirical research (e.g. Meltzoff, 2007, 2013) and that new understandings of how the brain "learns" – which are relevant to the teaching of children (e.g. Thomas, 2013) – have been advanced.

We do not know however, to what extent this new research has penetrated into the educational sphere. Some have suggested that it is not sufficiently integrated, and mention the lack of a coherent and integrated knowledge base for education as a potential reason (e.g. Hargreaves, 1996; Brante, 2010) or that a large part of teachers' knowledge is implicit rather than explicit, making it difficult to be codified and thus transferred or shared within the profession. While there has been much speculation about why teachers' knowledge

is thought to be outdated, the dynamics underlying the knowledge base of the teaching profession are still not well understood.

This chapter, therefore, aims to review the processes and factors affecting the dynamics of teachers' knowledge by triangulating evidence from different but strongly interrelated disciplines, including knowledge management, the economics of knowledge codification and educational sociology. The goal is to synthesise major theories relevant for the teaching profession and to propose a framework within which to analyse the dynamics of teacher's knowledge. Understanding what influences teachers' knowledge base, how teachers acquire, develop and update their knowledge, and how policy and research affect this knowledge base is hoped to contribute to establishing a framework on the basis of which the knowledge dynamics in the teaching profession can be studied.

The main question we investigate in this chapter is: How can the dynamics of teachers' knowledge be described and characterised? To answer this, we conducted a review of the literature to address the following three sub-questions:

- What is the nature of teachers' knowledge? How can the different definitions and typologies of "knowledge" be applied for a better understanding of teachers' knowledge?
- What are the main processes influencing the dynamics of teachers' knowledge?
- What do we know about these processes? How can they be governed to better facilitate the integration and sharing of new knowledge in the profession?

This review is not meant to be comprehensive, nor systematic. Nevertheless, we endeavoured to review the most salient sources involving various different fields of research. Sources were identified through keyword searches[1] in educational and sociological databases (ERIC and EBSCOHost) and, where relevant, the references of primary sources were reviewed. To ensure all relevant sources were captured, we also included recommended sources from experts in the field of teachers' knowledge. Finally, we reviewed and included, where relevant, previous OECD works on the topic.

We start with a review of how different conceptualisations of "knowledge" relate to teachers' knowledge. Then, we analyse knowledge dynamics from three aspects: the *structural* aspect, or knowledge dynamics as codification; the *functional* aspect, that is, knowledge dynamics in terms of production, use and mediation; and lastly, the *social* aspect, which corresponds to knowledge dynamics as the interplay between the various agents of a social-professional field. We argue that knowledge dynamics can be considered a complex system and draw conclusions on how these dynamics may be governed in an attempt towards creating a solid and integrated knowledge base for teachers. We hope that the insights this chapter provides may facilitate the development of mechanisms that bring educational research closer to practice and vice versa, and thus contribute to strengthening teaching as a profession. The ultimate goal of a professional teaching workforce with a sound professional knowledge base is to provide better learning opportunities for all students across the world.

Knowledge and knowledge dynamics

The nature of knowledge

Studying the knowledge dynamics of the teaching profession, or any profession for that matter, is not possible without first understanding the nature of knowledge. Theories of knowledge fall within a vast literature involving many different disciplines: cognitive psychology, sociology, information science, economics and philosophy; each of

which has their own unique, yet overlapping, conceptual approaches, typologies of, and reflections on knowledge. Since the focus of this chapter is on the dynamics of knowledge, rather than on knowledge *per se*, we use the concept of knowledge in a sense borrowed from complexity theory: "as continuous invention and exploration, produced through relations among consciousness, identity, action and interaction, objects and structural dynamics" (Fenwick, Edwards and Sawchuck, 2011: 28). Still, it is important to begin with a review of some of the various approaches to the study of knowledge so that we can later specify a particular approach or refer to some of these typologies when discussing the dynamics of teachers' knowledge.

In the case of teachers, Shulman (1985; 1986) proposed that the knowledge base of the teaching profession would comprise the following categories. We define "base", as the collection of knowledge in the profession, as follows:

- "general pedagogical knowledge (principles and strategies of classroom management and organisation that are cross-curricular)
- content knowledge (knowledge of subject matter and its organising structures)
- pedagogical content knowledge (knowledge of content and pedagogy)
- curriculum knowledge (subject and grade-specific knowledge of materials and programs)
- knowledge of learners and their characteristics
- knowledge of educational contexts (knowledge of classrooms, governance and financing of school districts, the culture of the school community)
- knowledge of educational ends, purposes, values, and their philosophical and historical grounds."

The above and other work in the study of teachers' knowledge (e.g. Ball, Thames and Phelps, 2008; Depaepe, Verschaffel and Kelchtermans, 2013; König et al, 2011; Verloop, Van Driel and Meijer, 2001; Voss, Kunter and Baumert, 2011), which has led to much writing and debate, are mainly concerned with the content of teachers' knowledge base. But what, exactly, is meant by "knowledge?" Below we review various conceptualisations of knowledge stemming from different disciplines. The purpose of this short – and consequently somewhat superficial – review is first, to show the reader that the different conceptualisations influence the way we think about teachers' knowledge, and second, to give a basic introduction to some concepts we will refer to in this chapter, as well as later in the book.

Conceptualisation 1: Individual vs collective knowledge

Is it possible to speak about knowledge as such without linking it to actual people who possess the knowledge? For example, Polányi (1958) claimed that all knowledge must rely on personal judgements and commitments, which he describes as "personal knowledge". But can we interpret the knowledge of an individual independently? Or is knowledge necessarily embedded in a social context? Such questions have long been the subject of studies of philosophers, sociologists and psychologists and belong to the field of epistemology – or theory of knowledge – that is concerned with the nature, conception and scope of knowledge.

Throughout the history of epistemology, one of the main distinctive factors is whether reality is conceived as an external or objective truth and whether it is embedded in the belief of a group of people. An external and objective reality perspective is thought to be the basis of global and common knowledge that is independent from personal or group interpretations of knowledge. This perspective entails that knowledge is deduced from a set

of axioms through reasoning, and new knowledge is created by combining existing sets of information (Kimble, 2013). Knowledge that is embedded in social groups holding the same epistemic beliefs is thought to be an interpreted reality. This view entails that knowledge is socially negotiated and "constructed", and thus suggests a constructivist view of knowledge (Kimble, 2013).

We can equally distinguish between individual and collective knowledge based on the level of analysis employed. This distinction is relevant to an understanding of teachers' knowledge because the processes that influence the knowledge of an individual teacher, the collective knowledge base of a smaller, local community of teachers, or that of the global teaching community, for example, will differ.

Conceptualisation 2: Tacit vs explicit knowledge and the codification of knowledge

In the domains of information sciences and economics, knowledge is conceptualised in terms of information, data, messages and codes. According to Hess and Ostrom, "Knowledge is assimilated information and the understanding of how to use it" (Hess and Ostrom, 2007, cited in Fazekas and Burns, 2012: 8). Here, information refers to organised data that is understood in its context (Davenport and Prusak, 1998).

Economists' approach to knowledge gains its importance when considering codification as a process in knowledge dynamics. For teachers, this can involve, for example, the efficient management of knowledge within a school by teachers who attend a formal professional development course. Teachers will interpret the "data" they hear during the course as it applies to their own context. Codification is the process by which they transfer this "interpreted" information to their colleagues. Another example is how a member of the teaching staff, after observing a colleague's lesson, will then articulate what he/she observed about the colleague's practice into a "coded message", which thus becomes "codified knowledge".

Information sciences and economics make a distinction between tacit and explicit knowledge, which is relevant to our investigation of knowledge dynamics. Explicit knowledge is conceptualised as knowledge that can be expressed in words or other symbolic representations (e.g. text) in a way that can be comprehended by another person (Bennet and Bennet, 2008). Tacit knowledge, on the other hand, is specified into two types: (1) knowledge that is not articulable, that is, knowledge that is impossible to describe in propositional terms and (2) knowledge that is implicit or articulable but with some difficulty (Kimble, 2013), thus suggesting that implicit knowledge is potentially codifiable. Tacit knowledge is furthermore thought to be personal in that it can only be transmitted through direct contact with the person possessing the knowledge. This is consistent with Polányi, who originally formulated the concept of tacit knowledge, when writing: "*we can know more than we can tell*" (1967: 4).

This distinction is important for the codification of knowledge. Codification is the process by which knowledge is converted into transmissible messages (Cowan and Foray, 1997). It thus involves making implicit knowledge explicit. As it pertains to the teaching profession, teachers' knowledge is often thought to be largely tacit (OECD, 2000); hence the absence of a knowledge base for teaching. The literature on this issue shows a complex picture, however, so this will be reviewed in more detail in the section on codification.

Conceptualisation 3: Declarative and procedural knowledge

In the domain of cognitive psychology or the cognitive sciences in general, a distinction is made between "declarative knowledge" and "procedural knowledge." Simplistic conceptualisations of declarative and procedural knowledge define these as

"knowing that" (e.g. knowledge of the facts of teaching) and "knowing how" (e.g. knowledge of how to teach), respectively. But in actuality the issue is more complex, and essentially has to do with how knowledge of skills is stored and organised in memory and how it is used and developed into mastery performance (Anderson, 1982).

More specifically, the distinction between declarative and procedural refers to how knowledge is stored in long-term memory, and as such, cognitive scientists use the word "memory" rather than knowledge (and for some, the term "procedural" is replaced with "non-declarative", e.g. Squire and Zola, 1996). Declarative and procedural are the two main types of long-term memory: Declarative memory is memory of facts (e.g. through textbook learning) and events (e.g. through experiential learning). Declarative memory can be articulated, or "declared", and is often referred to as "explicit" memory. Procedural memory is memory of a skill (e.g. how to do things, such as teaching). Procedural memory is difficult to articulate, and therefore, also referred to as "implicit" memory. Anderson and colleagues (1982, 1987; also Corbett and Anderson, 1995), who study student learning, define declarative knowledge as factual or experiential knowledge and procedural knowledge as goal-oriented knowledge that mediates problem-solving behaviour.

Whether the initial learning is from a textbook or experiential, information enters the brain and is stored at a surface level in declarative or explicit memory and then consolidated into deeper, implicit memory stores (Gluck and Myers, 1997). Performance of a skill (e.g. teaching) improves through repeated practice as both declarative and procedural knowledge are strengthened. This distinction is important because it forms the basis for understanding how knowledge (e.g. of teaching) is learned and developed into mastery (e.g. expert teaching). How novice teachers become expert teachers is discussed further in Chapter 4 by Guerriero on teachers' pedagogical knowledge.

The domain of educational sociology sometimes distinguishes between vertical and horizontal discourses based on Bernstein's work. According to Bernstein (1999), a horizontal discourse refers to a discourse realised in everyday language and expresses common-sense knowledge related to practical goals. A horizontal discourse is context-specific, concrete and related to particular practices (Beck and Young 2005; Player-Koro, 2012 in Beach and Bagley, 2013). A vertical discourse on the other hand, is characterised by either a coherent, explicit and systematically principled structure, or takes the form of a series of specialised languages with specialised modes of interrogation.

Distinguishing between vertical and horizontal discourses in connection with pedagogic discourses is based on how different forms of knowledge are realised. The individual teacher's knowledge as described in the literature takes the form of academic and codified (i.e. declarative and explicit) knowledge acquired in higher education and realised in vertical discourses on the one hand, and of practical and highly contextualised (i.e. procedural) knowledge, mostly tacit in nature and realised in horizontal discourses on the other (Wilson and Demetriou, 2007; Bernstein, 1999; OECD, 2000). This distinction is used, for example, for the purposes of analysing teacher education policies as we will see in Section 5.

Knowledge dynamics

As stated earlier, knowledge is dynamic in nature: it continually changes through experience and learning (McInerney, 2002). For example, the knowledge of an individual teacher changes as the person learns, where learning is to be interpreted in a broad sense occurring through initial teacher education, communities of practice, personal networks and work-related experiences (Siemens, 2005). The individual teacher's knowledge, as part of the

collective knowledge of a group (e.g. the community of practice or network), thus transforms this collective knowledge, which in turn feeds back into the individual teacher's knowledge base (Siemens, 2005; McInerney, 2002). Viewed from a macro perspective, the knowledge base of the profession likewise goes through continuous transformations, through the knowledge of practitioners generated within this cycle, but also through a growing body of research.

However, while this cycle of knowledge dynamics suggests that teachers' knowledge is continually changing and evolving, much criticism has been articulated in that on the whole teachers' knowledge is rather static and has not changed much during the last 50 years. For example, some critics argue that teachers' pedagogical knowledge is not based on recent research evidence (Dumont, Istance and Benavides, 2010), and international comparisons such as the Teaching and Learning International Survey (TALIS; OECD 2014a) indicate that beginning teachers' beliefs about teaching (e.g. whether it is a direct transmission or a constructivist belief) do not differ much from their senior colleagues. This may be an indication of a low level of knowledge dynamics, although it may also be the consequence of other factors such as centrally-prescribed curricula and teaching methods.

While this seems to suggest that teachers' pedagogical practice is still characterised to a large extent by traditional, rather passive types of teaching (e.g. lecturing), there have been changes in their instruction in other areas (OECD, 2014b). For example, in a comparative analysis of teaching practices between 2001 and 2011, teachers across all grades and subjects report that they ask students to relate what they learned to their daily lives, to explain and elaborate their answers, interpret data and text, and to observe and describe natural phenomena to a greater extent in 2011 than in 2001 (OECD, 2014b), suggesting more active, as opposed to passive, teaching practices. Presumably, these changes in practice would not be possible without a corresponding change in teachers' knowledge. Overall, the debate about whether teachers' knowledge is or is not changing has not been resolved. As the evidence seems to rest more on anecdotal than empirical evidence, it arguably is weak and controversial. It is therefore clear that there is more research to be explored in this domain.

There is a large body of literature in the field of economics, and organisational development in particular, which deals with various aspects of knowledge dynamics. Terms such as knowledge management, knowledge-to-action, knowledge translation and knowledge utilisation consider the transmission, flow, or the generation of knowledge from different angles. We will use the term "knowledge dynamics" as a broad concept to refer to the characteristics of knowledge that transform, change and evolve as a result of various processes and influences. In the following sections, we review the main processes of knowledge dynamics from three different, albeit interrelated, perspectives:

1. Knowledge dynamics as a structural process: What are the dynamics between tacit and explicit knowledge, and what does codification involve?
2. Knowledge dynamics as a functional process: What processes does knowledge to action involve; how is knowledge generated, mediated and used; and what are the dynamics between research and practice?
3. Knowledge dynamics as a social process: What are the processes within the teaching profession as a social-professional field; how do different actors (e.g. researchers, teachers, teacher educators, policy-makers) influence the dynamics of teachers' knowledge by their actions and interactions?

Knowledge dynamics as structural dynamics: Codification processes

A significant body of research on knowledge management argues that knowledge needs to be made explicit in order for it to be effectively shared across a community or organisation. Very little research is available on knowledge codification specific to the education sector. For example, a search in the Education Resources Information Centre (ERIC) database for "codified knowledge" or "knowledge codification" resulted in only 16 peer-reviewed papers[2], and a search in EBSCOhost for "teacher" and ("codified knowledge" or "knowledge codification") gave eight results. On the other hand, many argue that teachers' knowledge is largely tacit and that it needs to be codified in order for the profession to establish a robust knowledge base, while recognising that not all knowledge is codifiable (e.g. OECD, 2000). The issue of tacit vs explicit knowledge and its codification is a complex one, and we expand on this below. In this paper, we will use the term "tacit" in the general sense to refer to both articulable and inarticulable knowledge.

Tacit and explicit knowledge – Different conceptual approaches

Conceptualisations of tacit and explicit knowledge and its codification find their roots in economic theory and philosophy, and in the last two decades, increasingly more from the fields of economics and information sciences. In these fields, many have drawn attention to differences in the definition of these terms (e.g. Cowan, David and Foray, 2000; Kimble, 2013; Johnson and Lundvall, 2001). The different conceptualisations have significant consequences on issues concerning teachers' knowledge.

In much of the literature on codification, tacit and explicit knowledge are seen as a dichotomy, that is, knowledge is either tacit or explicit, or they are conceived as the two extremes of a continuum with tacit knowledge at one end and explicit knowledge at the other (Nonaka, 1994; McInerney, 2002; Kimble, 2013). (See Figure 2.1) This view suggests the existence of a spectrum on which one can move from tacit to explicit, which is the underlying assumption behind arguments about the need or desirability of making tacit knowledge explicit.

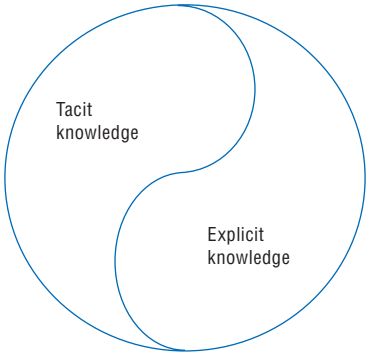
Figure 2.1. **Tacit and explicit knowledge as a dichotomy**

One of the ways in which teaching can become professionalised is by exploring and documenting (i.e. transforming into storable and transmissible information) the knowledge behind daily professional decisions, much of which seems to be difficult to articulate, and thus tacit. This process is believed to contribute to constructing a knowledge base for teachers that could be easily shared or learned and could in turn enhance professional practice. Thus, for example, whether and how a teacher intervenes when he/she experiences "inappropriate behaviour" in the classroom – a professional decision teachers face on a daily basis – could be analysed and coded. Clearly, behind this thinking lies the dichotomist approach of tacit versus explicit knowledge.

However, when Polányi originally theorised about tacit and explicit knowledge as a duality, he conceived of one existing in symbiosis with the other: there is no explicit

knowledge which could exist independently of the tacit knowledge of the individual (e.g. see Polányi, 1967; Johnson and Lundvall, 2001; Kimble, 2013; Kabir, 2013).

Figure 2.2. **Tacit and explicit knowledge as a duality**



This view could be illustrated by the yin and yang model. In Chinese philosophy, yin and yang "describe how apparently opposite or contrary forces are actually complementary, interconnected and interdependent in the natural world, and how they give rise to each other as they interrelate to one another" (Wikipedia, Yin and Yang[3]). This description fits the dualistic approach, which emphasises that tacit and explicit are complementary dimensions of knowledge rather than disjoint parts of a knowledge stock (Johnson and Lundvall, 2001). In view of this approach, the individual knowledge of a teacher that forms the basis of his/her reaction to, for example, disciplinary problems in the classroom, has both tacit and explicit dimensions, which are hardly separable. The teacher may have explicit knowledge about, for example, the effects of punishment or reward on student motivation and many other psychological and pedagogical processes that merges with their tacit knowledge, for example, of how they interpret psychological theories for themselves and how they translate them to a particular context and situation.

Is it possible then to codify teachers' tacit knowledge? If so, what would codification involve and what would be gained?

Codification – What? How? Why?

According to Cowan and Foray (1997), in the domain of organisational knowledge management theories and techniques, codification is the process of converting knowledge into storable and transmissible messages. Despite some evidence of the benefits of codification in various fields (e.g. Edmondson et al., 2003; Janicot and Mignon, 2012), many concerns have also been raised. Debates about what can be codified, how codification happens and why it would be a desirable strategy are still open, and educational research has yet to contribute to these issues.

The first concern raised in connection with codification relates to what kind of knowledge can be codified in the first place and what the process of codification actually involves. Johnson and Lundvall (2001) argue that different types of knowledge are codifiable to different degrees; for example, procedural knowledge is almost never fully codifiable, but is most of the time partially codifiable. An often cited example is that it is unlikely that someone will learn to ride a bike by reading a text or watching a video. Likewise, with the

example of the teacher managing a classroom. It is thus important to distinguish different types of knowledge when considering codification, for which a helpful concept is that of implicit knowledge referring to potentially articulable or codifiable knowledge (Cowan, David and Foray, 2000). This would imply that although some of the classroom management know-how of an expert teacher can never be captured by words or images, this being the fully tacit knowledge, there is a part of his/her implicit knowledge that is potentially codifiable.

A second concern relates to the result of codification. Cowan and Foray (1997) emphasise that the process of codification is never complete, because codification involves the construction of new tacit knowledge. For example new codes (e.g. specialised language) need to be understood and interpreted by the person accessing the codified knowledge. Thus, the belief that "efficient" codification (economists interpret the efficiency of codification in terms of cost-benefit) of teacher knowledge would reduce the tacit dimension of teachers' knowledge base is far from being self-evident.

Knowledge management literature reveals little about how codification may take place and emphasises mostly organisational techniques, such as procedure descriptions, frameworks of references, policy documents, data collection, typical cases, and so on (e.g. Wyatt, 2001). The economists' approach to codification examines the costs of this process and lists some cases and conditions in which codification is difficult and not efficient (Cowan and Foray, 1997).

To illustrate how teacher knowledge may be codified, studies on teacher learning are worth exploring. Cordingley (2008) reported that a crucial element of effective continuing professional development (CPD) programmes was supporting teachers in "making their beliefs, ideas and practices explicit" (2008: 45), which in our terms would mean supporting them in codifying their knowledge. Professional development is certainly one of the dynamics through which knowledge codification for teachers can take place. Teacher knowledge can also be codified through professional collaboration, which is illustrated by the following vignette.

The vignette (see Box 2.1) demonstrates the process of codification at the level of the individual teacher and at a collective level. At the individual level, Mrs. Binn's knowledge about error correction and feedback had explicit and tacit dimensions throughout the discussions: she distinguished different types of mistakes and applied different error correction strategies for these (explicit knowledge). However this practice seems to have derived from beliefs and probably experience, so why she applied the practice is at least partly tacit knowledge. By conducting a review of the research evidence, part of her implicit knowledge became codified, and she is now able to express this in a specialised language. At the collective level of teachers teaching the same subject in the same school, some knowledge which was previously held by individual teachers separately or in the research literature, became more easily accessible, shareable and transmissible for others.

Codification of teachers' knowledge also takes place when teachers are involved in classroom-based research activities. Hiebert, Gallimore and Stigler (2002) suggest that building an integrated knowledge base for teachers should start from teachers themselves, for example, by constructing local theories of learning starting from daily lessons, testing and verifying them, and finally making them publically accessible, shareable, open for negotiation, verification and refutation, or modification within the profession. For this, the authors list various ways that knowledge can be made explicit, such as by videotaping, digitalisation and indexation. They underline the importance of creating knowledge that is

Box 2.1. **Vignette: Codification of teacher knowledge through professional collaboration among teaching staff.**

The ESL teachers of a school noticed through discussions in the staff room that their error correction strategies differed to a large extent. They thus decided to organise a departmental workshop to discuss error correction and feedback strategies. They all corrected the same assignment written by a student, which they then analysed.

Sarah's copy corrected by Mr. Johannson and Mrs. Binn respectively:

~~In the~~ last weekend I went to do ~~a~~ shopping with my friend to buy ~~for~~ myself a dress. The dress, ~~that~~ which I will also wear in my sister's wedding, has flowers on it.

In the last weekend [preposition] I went to do a shopping [article] with my friend to buy for myself [preposition] a dress. The dress, that I will also wear in my sister's weding [spelling], has flowers on it.

Extract from the discussion:

"Mr. Johannson: Jane, why didn't you correct "that" in the relative clause in this copy?

Mrs. Binn: This class hasn't yet learnt relative clauses, so Sarah couldn't have known how to say it correctly.

Mr. Johannson: Yes, but it is still wrong. She won't learn English if you don't tell her what is correct and what is wrong.

Mrs. Smith: Sarah was actually experimenting with the language. Why would we want to discourage her from doing that?

Mrs. Binn: Actually, this mistake doesn't even impede on understanding the meaning of the sentence, so it is not so important to get it right at this level.

Mr. Johannson: Well, I still think accuracy is crucial in language learning. Do you have any evidence proving that not correcting everything will result in better learning?"

The teachers found that they could not answer Mr. Johannson's question and thus decided that they would look for evidence in the field of error correction for the next session. During the second meeting, they discussed Sarah's copy again in view of the evidence found. They determined the type of each mistake using typologies found in literature (e.g. local vs. global errors, treatable vs. untreatable errors). They also identified and defined error categories specific to the native language of their students. A third workshop session opened the floor for discussion and agreement about feedback and correction strategies based on literature and experience, and resulted in a document on a "framework for correction and feedback".

"represented in a form that enables it to be accumulated and shared with other members of the profession" (2002: 4), which would correspond to codified knowledge. Although contributing to classroom-based research activities would indeed be a way of codifying some of teachers' knowledge because research requires the explicit formulation of knowledge, the generalisability and universality of the findings are not without obstacles and fallacies.

In the above examples, codification took place locally within a small professional community of participants at a continuous professional development (CPD) course or the teaching staff of a school. A more distant cross-contextual transfer of knowledge codified in this manner is not evident because of the context-dependence of this knowledge. As Johnson and Lundvall (2001) point out, a major problem with the transferability of codified knowledge is its context; we cannot be sure that the "receiver" will be able to efficiently apply this knowledge

in his/her cultural and professional context. While declarative knowledge may be easier to transfer, procedural knowledge is more problematic. A teacher can, for example, write down how she/he manages classroom disciplinary problems, but this description may prove to be irrelevant in a different context. In addition, transferring this type of knowledge may actually have negative impacts in a different educational-cultural context (Best and Holmes, 2011).

This observation leads us to the question of why would codification be desirable. The economist approach analyses the cost-benefit ratio of codification; it draws conclusions based on initial fixed costs and marginal costs, and sets conditions for profit maximisation (e.g. Cowan and Foray, 1997; Cowan, David and Foray, 2000). In general, the organisational literature – a specific area of economics – states that if knowledge has value, it should be captured, stored and shared, and cost-benefit analyses should show that codification represents the most cost-effective way (Kimble, 2013). We have seen however that "the more knowledge is codified the easier it is to access, share and transfer" is not necessarily the case. Nor it is true that codified knowledge is immediately more accessible publicly. As Johnson and Lundvall (2001) point out, local codes developed, for example, by professional communities may make communication more efficient at a local level, but can easily exclude outsiders. Additionally, Cordingley (2008) notes that few of the numerous terms accumulated by the education community to explicate concepts are, in fact, essential. On the other hand, they create barriers to wider communication. It has also been emphasised that by focusing exclusively on codified knowledge "one may lose sight of the intimate linkages between tacit and explicit knowledge" (Kimble, 2013: 19). In addition, it is by no means evident to identify what knowledge is codifiable, and what we could gain exactly from codifying knowledge (Kabir, 2013; Kimble, 2013; Johnson and Lundvall, 2001).

The application of codified knowledge in practice resulting in more effective teaching and learning processes is not straightforward. Its effectiveness will depend on the tacit knowledge of the individual teachers as well as other factors such as the pupils' and teachers' beliefs or motivation (Cordingley, 2008). Nevertheless, examples cited relating to the codification of teachers' knowledge do seem to show beneficial effects of making implicit knowledge explicit, and some evidence does suggest that it can potentially lead to enhanced student learning. For example, evidence related to CPD suggest that a crucial factor in the effectiveness of CPD programmes in terms of changing teachers' practice and improving pupil learning is that they involve processes supporting teachers in making their beliefs, ideas and practices explicit (Cordingley, 2008).

The Codification of teachers' knowledge – Questions and consequences

Clearly, the debate over tacit and explicit knowledge and codification is still open, and the multiplicity of different approaches suggest that, for the moment, there is no simple approach applicable that would create an integrated knowledge base for teachers and directly lead to higher quality professional practice. At the same time, codification is one of the processes influencing the dynamics of teachers' knowledge base and this process can increase the shareability, the transmissibility, and the accessibility of knowledge within the teaching profession, even though the conditions and circumstances under which codification processes achieve these effects are yet to be explored and clarified.

We have seen that codification is happening in various forms during initial teacher education, professional collaboration and development or during teachers' involvement in research. These processes shape teachers' knowledge base even though these dynamics cannot

be as simply conceived of as "the reduction of tacit knowledge and a way towards a codified knowledge base". More is to be explored in terms of how such processes can be facilitated towards building a more coherent knowledge base. New technologies (including artificial intelligence) open new dimensions in codification (Kabir, 2013), which could also be considered for teaching.

It has been suggested by economists that a more interdisciplinary approach to the issue of codification, namely including research on teaching and learning could make a valuable contribution (Johnson and Lundvall, 2001). At the same time it seems that theories and results of knowledge management literature on codification (from the field of economics or information science) haven't been sufficiently considered and integrated in educational literature e.g. on teacher knowledge, which represents a gap in understanding in the field of education. More than a decade ago the OECD (2000) proposed to use guidance from business and industry to help construct a "common body of codified, explicit knowledge" (2000: 70) for teachers. Now it is time to use results accumulated since then. The following questions would be worth exploring more deeply:

- How could codification improve the professional practice of teachers and through that student learning?
- In what ways and at what level would it be a good strategy to codify teacher knowledge?
- Under what conditions could codification facilitate extended access to knowledge for teachers?

To date there is little known about this particular area within the field of education, and although the questions raised above can be important, it must be acknowledged that codification is only one aspect of knowledge dynamics. Let us now move on to a related but different aspect: the creation, mediation and use of knowledge.

Knowledge dynamics as functional dynamics: Knowledge-to-action processes

Knowledge dynamics can also be captured as the production, use and transfer (or mediation) of knowledge within and between different stakeholder communities such as researchers, practitioners, and policy-makers. A proliferation of terms, definitions and models characterise the field: knowledge management, knowledge to action, knowledge mobilisation and knowledge utilisation. Attempts made to systematise the multitude of theories and concepts (e.g. Graham et al., 2006) suggest that the complexity of the issue cannot be reduced to any simple model. Although the most widely examined field from this perspective is medicine, many of these issues have been considered from an educational point of view as well, and many have written about the obstacles to and deficits of a good research-practice link and the various conditions for facilitating it. The OECD has also contributed to this discussion with a series of projects and publications (e.g. OECD, 2007; OECD, 2000). In this section, we review theories relevant to the study of teachers' knowledge and focus on the relationship between educational research and the professional practice of teachers. We use the term "knowledge-to-action" (KTA) to label this relationship.

A range of studies suggest that education is characterised by a lack of evidence-based practice: research does not consistently constitute the scientific basis of teachers' everyday pedagogical judgements (Hargreaves, 1996; Dumont, Istance and Benavides, 2010; Levin, 2011; Goldacre, 2013, etc.). Accepting the starting point that research has the potential to increase the quality of teaching practice and thus to enhance student learning, strengthening the link between research and practice (as well as policy) has long been on the agenda (Levin, 2011; Hargreaves, 1996). Levin (2011, 2013) modelled knowledge-to-action as the intersecting union

of production, use and mediation; where these three are regarded as functions rather than structures and acknowledging that some people or groups are active in more than one context. The key questions regarding knowledge production have to do with how educational research is produced; what kind of research has the potential to enhance professional practice; and who plays what role in the production of research knowledge. Questions about knowledge mediation are concerned with how research results reach and inform professional practice; and who plays what role in the mediation of research knowledge. With respect to knowledge use, the key questions address how teachers access, understand and apply research knowledge, and who plays what role in the use of research knowledge in teaching practice.

Figure 2.3 highlights the main issues and challenges that have been identified in these three functions. Several studies suggest that educational research is not carried out in a cumulative way, as is research in the sciences underlying the medical profession (Hargreaves, 1996; Levin, 2013), and there is no consensus around what counts as good evidence for professional practice (Fazekas and Burns, 2012; Nutley, Powell and Davies, 2013). The different types of evidence are organised hierarchically according to the methodology of the studies by some authors. These standards of evidence often place quantitative studies, in particular randomised control trials, on top of the hierarchy, followed by quasi-experimental research and lastly, by qualitative studies (Fazekas and Burns, 2012; Nutley Powell and Davies, 2013). Nutley et al. also distinguish between evidence-based and research-based practices, where the former refers to practices that have been "rigorously evaluated and consistently been shown to work", whereas the latter to those that are "based on sound theory informed by a growing body of empirical research" (2013: 9).

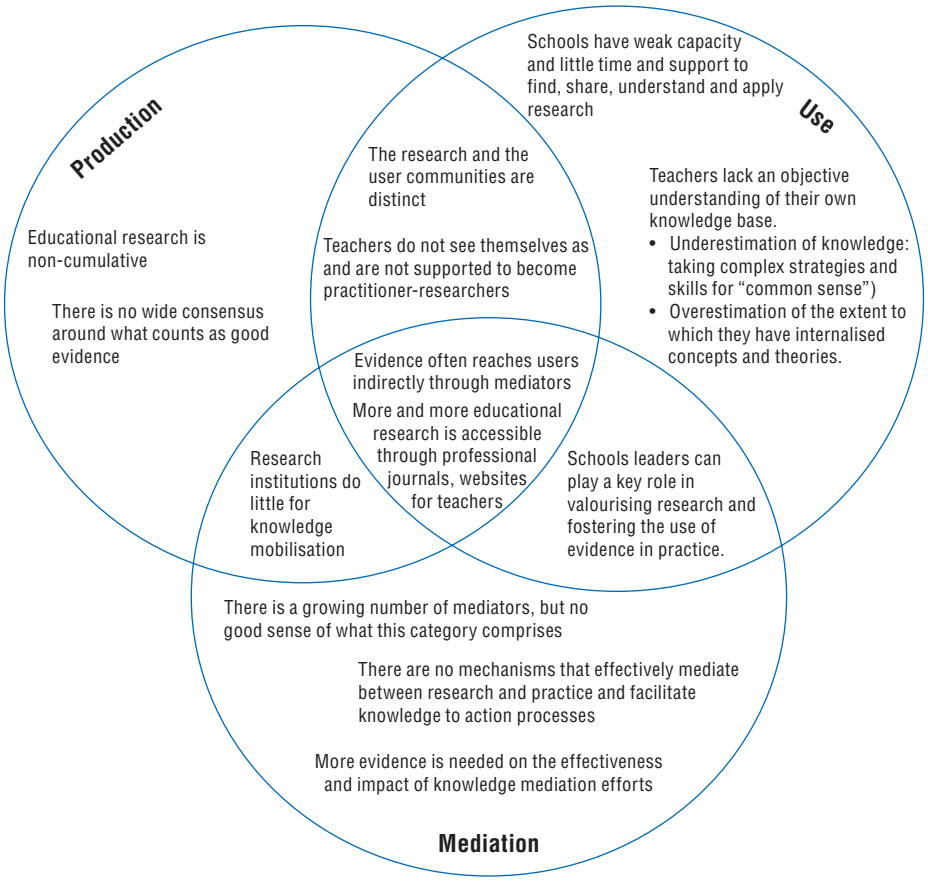
Moreover, production of research in the classroom is not or rarely supported. Teachers, unlike doctors, have little time, opportunity and support to engage in research activities. Although in some countries this has considerably changed. In England, for example, approximately one third of teachers are engaged actively in research according to 2010 data (Cordingley and Mitchell, 2013) as a result of numerous initiatives. Singapore also invests considerably in engaging teachers in research (Jensen et al, 2012). A number of suggestions have been made to address these challenges, some of which are reviewed subsequently.

Knowledge production

It has been suggested by several studies that the research agenda, process and the culture of producing educational evidence should change (Goldacre, 2013; Hargreaves, 1996). Such a global change could include the negotiation of standards of evidence, keeping in mind that rigid and prescriptive schemes will not facilitate the production of good evidence (Nutley, Powel and Davies, 2013). It is not yet clear what kind of research methodologies should be privileged (if any at all). Some argue for using more trials (such as randomised control trials) as this would foster gathering evidence cumulatively on what works best (Goldacre, 2013), while others envisage building the knowledge base starting from practice, for example, through lesson observations, analysis, recording and storing (Hiebert, Gallimore and Stigler, 2002) or recommend using more design-based research, which incorporates feedback and allows modifications in the intervention during the research process. Theories such as activity theory or expansive learning (Engeström and Sannino, 2010) link the creation of knowledge closely to learning (focusing in particular on professional communities) and reinforce the argument that new knowledge is produced also through the professional activities of teachers. Engeström and Sannino (2010) use the metaphor of "expansive learning" to highlight that professional learning is often not about learning something that is already known, but the design of new activities merges with the acquisition

of knowledge they require. Paavola, Lipponen and Hakkarainen (2004) and Bereiter (2002, in Paavola, Lipponen and Hakkarainen, 2004) also emphasise this aspect of collective knowledge creation during professional learning and activities. Some of these models have been used in schools to engage teachers in collaborative efforts (Paavola, Lipponen and Hakkarainen, 2004). This broad view of knowledge production is in line with the conceptualisation of knowledge adopted in this chapter (see Part 2 on Knowledge and Knowledge Dynamics).

Figure 2.3. **Challenges of knowledge to action in education**



Changing the research culture also means including a strengthened cooperation among researchers of different fields because fostering a multidisciplinary approach is key to effective knowledge-to-action in education (Levin, 2011; Goldacre, 2013). Furthermore, changing the education research paradigm would require the creation of a whole ecosystem some of the most important elements of which are established networks, new funding mechanisms, active implementation strategies and incentives, as suggested by several studies (Goldacre, 2013; Levin, 2011; Hargreaves, 1996). A key and common element of all recommendations is the collaboration of teachers and researchers in knowledge production (e.g. OECD, 2007; Van de Ven and Johnson, 2006; Levin, 2013, 2011; Hargreaves, 1996; etc.). It is argued that teachers will find research relevant and applicable for their practice if on the one hand, research questions stem from professional practice, and on the other hand, if they have ownership of the research itself. Ownership is achieved by involving teachers in the whole research process from identifying the questions and conducting the research to dissemination and implementation of the findings in their practice. School leaders play a key role in encouraging teachers to engage in research, so the question of ownership is

crucial for them too. This means that research should be organised as a collaborative activity. Such change requires policy incentives for all stakeholder groups involved.

Recommendations regarding the knowledge production culture have been taken on board by policy-makers in some countries and a set of initiatives have been undertaken in line with these suggestions. Some focused on fostering partnerships between teachers, researchers and policy; others aimed at building evidence on the basis of classroom observations and reflections; others had the objective of involving teachers actively in the research process from start to finish (See Box 2.2 for specific examples). Some of these initiatives have been evaluated and valuable consequences have been drawn as to what worked and what did not, whereas the impact of some others is not yet known. For example the evaluation of the *School Based Research Consortia* revealed numerous benefits of the initiative including "an improvement in teachers' skills and capacities, learning gains for pupils, and changes in knowledge of, and attitudes to, research across schools" (GTC, 2003) (Nutley, Jung and Walter, 2008: 60). This latter is particularly relevant to knowledge dynamics, as it concerns the engagement of teachers with research. The evaluation reported furthermore, that teachers "came to value increasingly complex models of research and more extended forms of inquiry" (Simons et al., 2003: 361.).

Box 2.2. **Policy initiatives influencing the educational research agenda and process**

***Facilitating partnerships*:**

The School-Based Research Consortia implemented in four university cities in England had the aim to 'explore how research and evidence can contribute to improving teaching and raising standards of achievement' (Kushner et al., 2001, p. 3 as cited in Nutley, Jung and Walter, 2008). This initiative consisted of creating partnerships between universities, local education authorities and schools. Engagement with research was realised in various ways such as pairs of teachers and academics working together, individual school research co-ordinators, or action research along different thematic priorities set by the consortium itself.

***Building evidence on the basis of teaching practice*:**

Hiebert, Gallimore and Stigler (2002) give the example of lesson study groups (as in Japanese elementary schools) as a good practice to illustrate how evidence can be built on the basis of teaching practice. In these study groups, teachers meet regularly to collaboratively plan, implement, evaluate and revise lessons, while university researchers are involved as consultants to add their perspectives and share the results of other groups. These groups generate knowledge by working on a problem directly linked to their practice.

***Involving teachers in research*:**

England is an example where numerous research programmes for teachers have been launched since the end of the 1990s. Cordingley and Mitchell (2013) list the following:

- Post Graduate Professional Development Programme funded by the Teacher Training Agency (CUREE, 2008)
- Best Practice Research Scholarships (Street and Temperley, 2005) funded directly by the Department for Education and Skills (DfES)
- General Teaching Council's Teacher Learning Academy
- Networked Learning Communities programme (Katz and Earl, 2006) funded by the National College for Teaching and Leadership (NCTL)
- Research Associate programmes also funded by the NCTL.

Last but not least, how and by whom knowledge is produced is also a question of funding mechanisms. Initiatives aiming at increasing the number of teachers engaging in and with research (such as the ones in the UK and in Singapore mentioned above) are accompanied by financial incentives. In Singapore, for example, substantial funding is allocated for school-based research that must aim to improve student learning (Jensen et al., 2012). The Teaching and Learning Research Programme (TLRP) in the UK or the "No Child Left Behind" programme in the USA are also examples for how funding mechanisms can influence the nature and the participants of research (Cordingley, 2008; Fazekas and Burns, 2012).

Recommendations with regard to the knowledge production culture in education research as well as initiatives that have attempted to implement some of these recommendations emphasise the importance of facilitating dynamics between knowledge production and use. These functions can be linked directly and indirectly through mediation.

Knowledge mediation

Knowledge mediation has become an issue of its own due to the rising need to transfer research knowledge into teaching practice. However, despite the fact that more and more educational research is accessible through professional journals and websites for teachers, mechanisms effectively mediating between research and practice haven't yet been established (e.g. Levin, 2011; Cordingley, 2008; Hargreaves, 1998). Levin (2011) contends that while research institutions do little for knowledge mobilisation, schools' capacity to find, share, understand and apply research is far from being sufficient. Mediating, that is making sure that research findings on education reach all relevant stakeholders such as school leaders, teachers or policy-makers and are applied to improve practice and the different educational stakeholders' questions and concerns reach researchers, should be a common effort of all these communities. At the same time, a growing number of mediators, including stakeholders from the research, practice and policy communities (e.g. university teachers, local authorities, teachers and school leaders), and specialised knowledge brokers are involved in bringing evidence to practice.

Mediation can take place in a variety of ways: through websites, newsletters, online communities, conferences, workshops and other forms of interaction that can potentially be effective tools (Fazekas and Burns, 2012). On the other hand, the impact and potential of creating more websites and virtual interaction spaces is not clear (Levin, 2011). Conditions for achieving impact include connecting with the right stakeholders (Fazekas and Burns, 2012) or producing materials that practitioners can use and apply. Criteria for research outputs that are easily applicable for practitioners include providing detailed analysis and description of the teaching intervention; providing detail about the starting points of pupils and the communities, phases, or subjects involved in research outputs; or ensuring clear, simple, short and jargon-free writing (for a list see Cordingley, 2008), however, often runs counter to what is expected within the research community, and in certain cases even "constrains research writing in ways that could undermine the accumulation of knowledge" (Cordingley, 2008: 39). Mediation mechanisms and efforts are therefore necessary to translate research for practice.

The OECD (2007) presented several case studies on brokerage agencies specifically created for knowledge mediation, and other similar initiatives are mentioned by, for example, Cordingley (2008) (see Box 2.3 for details), whose activities include producing

systematic research reviews specifically written for practitioners. In addition, brokerage agencies or knowledge brokers often also take part in knowledge production (Fazekas and Burns, 2012), which may contribute to the effectiveness of knowledge-to-action processes. Practitioners engage in mediation initiatives as well: websites are mentioned as examples in which teachers have access to journals and resources, can form communities of practice (e.g. learning hubs) and teacher enquiry and research are supported in various ways. More evidence is nevertheless needed on the effectiveness and impact of knowledge mediation efforts to understand how these processes can be facilitated for greater impact on teacher knowledge (Fazekas and Burns, 2012).

Box 2.3. **Knowledge mediation in action**

Brokerage agencies

The OECD (2007) looked at linking research to policy and provided a set of examples for brokerage agencies with varying goals and means:

- What Works Clearinghouse (United States)
- Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) (UK)
- The Iterative Best Evidence Synthesis Programme (New Zealand)
- Canadian Council on Learning (CCL)
- The Knowledge Clearinghouse (Denmark)
- The Knowledge Chamber (Netherlands) (OECD, 2007).

Associations and other types of organisations acting as mediators

- Centre for the Use of Research and Evidence in Education (CUREE) (UK)

The CUREE created, for example, a National Framework for Mentoring and Coaching on the basis of two systematic reviews of the impact of CPD, highlighting evidence from research and facilitating access to research features as core knowledge for mentors, specialist coaches and co-coaches (CUREE, 2005). The framework has been used in a number of ways in England to support the transformation of knowledge about CPD into practice (Cordingley, 2008).

- International Society of the Learning Sciences
- Evidence Informed Policy and Practice in Education in Europe
- The Campbell Collaboration
- The Education International (EI) (Cordingley, 2008).

Practitioners' mediation activities:

- Association for Science Education (www.ase.org.uk/)
- National Centre for Excellence in the Teaching of Mathematics (www.ncetm.org.uk/) (Cordingley, 2008).

Knowledge use

Concerning how research knowledge is integrated in teachers' knowledge base, certain studies suggest that teachers lack an objective understanding of their own knowledge base: on the one hand they often take complex strategies and skills, which are in fact based on professional expertise, analysis and critique for "common sense" approaches, while on the other hand, they also overestimate the extent to which they have internalised

theories and concepts (Cordingley, 2008; Cordingley and Mitchell, 2013). A first step towards a research-based knowledge base is to support teachers in making their existing practices and the underlying knowledge explicit (Cordingley, 2008). As we have noted in Section 3, the conditions, strategies and platforms of codifying teacher knowledge are yet to be explored. One of the main platforms of learning for in-service teachers is CPD, which thus plays a key role in transferring research knowledge to teachers. CPD programmes should not only be based on research knowledge but should also be designed in a way that they effectively transfer this knowledge and facilitate its integration into everyday teaching practice (OECD, 2007; Graham et al. 2006). How this should be achieved can be studied for example through comprehensive evaluations of such programmes.

Helping tie together research and practice takes place in essentially two ways: producing or transforming research outputs that are more easily accessible for teachers or giving teachers sufficient background in research to be able to interpret and critically reflect on research. From the point of view of fostering research-based practice and facilitating dynamics in teacher knowledge applying both ways at the same time seems the best strategy (OECD, 2007; Cordingley, 2008). Again, several initiatives have experimented with these strategies. Learning research methodology and engaging in research is an important part of initial teacher education in many countries. For example, in Denmark, Finland, Norway and Italy teachers participate in collaborative research or development activities both during their pre-service preparation and during their work as a teacher (Darling-Hammond et al., 2010).

An interesting example of the intersection of knowledge production and use is the way that education researchers engage in meta-studies and examine the relationship between education research and the teaching practice to draw conclusions on how to change research outputs to make them more adaptable for practitioners, how to design professional development for a greater impact on teacher learning, or what kind of mediation mechanisms to put in place to facilitate research-based practice (e.g. Cordingley, 2008; Hargreaves, 1996). Research about the use of research and evidence is only beginning to emerge (Cordingley, 2013), and subsequently a more visible impact on teacher knowledge can be expected.

To sum up, the interactions and processes influencing the creation, mediation and use of knowledge include issues about methodologies, the roles of different actors and the support mechanisms that enable different stakeholders to engage in KTA activities, as well as criteria for tools and products that facilitate knowledge-to-action in education. The general finding is that interactions and collaborations between different stakeholders should be stronger and need to be facilitated. Indeed, nearly all knowledge-to-action studies over the last two decades indicate that researchers and teachers should produce knowledge jointly in a collaborative manner (e.g. Levin, 2013; Best and Holmes, 2010; Vanderlinde and Van Braak, 2010; OECD, 2007). This can mean strengthening practitioners' involvement in all (or some) phases of the research process, building research evidence that is practice-based through more design-based research or based on lesson observation and analysis. Such collaborations would entail more direct and straightforward mediation processes.

In terms of knowledge dynamics the above means that the different functions of knowledge – its production, mediation and use – interact and influence each other and evidence suggests that strengthening the links between these functions contributes to the solidification of teachers' knowledge base.

Knowledge dynamics as social dynamics: Processes within the social-professional field

The knowledge base for teaching (i.e. a tripartite model comprising the sciences, professional practice and student learning) is embedded within a social-professional field in which a great number of stakeholders act and interact, thus influencing the dynamics of the knowledge base. In this section we will illustrate the complexity of this influence with examples for the diversity and variety of processes affecting teacher knowledge. The three main functions of knowledge described in the previous section are deeply influenced by the institutional and social context of ideas, technology developments, legal system, public beliefs and so forth (Levin, 2013). Thus the social dimension of knowledge dynamics encompasses not only the social interactions between the different educational actors but also the complex interaction of the elements of the whole social environment – or sociomaterial as it is referred to in recent studies (Fenwick, Edwards and Sawchuk, 2011). In the following we illustrate these processes with some specific examples.

Interaction among agents: actors and other elements

Cordingley (2013) illustrates the linkages between the key players of education governance and knowledge networks to show how the work of each is mediated through other groups and players before it exerts influence on student learning. Stakeholder groups such as researchers, policy-makers, school boards, school leaders, teachers and students should be conceived as a dense network of educational actors (interpreted either at the local [e.g. regional, national] or at the global level), in which some sub-groups or clusters are distinguishable. Here are a few examples on how each of these players can influence teacher knowledge.

Firstly and most evidently, the community of practitioners is the one which is directly and constantly shaping their own knowledge base. Continuing professional development, professional networks, or collaborating in various ways with colleagues are platforms of formal and informal learning through which teachers shape their knowledge every day. Knowledge sharing within the teacher community has taken new forms in the last decade: TeachMeets, organised meetings where teachers share good practice, innovations and personal insights in teaching, are increasingly more popular. Online resource pools, forums and webinars create the possibility for teachers to share teaching materials, good practices, or insights into teaching and engage in reflections, even when geographically far apart.

Practitioners' networks are emerging and growing on all levels. Teachers have professional networks in more and more countries. Platforms facilitating this networking are sometimes initiated by policy, in other cases they are created from the bottom-up based on the needs of teachers (see some examples in Box 2.4). Increasingly, more studies are dealing with informal learning (such as networked learning in the teaching community) and are coming to the conclusion that this kind of "invisible learning" is as important a platform for professional development as formal courses (De Laat, 2012; Vaessen et al., 2014). Simultaneously, some studies also underline the difficulty of making the most of informal learning networks, and stress that empowering rather than controlling professionals through, for example, planned interventions are key to enabling a well-functioning network (De Laat, 2012).

Box 2.4. **Facilitating teacher networks**

European teacher networks

The European Union invests a considerable amount of resources into facilitating teachers' collaboration across the countries: the Erasmus+ Programme (previously Lifelong Learning Programme) supports the implementation of 1-2 year projects, including teacher and student mobility and strategic partnerships between schools both of which provide ample opportunities for knowledge exchange between teachers.

Launched as the main action of the European Commission's eLearning Programme, *E-twinning* offers a platform for staff (teachers, head teachers, librarians, etc.) to communicate, collaborate, develop projects, share and be part of a learning community in Europe. Visit www.etwinning.net to learn more.

National platforms to facilitate teacher networks

Viaeduc (France)

Viaeduc is a promising initiative launched in France. It is a social networking platform for teachers, school leaders and other educational practitioners through which they can share knowledge, good practices, launch common projects, organise training or form working groups. Viaeduc is managed by the public interest group "Teachers' Professional Network" that comprises public and private institutions. Viaeduc counts over 14000 users in 2015 with over 2300 groups. While it is a public service, the network is self-organised by the users on the basis of local initiatives based on local needs. Visit www.viaeduc.fr to learn more (Muller, 2012; Muller and Normand, 2014).

Journal Clubs (Shanghai and Singapore)

An example of a practitioners' network is reported in Goldacre (2013). Teachers in Shanghai and Singapore participate in "Journal Clubs" where they discuss a new piece of research and critically reflect on its potential application in practice. In case they identify shortcomings in the study design, they suggest ways to improve evidence related to the question.

Professional networks also provide opportunities for different actors to collaborate, in particular, teachers and researchers. The impact of networked learning in understanding the teaching and learning processes is underlined (Wilson and Demetriou, 2007; Vaessen et al., 2014), while its full potential is not yet fully revealed. The various characteristics of networks that influence the impact on knowledge exchange have been studied in other fields such as regional innovation networks (Fritsch and Kauffeld-Monz, 2008), but little has been studied specifically in educational networks. In order to understand how various actors or groups influence each other, how knowledge flows, what matters in, for example, the spreading of innovation, today network analysis provides a number of suitable methods (see Box 2.6. in Section 6).

Actors in the social-professional field of education exert their influence on teachers' knowledge not only through interactions with each other but also through interactions with other elements of the field such as social technologies and material entities. Teachers "interact", that is, engage with textbooks, policy documents, educational media, or technology. They interpret, translate, apply, or adapt them in unique ways, and these interactions shape their knowledge. For example, textbooks can enact certain pedagogical activities, align curricula across space and time, or limit the teacher's academic freedom (Fenwick, Edwards and Sawchuk, 2011).

Research exerts impact on teacher knowledge often through intermediary processes, in which interactions between human and material elements are involved. Researchers conducting scientific studies in the field of teacher education explicitly address teacher knowledge and teacher learning. They investigate for example the effectiveness of professional development opportunities and look at what factors of teacher learning exert influence on teachers' knowledge and teaching practice (e.g. Cordingley, 2008; Timperely, 2008). Research findings are then reviewed in reports, summarised in policy briefs and recommendations, or presented in conferences. Policy-makers engage with these reports, briefs or presentations, which then influence policies and teacher education practices. In Sweden, for example, a series of teacher education inquiries were carried out, which for a long time underlined the importance of research skills for teachers and valued research-based professional knowledge until a switch in 2008 with a published report (SOU, 2008) that emphasised skills-based teacher-training as opposed to research-based teaching. A similar shift in reports influenced teacher education policies in England (Beach and Bagley, 2013). In these examples, researchers' influence is enacted indirectly through reports that influence, for example, teacher education policies, which in turn impact on teachers' knowledge.

Governance of teacher knowledge

The various processes and interactions among the agents (actors, technologies and so on) of the social-professional field of education together govern teachers' knowledge. Governance is exerted both directly through, for example, legal actions and regulations by the state, and indirectly through "soft governance". Soft governance refers to "a persuasive and attracting power", which draws actors from across different levels and spaces in a community engagement (Lawn, 2011: 259). It includes tools such as networking, seminars, reviews, expert groups, processes and social technologies. These technologies are used for specific social purposes, which influence people's perception of themselves, their relationships, and affect their thinking (Moos, 2009). For example, international measurements like the Programme for International Student Assessment (PISA) have made significant impacts on educational policy and practice (explored for example in the KNOW and POL research project[4]). Surveys like Trends in International Mathematics and Science Study (TIMSS) or TEDS-M[5] can exert influence on teachers' knowledge. Studies on governance and policy (Moos, 2009; Grek and Ozga, 2010; Lawn, 2006, 2011; Halász, 2016) show how these forms of governance, such as the use of data or standards, operate and can sometimes have profound effects. Let us see a few examples relevant to teachers' knowledge.

A greatly debated issue is the role of the state and of policy-makers in governing teacher knowledge. The creation of accountability systems is one of the ways the state exerts influence on teacher knowledge. Setting professional standards, school and teacher evaluation mechanisms (e.g. inspection), introducing national testing schemes represent expectations to which teachers have to live up and adjust their knowledge base accordingly. Unlike in the medical profession, where standards are set by the profession, teacher standards[6] are in many countries set by government-founded (or governmental) institutions, which are rarely fully independent and autonomous professional bodies (Beck, 2009). Beck (2009) argues that a real and larger self-governance should be given to the profession (and to schools) for example each school should have the right to decide at least a proportion of the criteria against which it evaluates its teachers' performance. An example for a more profession-governed system is the review and revision of the

Scottish teacher education standards carried out in 2013-2014. This process was a joint collaborative effort of a number of different actors and based on extensive feedback from many different educational stakeholders. In addition, a regular revision of the standards is envisaged, which has the potential to take into account the dynamics of teachers' knowledge and integrate new evidence. (See Box 2.5, Example 1 for further details.)

International policy networks provide another example for new modes of governance. As it has been emphasised in various sources the role played by such policy networks in knowledge governance has become increasingly influential (Fazekas and Burns, 2012). Several such networks have been created to facilitate consensus-making around certain issues of education ("key nodes" identified by the European Commission in this case) by involving a range of stakeholders in a collaborative process. (See details in Box 2.5, Example 2.)

Regulating teacher education is also a strong tool by which teacher knowledge is shaped. Where teacher education takes place (e.g. at the university, at a school or a specially designed teacher training academy) and who teacher educators are (e.g. researchers or expert teachers) strongly influence the kind of knowledge base teachers will have. Education policy in some countries and economies (e.g. England [United Kingdom] or Sweden) has recently been pushing teacher education towards teacher training, where teaching is considered increasingly more as a craft – thus teaching being conceptualised less as a research-driven profession and emphasising horizontal knowledge (practical and procedural) over vertical knowledge (academic knowledge realised in a specialised language) (Beach and Bagley, 2013). Similarly, continuing professional development is often regulated by the state through for example determining accreditation criteria for courses, which in turn have an important influence on teacher knowledge. If skills-based, craft-orientated teacher education dominates policies then teachers will have less opportunity to acquire knowledge and skills to interpret highly theoretical research and engage in critical reflections over their everyday practice.

Policy-makers can also influence the nature of educational research and the composition of the researcher communities through which they again affect teacher knowledge. Funding schemes can encourage certain kinds of research within the programme, or can prescribe the participation and involvement of certain stakeholder groups, such as teachers, in the research processes (Cordingley, 2011). Accountability systems for education institutions and public investment in research can set criteria for assessing research, which may have an indirect influence on the different stakeholder groups (Cordingley, 2008; OECD, 2007). In particular it can also influence teacher knowledge: if researchers are acknowledged for publishing and being cited they are less likely to concentrate on producing work that can be more easily applied in teaching practice. The mechanisms through which policy-makers and governmental institutions influence teacher knowledge are clearly diverse and complex.

We have seen that teachers' knowledge is affected by a range of highly complex social processes such as the interaction between the different actors and that of the various other elements of the social-professional field. These interactions and processes can be viewed as the complex governance of teachers' knowledge. In the next section we go into some details about what complex exactly means in this context and offer to interpret teachers' knowledge dynamics through complexity thinking.

Box 2.5. **Modes of knowledge governance**

Example 1: Review and Revision of the Scottish Teacher Education Standards

The General Teaching Council for Scotland (GTCS) (the Professional Statutory Regulatory Body that sets the standards for teachers in Scotland) undertook a major review and revision of teacher standards taking into consideration the recommendations of the Donaldson report (*Teaching Scotland's Future*, Donaldson, 2011).

The main goal of the revision of the standards was "to support the creation of a reinvigorated approach to 21st century teacher professionalism." (GTCS, 2015) Elements of the Donaldson report that are emphasised in this approach are to:

- "build the capacity of teachers, irrespective of career stage,
- have high levels of pedagogical expertise, including deep knowledge of what they are teaching;
- be self-evaluative;
- be able to work in partnership with other professionals; and to engage directly with well-researched innovation." (Donaldson, 2011: 19)

The review involved extensive consultation with the profession and other stakeholders. A steering group with a wide range of stakeholders, including parents and students, was set up and three writing groups formed. Face-to-face consultation meetings were held in four Scottish cities and online responses were sought through social media (such as Twitter) and synchronous online consultation meetings to encourage engagement from more remote parts of Scotland. The three working groups, each led by GTCS officers and drawing their membership from stakeholders, including practising teachers, reviewed existing provision and developed proposals for new Standards. One group looked at Standards for the early phase of teacher development, another looked at accomplished teaching and the final group considered leadership and management. The three groups worked in parallel but regularly also met together to ensure that there was consistency and coherence across all of the proposed new Standards.

Examples for two overarching goals of the revision of the standards were to:

- encourage all teachers to play a leadership role throughout their whole careers;
- develop further the values within the standards so as to encourage increased equity within Scottish education.

GTCS recognises that standards have a restricted shelf life and intends to review them approximately every five years. By the next revision GTCS also intends to gather evidence to gauge whether the current standards have been effective and have influenced practice in Scottish education with a positive effect on pupil learning (Hamilton, 2014).

Example 2: European Policy Networks

Policy networks financed by the European Commission in the framework of the Lifelong Learning Programme are European level policy experimentations on governing various aspects of the education system. They have included among others:

- the *Key Competence Network on School Education* (KeyCoNet), focused on identifying and analysing initiatives on and thus improving the implementation of key competences in primary and secondary school education http://keyconet.eun.org/;
- the *European Policy Network on School Leadership* (EPNoSL), aims at improving school leadership in Europe through a collaborative network in which members co-construct, manage and share knowledge intended to inform policy in the area of school leadership (2011-2015) www.schoolleadership.eu;

Box 2.5. **Modes of knowledge governance** *(continued)*

- the European Policy Network on the education of children and young people with a migrant background (Sirius Network) transfers knowledge and influences policy developments in order to help pupils from a migrant background achieve the same educational standards as their native peers (2012-2014) www.sirius-migrationeducation.org/;
- the European Literacy Policy Network (ELINET), aims to improve literacy policies in member countries, reduce the number of children, young people and adults with low literacy skills in Europe, and help increase reading skills and reading for pleasure (2014-2016) www.eli-net.eu/.

Complexity of knowledge dynamics and consequences on governance

The above review of the main processes characterising the dynamics of teacher knowledge showed that multiple factors and actors shape and influence teacher knowledge. The nature or structure of the knowledge base can change through the process of codification, which transforms the explicit and tacit dimensions of knowledge. The interplay between educational research and teaching practice impact on teacher knowledge as research results get mediated into practice or as teachers get involved in research themselves. Moreover, the multiple social interactions and processes also influence teachers' knowledge whether it is through networked learning or is a result of policy initiatives. The system describing the dynamics of teachers' knowledge is certainly complex. The question remains however whether these complex dynamics can be manipulated – or rather governed – in a way that facilitates the creation of an integrated and robust knowledge base for teachers that is capable of renewing and adapting to new circumstances and the ever-changing environment and thus being the basis of high quality professional practice. This section will first give an overview of how a complexity approach can be interpreted for the knowledge dynamics in the teaching profession, then explore the consequences of this approach to governing teachers' knowledge.

Increasingly more studies investigate certain processes in education adopting a complexity perspective. Complexity theory – originating in physics, chemistry, cybernetics and information science, among other disciplines – is a transdisciplinary field by nature, which makes it difficult to give one comprehensive definition of this approach (Davis and Sumara, 2009). The main assumption of complexity theory is that in certain systems changes do not occur in a linear fashion. Complex adaptive systems (CAS) – as particular cases of complex systems – are a self-similar ensemble of multiple agents (such as actors or organisations) interacting at multiple levels. (Duit and Galaz, 2008) Some of the most important characteristics of CAS (a non-exhaustive list) are the following:

- Connectivity: the inter-connectedness and inter-relationship between multiple agents of the system, and between these agents and their environment. In the case of knowledge dynamics the agents can be the actors of the education system: researchers, teachers, school leaders, policy-makers, students, parents, etc. or e.g. the different groups of local actors: the teaching staff at a school, the members of a school board and so on. But agents can also be material elements such as textbooks or policy documents.
- Co-evolution: elements of the system change based on interactions between them. The interactions provide feedback on themselves (and on the relationships and actions) after a number of steps, and these feedback loops are the drivers for the evolution of the system. For example, researchers investigating teaching and learning processes

accumulate evidence on teaching, which (e.g. through professional development) will affect teachers' knowledge and thus teaching practice, which again can be the object of study of educational research.

- Emergent order: The interactions of the agents result in some kind of global property or pattern that could not be predicted by any individual agent's actions or interactions. Thus, unpredictable behaviours and patterns arise.
- Cascading effects: The interactions are non-linear, and even small changes in inputs, interactions, or stimuli can cause very significant changes across the system. These moments of critical mass or thresholds that trigger large changes are called tipping points. (e.g. Chan, 2001; Snyder, 2013; Gladwell, 2000)

Knowledge in complexity theory is understood "in terms of potentials to action — necessarily dynamic, even volatile, subject to continuous revisions as the knowing agent integrates/embodies new experiences" (Davis and Sumara, 2008: p. 40). For Davis and Sumara (2009) the importance lies in activating these potentials. The emergent property of a CAS implies that the knowledge and capacity emerging from such a system is actually more than the sum of the knowledge of its agents, and thus can contain elements or features that are not present within any of the individual elements of the system (Osberg and Biesta, 2007 In: Fenwick, Edwards and Sawchuk, 2011; Mason, 2009). Moreover, the system is characterised by a high degree of adaptive capacity, meaning that it can react in a creative and intelligent way to changes or stimuli occurring in the system.

Davis and Sumara (2009) underline four conditions that must be present in an educational context in order to expand knowledge or activate a high potential in the system to action:

- Internal diversity: the diversity of the elements or agents is an important source of "intelligent" responses to emergent circumstances. Teachers; researchers; teacher educators; knowledge brokers; schools; professional communities, etc. at any level represent a large diversity of professional and educational backgrounds, interests and experiences, and thus can better react to the changing environment.
- Internal redundancy: the duplications and excesses of some aspects of the agents, meaning, a certain extent of uniformity, is also necessary. For example, in order for teachers to reflect on or investigate the teaching and learning process, they need to speak a common language and need to have some common knowledge base, etc. The role of redundancy is on the one hand to enable interaction and on the other hand to compensate for the failings of some agents.
- Neighbour interactions: neighbours in this context are interpreted as ideas, views, etc., that must be able to interact. It is thus not necessarily enough that researchers and teachers meet and talk, what matters is that there is space and opportunity for them to compare, contrast, collide, or juxtapose their ideas.
- Decentralised control: in order to enable neighbour interactions the control of the structure and outcomes of a knowledge-producing collective must be decentralised, that is, arising in local activities. For example, strictly regulating who plays what role in a researcher-teacher collaboration may diminish if not extinguish the potential of this collective to produce knowledge, as suggested by Davis and Sumara (2009).

Complexity theory is beginning to contribute to governance models and this approach has also appeared in the field of education (e.g. Snyder, 2013; Davis and Sumara, 2009; Liechtenstein et al., 2006). It has, for example, been applied in the context of knowledge

mobilisation, in particular to consider knowledge-to-action processes (see Box 2.6). Having explored the properties of complex adaptive systems in education governance, Snyder (2013) drew a number of conclusions on what is needed to operationalise a complexity approach to educational reform:

1. "fostering a collaborative environment throughout the system by actively creating opportunities for interaction […]
2. designing ways for collaboration and interaction to be continuous […]
3. making reforms iterative, experimental and flexible […]
4. adapting a "non-deficit" approach to reform […]
5. focusing on a few key nodes and pursuing them collaboratively […]
6. engaging and energising teachers through collaborative research and longer term peer-to-peer mentoring […]
7. taking on board the developments and management structures of other sectors and industries." (Snyder, 2013: 28-29.)

Many of the above criteria have been applied in the two examples of governing teachers' knowledge mentioned in Section 5, the review and revision of the Scottish teacher standards and international policy networks. Regarding the revision of the teacher standards in Scotland, we saw that this process was a joint collaborative effort involving and facilitating the interaction of a number of different actors. Two examples of the key nodes identified and emphasised in all domains of the standards were equity and leadership capacity building. The envisaged regular revision of the standards corresponds to an iterative and experimental process, which will integrate evidence on the effectiveness of the standards gathered by then in an adaptive fashion. Although results of the new standards on teacher knowledge are not yet known, this case is clearly a suitable illustration of how the above criteria can be applied. The other example we have looked at is international policy networks. At the heart of these initiatives lies the intention of fostering collaboration through intensive international and national networking. A key challenge for these networks is the issue of sustainability once funds end, as this would be necessary to allow the reiteration of the processes and work carried out. Again, an extensive evaluation has yet to be conducted to study the impact of policy networks on education systems. For the moment these are experimental initiatives for a new governance model.

Let us now look at some of the above criteria to get a better understanding of what they imply in terms of the knowledge dynamics in the teaching profession. The first two are closely connected: enabling a collaborative environment and ensuring that there are sustainable ways of collaboration are conditions often mentioned with regards to nearly all of the processes described earlier. Firstly, codification processes can be effectively stimulated by professional collaboration. Secondly, close collaboration between teachers and researchers was identified as a key condition for successful knowledge-to-action mechanisms. Thirdly, a truly collaborative environment would be a strong driver of the social processes for facilitating knowledge exchange in networks.

Coming back to Snyder's (2013) conclusions on what is needed to adapt a complexity approach to educational reform, Criteria no. 5 – focusing on a few key nodes and pursuing them collaboratively – raises the question of what would be key nodes in governing teacher knowledge. Among many others, Cordingley (2013) emphasises the role of teachers in educational achievement:

Box 2.6. **Emerging approaches to studying knowledge dynamics**

Knowledge-to-action as a complex adaptive system

A complexity theory perspective has been applied to knowledge-to-action processes (Fazekas and Burns, 2012; Best and Holmes, 2011). KTA viewed as a complex adaptive system is characterised by multiple agents interacting in a highly connected multilevel system, in which non-linear processes and feedback loops result in a high potential for emergent and unpredictable phenomena (e.g. Chan, 2001). Best and Holmes (2011) list some implications for policy, practice and research considered in a complex system such as:

- "the importance of coordinated and effective interventions across multiple levels of change (e.g. individual, organisational, community);
- the need to ensure readiness and sufficient capacity before launching major KTA initiatives;
- the importance of distributed, collaborative leadership and accountability throughout the system;
- the critical role of strategic communications to catalyse, coordinate and support change." (2010: 154-155).

Studying knowledge dynamics through social network analysis

Social network analysis (SNA) is a method used to investigate social structures through network and graph theory. It is used in the social and behavioural sciences, as well as in economics, marketing and industrial engineering. SNA makes it possible to study various phenomena. For example, one can look at the density of the network, clusters (dense parts of the network) can be identified or the reciprocity (mutuality) of relations mapped, or the individual actors and their specific functions or roles can be examined, e.g. who is 'powerful' in the network or who the brokerage (mediating) actors are (Kadushin, 2004). The analysis of education networks (e.g. local or regional networks including teachers of local schools, school leaders, people from educational authorities, teacher educators, mentors, inspectors, etc.) can reveal, for example, who are the key players in terms of accessing information, or those who connect clusters.

SNA can also be used for studying how certain attributes of actors (e.g. their gender) can explain their position in a network (e.g. how often they act as a bridge between other actors) or explaining relations among actors in a network (Hanneman and Riddle, 2005). In terms of knowledge dynamics, social network analysis helps to understand social processes such as knowledge transfer, information sharing, or power relations. Quantifying teachers' professional relationships has revealed, for example, that teachers who have more frequent and useful interactions around teaching and learning report more use of research evidence in their schools (Brown, Daly and Liou, 2015). SNA has also proved to be a useful tool for enhancing teacher learning in collaborative professional development programmes by developing their knowledge of the distribution of expertise (Baker-Doyle and Yoon, 2010).

> *Although stakeholders in education knowledge systems are many and various, the actors who make the most difference to achievement within educations systems, whether simple, or complex, are teachers. […] So a knowledge and capacity building system and engagement in and with research by practitioners within it as a means of improvement, needs to focus on them; on what teachers know and do and the ways they interpret, fashion and enact professional knowledge about teaching and learning. (Cordingley, 2013: 4)*

If teachers are the key players in enhancing students' knowledge, teacher educators certainly play a key role in developing teachers' knowledge. To avoid the pitfall of planning

any intervention targeted at a small number of actors and a restricted specific element of a complex system (Snyder, 2013; Mason, 2009), teacher education has to be understood in a wider perspective. Changing only the curriculum of initial teacher education, for example, would most probably not lead to significantly more dynamics in teachers' knowledge base. Instead, targeting the improvement of teacher learning – a broader concept than teacher education that sees teachers as lifelong learners and includes teachers' formal learning such as initial teacher education, induction or continuing professional development and informal learning such as professional collaborations or networking – with a special focus on strengthening the links between the agents of teacher learning, may prove to be an approach that has potential to trigger systemic change. What could then be a potential approach to influence teacher learning in a way that it reinforces the dynamics of teachers' knowledge?

One of the key consequences of a complexity perspective is that top-down interventions in some specific and small element of the system are not effective for CAS (Snyder, 2013, Davis and Sumara, 2009). Instead governance should focus on empowering the actors themselves to govern their own knowledge.

> *An education that is understood in complexity terms cannot be conceived in terms of preparation for the future. Rather it must be construed in terms of participation in the creation of possible futures. Educational research, framed complexly, must also be interpreted as participatory—meaning that (following Jenkins et al., 2006), there are opportunities for expression and engagement, there is support for creating and sharing creations, there is some type of teaching so the most experienced can mentor new members, members believe their contributions matter, and members feel social connection with one another. (Davis and Sumara, 2009: 43)*

Teacher education, or rather, teacher learning in this perspective should recognise the needs of (pre-service or in-service) teachers, connect research to their everyday practice, create a safe place in which they can critically reflect on their practice, and most importantly giving teachers a sense of ownership in education research. Since teacher educators in many countries largely overlap with the researcher community, this can mean involving and engaging teachers in research, as well as connecting to and getting involved in teachers' networks. In parallel, teachers also need incentives to take responsibility for their own knowledge base, get engaged in enquiry, research and share their knowledge widely. Criteria no. 6 – "Engaging and energising teachers through collaborative research and longer term peer-to-peer mentoring" – reflects this approach and is certainly an important criterion in terms of governing teacher knowledge.

Coming back for a moment to the case of Scottish standards, besides satisfying several of the criteria for governing a complex system, this example was chosen because it represents self-governance in a sense. The process was led by the General Teaching Council of Scotland (GTCS), which – unlike many similar bodies – has been an independent (non-governmental) professional body since 2012, and as such the world's first independent professional, regulatory body for teaching. Thus, similar to the field of medicine, in this example it is in a sense the profession itself that is responsible for regulating itself and governing its knowledge. We have seen in Chapter 1 that unlike teachers, doctors are widely recognised high-status professionals, which is partly due to the fact that the practitioners themselves assume their active role in governing their knowledge base.

All in all, to govern a complex system, a "robust governance" is needed that combines high capacities for exploration – gathering and analysing information about processes, self-monitoring, processes of testing, evaluating and exploitation – strong mechanisms to ensure co-operation among actors such as network structure, trust, etc. (Duit and Galaz, 2008: 329).

This is in line with what has been concluded on the nature of leadership in a complex system: it should rely on facilitation, empowerment, self-organising structures, participatory action and continuous evaluation (Best and Holmes, 2012). We have suggested that with regard to teachers' knowledge dynamics, this should involve a strong focus on teacher learning interpreted in a wide sense and on the links between the agents of the system.

Conclusions

This review was undertaken to obtain a better understanding of the meaning of knowledge dynamics for teacher knowledge. The teaching profession is often regarded as a semi-profession because it does not have a robust and integrated knowledge base and it lacks strong and effective knowledge to action mechanisms (Brante, 2010; Hargreaves, 1996; Mehta and Teles, 2014). Understanding the dynamics of teacher knowledge can contribute to understand what is missing for teaching to become a profession.

The first question asked was what teachers' knowledge is like. Certainly, there is no simple answer to this question. It can be considered at different levels (individual, collective), where these levels are nested within each other, and it has to incorporate the different conceptualisations of knowledge. The ITEL Teacher Knowledge survey will contribute to getting a better understanding of a certain aspect of teacher knowledge, in particular of how teachers solve their everyday problems and what kind of knowledge they are using. Any results and conclusions of such a study have to be treated, keeping in mind the more complex picture of this knowledge base.

The second question addressed the main processes influencing the dynamics of teacher knowledge. The framework used to review these processes provided three interrelated perspectives of the complex processes of knowledge dynamics: structural dynamics, functional dynamics and social dynamics. An attempt to comprehend complex systems should begin with asking the right questions, which instead of seeking one particular and definitive answer, are open-ended and are driving at an integrative approach that encompasses existing knowledge as well as those emerging (Snyder, 2013). We attempted to formulate such questions for each of the 3 aspects of knowledge dynamics reviewed in this chapter.

Table 2.1. **Questions for understanding the 3 aspects of knowledge dynamics**

Knowledge dynamics in the teaching profession	Processes	Open questions
Structural dynamics	Codification: the interplay between the tacit and explicit dimensions of knowledge	How could codification improve the professional practice of teachers? How could codification facilitate extended access to knowledge for teachers? In what ways can codification processes be facilitated towards building a more integrated knowledge base for teachers?
Functional dynamics	Knowledge-to-action: the interplay between knowledge production, mediation and use	How can the linkages between knowledge production, mediation and use be strengthened? How can we build the capacity of the actors to improve KTA processes? How can we utilise existing knowledge and evidence on knowledge production, mediation and use to improve these processes?
Social dynamics	Social processes: the interplay between different stakeholders – policy-makers, researchers, teachers, students, parents, etc. – and between the elements of the social environment	How can we enhance and utilise existing mechanisms, structures and resources (such as networks and collaboration) to improve professional learning? How can stakeholder interactions and collaboration be exploited to facilitate the dynamics of teacher knowledge?

The above questions should help answering the third set of questions that were initially asked: what is known about these processes and how can they be governed to facilitate knowledge dynamics in the teaching profession? Emerging theories such as complexity theory and methods such as network analysis can greatly contribute to understanding how teachers' knowledge base is transforming, who are shaping it and how change can be triggered in this system. This chapter suggested that knowledge dynamics may be viewed as a complex adaptive system, and thus a complexity approach has implications to the governance of teachers' knowledge.

In a first step teacher education or, in a wider sense, teacher learning has been identified as a "key node", which potentially has a great influence on the whole system. Thus, when planning specific interventions towards a better governance of teacher knowledge, empowering teacher educators and teachers themselves to take charge of teachers' knowledge base seems to be crucial. This approach emphasises leveraging feedback from all stakeholders, building on stakeholder involvement and partnerships, capacity building, the continuous monitoring and re-evaluation of processes. The role of policy makers is rather the creation of a "greater connective tissue" between the levels, areas and actors of the system (Snyder, 2013).

The ITEL Teacher Knowledge survey therefore should also aim at exploring the factors affecting teachers' professional competencies, in particular their pedagogical knowledge base, and attempt to get a better understanding of how these factors facilitate the dynamics of teachers' knowledge.

Notes

1. Knowledge mobilisation, Knowledge translation, Knowledge dynamics, Knowledge codification were the main key words used together with Education and Teacher knowledge. Searches were carried out for English sources only.
2. Search done in December 2014.
3. http://en.wikipedia.org/wiki/Yin_and_yang.
4. Knowledge and Policy in Education and Health Sectors, EU FP6 IP 028848-2 (www.knowandpol.eu).
5. Trends in International Mathematics and Science Study (http://timssandpirls.bc.edu/), Teacher Education and Development Study in Mathematics (www.iea.nl/teds-m.html).
6. See more on teacher standards in Chapter 3.

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Chapter 3

Teacher professionalism and knowledge in qualifications frameworks and professional standards

by
Diana Toledo-Figueroa, Nóra Révai and Sonia Guerriero
OECD

This chapter explores how teachers' professionalism and teachers' knowledge are manifested through instruments such as qualifications frameworks and professional standards. National systems employ these documents as a reference to guide teachers on what they should know and be able to do. Firstly, we begin by exploring how qualifications frameworks and standards define and shape teachers' professional competences. We use the metaphor of a "knowledge wall" to explain how the two frameworks relate to each other. Secondly, we analyse the internal structure and the content of five professional standards in Australia, England and Scotland (United Kingdom), the standards developed by the National Board of Professional Teaching Standards (United States) and Ontario (Canada). In particular we examine how different types of knowledge components are described and which elements of pedagogical knowledge are specified.

Introduction

Defining the knowledge-base of a profession can be a shared challenge across professions. In today's global context, societies are becoming increasingly knowledge intensive, and knowledge has become the key connecting elements across multiple levels and dimensions of contemporary governance (OECD, 2013a). In this new scheme, multiple sources of knowledge will interact and contribute to the continuous generation of new knowledge. This leads to two challenges: the first is defining the knowledge base of a specific community of practice, and the second is defining how to make this knowledge meaningful and readily available from one context to another (Evetts, 2005; Fazekas and Burns, 2011). Succeeding the first challenge will help establish policies that foster the generation of the specific knowledge needed. Succeeding the second challenge will help strengthen the capacity of that knowledge to adapt to different contexts and needs, and become synergic with other types of knowledge.

In this chapter, we explore how teachers' professionalism and teachers' knowledge are manifested through certain instruments that help connect and mediate between education policies, professional bodies, and practitioners. Teachers' qualifications frameworks and professional standards provide a basic reference of how countries guide teachers and education systems on what teachers should know and be able to do to clarify their role in a knowledge-based profession. A key question raised relative to teachers' knowledge is how education systems translate the available scientific evidence about what constitutes a good teacher so that she can have an impact on student learning in the classroom. A shared understanding of what constitutes a good teacher is important in order to align the necessary resources at the classroom, school, and system levels that teachers will need in order to better impact student learning and to influence the profession in substantive ways (e.g. by offering competitive salaries or attractive career paths) (Ingvarson and Rowe, 2007). Qualification frameworks and professional standards help signal what is expected from teachers and how they can improve at different stages of their professional careers.

This analysis focuses mainly on professional standards for teachers in Australia, the United Kingdom (England and Scotland), Canada (Ontario) and the United States, and a few other international examples. The analytical work carried out is grounded in desk-based research, using documents available to the general public from official websites, as well as existent research on the topic. In recent years, the OECD has developed several publications and carried out various studies focusing on teachers specifically, or as components of policies for better learning, such as Teachers Matter (OECD, 2005a), the Teaching and Learning International Survey (TALIS)[1], Improving Schools[2], Equity and Quality in Education (OECD, 2012b), and Synergies for Better Learning (OECD, 2013b), among others. This review will build upon previous OECD work, as well as non-OECD sources from government, academia and international institutions.

Part I discusses how teachers' professionalism is reflected through a system of documents. It will look at how qualifications frameworks and professional standards define and shape teachers' professional competences. Part II focuses on teachers' professional

standards through an analysis of their general characteristics, and in particular, their internal structure and content. This part also discusses the knowledge components that professional standards promote as required by the professional in order to be successful during practice.

Teachers' frameworks, standards and the "knowledge wall"

Teachers face increasingly complex demands along their professional lives due to factors such as an increased focus on learning outcomes; a more diversified student population (e.g. immigrant or special needs); increasing external demands from parents, employers, media, advocacy groups, and other stakeholders; evolving cross-curricular content and new uses of technology, among others (OECD, 2005a; OECD, 2013b). Teachers' professional standards and competence frameworks are viewed by some as tools that can help teachers cope with these new challenges. Along with qualifications frameworks, they provide a window into how countries describe the knowledge required of teachers and how they plan improvement for the profession. There is nevertheless a debate regarding what these frameworks are and the effects they might have on improving teaching and learning. In order to understand how teachers' professionalism is manifested in these instruments, this section will introduce some key concepts and discuss the purpose and different possible uses of standards and qualifications frameworks.

Sociological literature on "professionalism" is vast and includes varying conceptions and definitions of profession, professionalism, and professionalisation (e.g. Evetts, 2009, 2012; Snoek et al, 2011; Brante, 2010; Hargreaves, 2000; Eraut, 1994). It is not the purpose of this chapter to review these conceptualisations, nor to take a stand on one definition over another. Rather we embrace each view and adopt a general and broad approach so as to be able to capture any characteristics, manifestations, or attributes of professionalism that might be reflected in the standards documents we have chosen to analyse. In this paper, therefore, we use the concept of professionalism based on Snoek et al (2011) as a term encompassing the qualifications and lifelong professional learning expected of teachers, including the use of professional standards; professional autonomy; the central values and ethical codes within the profession; the knowledge base and the expectations towards teachers in connection with their professional expertise; collaborations within and outside the profession; and accountability for professional quality. When speaking about the teaching "profession", we refer to the occupational group of teachers.

Literature about teachers typically refers to different kinds of "frameworks" such as competence frameworks, knowledge frameworks, qualifications frameworks and so forth. In addition to the variety of frameworks, the meaning of some related key concepts can also differ (e.g. qualifications, skills, competences, or competencies), despite existing international coordination efforts, such as the Common European Principles for Teacher Competences and Qualifications, the European Qualifications Framework or the European Higher Education Area (Brockmann, Clarke and Winch, 2008; FIER, 2009; Bourgonje and Tromp, 2011). As Allais (2010) highlights, the definition of qualifications frameworks "…are not empirically derived, but describe what people hope qualifications frameworks *should be* and *should do*. […] the terminology used in creating and describing qualifications frameworks is very similar in different countries—including terms such as "learning outcomes', "competence", "standards", "validation", and even, "qualification"—in fact, these terms often refer to very different things."

Qualifications frameworks

Qualifications frameworks can help clarify the specific formal qualifications that a teacher (or another occupation or profession) can receive within a specific education system in relation to other professions. They can thus be regarded as documents (among others) in which teachers' professionalism is manifested. A "qualification" is defined by the OECD (2007b; 2010) as the formal outcome (or award) of an accreditation or validation process that certifies that an individual has learned the knowledge, skills, and/or wider competences according to specific standards. Qualifications frameworks are considered mainly "outcome-based" (and in some contexts, "standards-based"), since they provide information about the learning outcomes against which learners' performance can be assessed in a process. For the purpose of this chapter, qualifications frameworks will therefore be defined as instruments that support the development and classification of qualifications according to a set of criteria for levels of learning achieved, and based on specific quality requirements. These instruments can allow, among others, a common understanding of the quality and content or outcome of an award achieved, comparability among qualifications and a certain transferability of knowledge across professions.

Despite their various forms and functions, qualifications frameworks have four basic or generic aims according to Coles and Werquin (2009):

1. establishing national standards (here, understood as common references) of knowledge, skills, and wider competences
2. promoting quality of education and training provision through regulation
3. coordinating and comparing qualifications by relating them to each other
4. promoting access to learning, transfer of learning and progression in learning.

Qualifications frameworks can vary depending on who they are developed by (centrally, by an agency, or by stakeholders), their main objective (prescriptive or communicative of main guidelines), or how detailed they are (covering all qualifications, or only some in the system) (OECD, 2007; Tuck, 2007). Countries do not necessarily define qualifications for teachers at the national level: several OECD countries have only broad descriptions of initial teacher education at the national or sub-national level, with more detailed descriptions at local levels. Qualifications frameworks can also be supra-national (across countries, also known as "meta-frameworks") such as the European Qualifications Framework (EQF), the Framework of Qualifications for the European Higher Education Area (EHEA), or the efforts to map qualifications frameworks across APEC economies (EU, 2015; Burke et al., 2009). The aim of these frameworks is often to link countries' qualifications systems in a region.

To function adequately, qualifications frameworks need occupational standards (mainly for vocational education and training, where these are also known as "unit standards"), or other measures of learning or information systems that clarify qualifications, pathways, providers, and expected performance (Coles, 2006; ILO, 2006). Providing a "competence-based" (sometimes equivalent to "outcome-based") approach to establish the outcomes and levels of the stages of study is sometimes difficult to achieve within one occupation, or to compare between different occupations. As a result, many national qualification frameworks sometimes include input measures in order to compare qualifications (e.g. number of years of study or number of hours of instruction) (Coles, 2006; OECD, 2010). Still, a challenge seems to persist in avoiding too narrow or vague definitions of what "outcome-based" means, or outcomes that are based on mistaken understandings of the nature of knowledge

and skills (Allais, 2010). Let us now have a look at what exactly professional standards and competence frameworks are, before discussing the details about how they connect to qualifications.

Professional standards and competence frameworks

Professional standards carry the challenge of providing a clear definition for the term "competence". In fact, the lack of a generally-accepted operational definition of competence is usually acknowledged (Kouwenhoven, 2009). The term "competency" is used in literature, either as a synonym of competence (e.g. OECD, 2001) or as a separate concept (Teodorescu, 2006). In the same way, the term "skills" is understood in different ways across literature. Ananiadou and Claro (2009) acknowledge that this term is sometimes used as the equivalent of competence or as a distinct term in itself. Within the OECD, a "skill" is understood in a broad and complex sense and is used as a synonym for competence (OECD, 2013c).

In the context of this chapter, "competences" are defined as the on-going and progressive ability to meet complex demands in a defined context by mobilising holistic psychosocial resources (cognitive, functional, personal and ethical) as needed to accomplish these demands. This definition of competence as a dynamic, process-oriented concept is key to the analysis of professional standards. "Competencies", on the other hand, are defined as components of this competence encompassing knowledge, understanding, skills, abilities and attitudes (thus also composed of multiple psychosocial resources) (based on Rychen and Salganik, 2003; OECD, 2005b).

The term "standard" is likewise used in a variety of ways across policy documents and research studies (Sachs, 2003). The literature often refers to the double definition of the word as both a "flag" and a "measure" in a broad sense. Ingvarson (2002) translates the first sense as articulating "core educational values that teachers seek to make manifest in their practice", that is, "standards, by definition, are statements about what is valued". Standards as measuring tools describe "what teachers need to know and be able to do to put these values into practice" but also "how attainment of that knowledge will be assessed". In this sense, therefore, a standard refers to "the level of performance on the criterion being assessed" (Ingvarson, 2002: 3). Qualifications frameworks sometimes understand "standards-based" as equivalent to "outcome-based" in the sense that they provide information on the expected learning outcomes or on the process of verifying learning outcomes through quality assurance procedures (OECD, 2007; Tuck, 2007; Coles, 2006).

In order to be able to analyse a variety of standards in this chapter, we use a broad understanding of standards based on Ingvarson's (2002) conception: standards describe what teachers should know and be able to do, including the description of a desirable level of performance. They are thus documents, or sets of documents, with different extensions and scope that state what is valued in a profession through a competence-based approach. We note that the term "competence framework" is also used, in some cases as equivalent to "professional standards", in other cases to refer to broader frameworks that can contain elements such as sets of general and professional duties for teachers, but also school improvement plans (OECD, 2013b). In this chapter we use the term "professional standards", since the documents we have chosen for analysis are referred to as standards.

Having discussed some key terms, we now turn to the connection between qualifications and standards frameworks and clarify what role competencies play.

The "knowledge wall": Linking qualifications frameworks and professional standards

How do qualifications and standards frameworks, separately and together, define and shape teachers' professionalism within an education system? It is not always clear how different types of frameworks relate to each other. For example, how do qualifications frameworks and professional standards frameworks interact with each other within an education system? What do competencies and standards mean for these frameworks and what is their role? Based on various OECD and non-OECD literature, this section will discuss how qualifications and standards frameworks interact within a country.

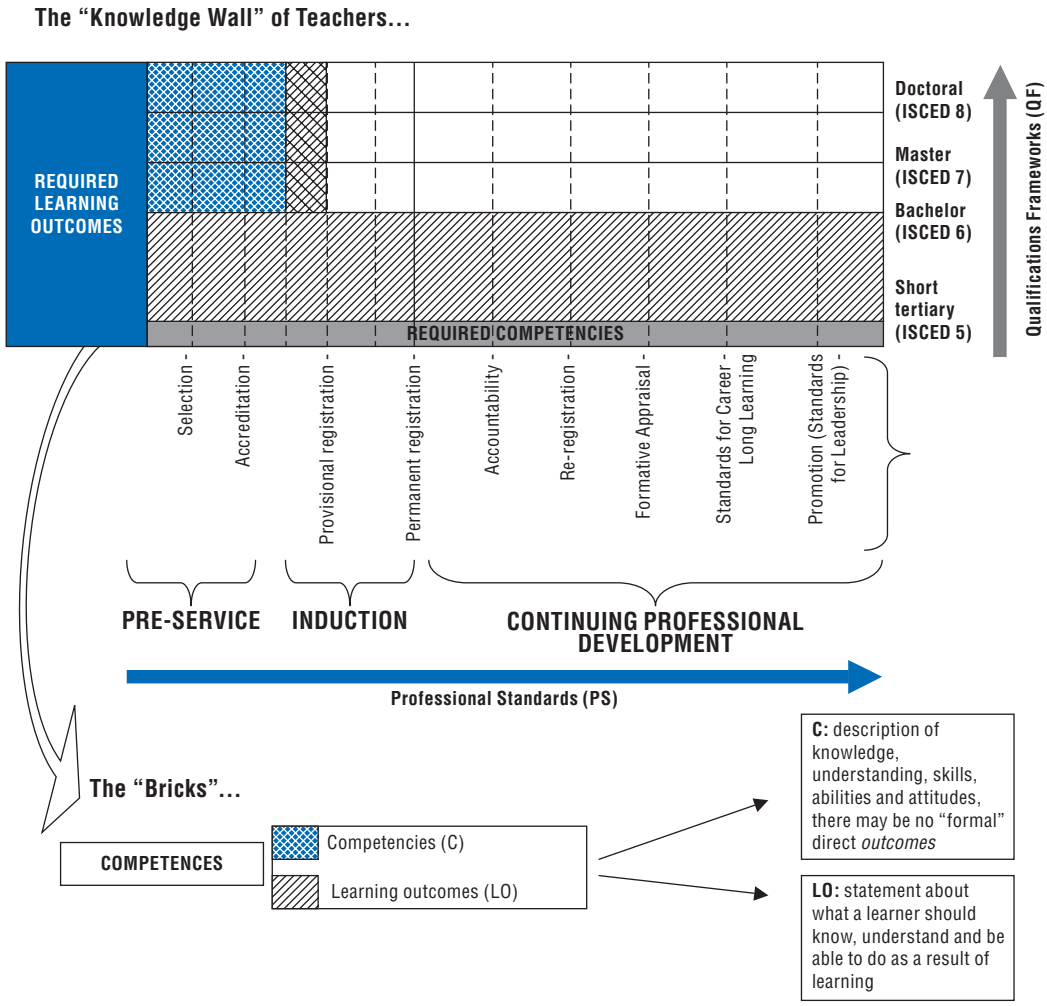
Along the continuum of a teacher's professional career, professional standards complement the qualifications acquired in formal teacher education programmes to promote teachers' lifelong improvement. As we have seen above, qualifications frameworks specify the formally-acquired knowledge in principle (e.g. bachelors, masters, or doctoral degree) (OECD, 2004). Professional standards, on the other hand, specify the on-going improvement of competencies (knowledge, skills and attitudes) from beginner to proficient that may eventually lead (or not) to additional formal outcomes in a teacher's career (e.g. practicum or induction requirements and continuing professional development). They may also allow the further shaping of teachers' knowledge at different stages of their careers according to the needs of the education system. From these different perspectives, both qualifications frameworks and professional standards contain information on the aspirations of education systems about what teachers' should know and be able to do.

We use the analogy of a teacher's "knowledge wall" to explain how these frameworks can influence a teacher's professional career. Figure 3.1 shows a possible interaction between a qualifications framework (vertical axis) and professional standards (horizontal axis) in a hypothetical country and illustrates a particular stage of development in a teacher's career. A teacher in this country has been awarded with an initial teacher education degree at the bachelor level, as represented on the vertical axis. This axis corresponds to the qualification framework. In this specific example, it shows the ISCED classification levels as well as the levels for the Framework for Qualifications of the European Higher Education Area (Bologna Working Group, 2005). In terms of professional standards represented on the horizontal axis, this teacher has demonstrated to have achieved the required standards for entering into a teacher education programme (e.g. the standards for Selection into the teacher education programme) and to become an accredited teacher (e.g. the standards for Accreditation), and could now be following a registration process. The competencies corresponding to the achieved standards are indicated in blue checkers, while the learning outcomes corresponding to the achieved qualifications are represented in dark stripes. Depending on the employer, the teacher could also be subject to a permanency appraisal, possibly during the first year of practice (Ingvarson, 2002). The competences are the "bricks" that show what elements of professional competency (e.g. knowledge, skills and attitudes) the teacher would have demonstrated to have acquired by having completed the given qualification and achieved the given standards.

The competences define the vertical and horizontal movement of a teacher in the knowledge wall. After completion of initial training, the progress in one framework may not necessarily imply progress in the other one. This will depend on a country's teacher policy and the personal ambitions of teachers. For example, in some countries a Master's degree is required to become a registered teacher, or a teacher can follow a doctoral programme by his/her ambition without necessarily advancing in the standards framework. From this

dynamic perspective of progressive improvement, standards, and qualifications frameworks can be an important influence in shaping the opportunities and incentives for teachers to follow informal, non-formal and formal continuous training.

Figure 3.1. **The "knowledge wall" of teachers' national qualifications and professional standards frameworks**



To summarise, we used the analogy of a "knowledge wall" to illustrate how teachers' professionalism is reflected in teacher frameworks as a progression of their professional competences, such as qualifications and standards frameworks, and how these together define and shape teachers' professional improvement. Teachers face increasing accountability and formative demands from education systems. Adequate, evidence-based training opportunities (non-formal, informal or formal) can help match these demands. However, challenges still remain for countries to: a) reach a common evidence-based understanding of key concepts related to these frameworks; and b) use this understanding to ensure adequate accountability and formative processes through a structure that provides a coherent view of professional knowledge required of teachers.

But how exactly do standards and qualifications frameworks help in shaping what knowledge is required of teachers? In the next section, we discuss how various frameworks conceptualise teachers' knowledge and improvement by analysing a selected set of frameworks of professional teaching standards. The purpose of the analysis is to describe how teachers' knowledge is manifested in professional standards and how this manifestation compares across countries.

An analysis of frameworks for teachers' professional standards

We begin by first analysing some general characteristics of the selected teacher standards. Then, we look at how specific elements of teachers' knowledge are contained in these professional standards. We focus only on general pedagogical knowledge, not content knowledge, nor pedagogical content knowledge. We use the term "general pedagogical knowledge" to refer to the specialised knowledge of teachers for creating effective teaching and learning environments for all students independent of subject matter. (For a detailed discussion of general pedagogical knowledge, see the chapter by Guerriero in this volume.)

The number of countries with professional standards has increased over the years. As with qualifications frameworks, the different contexts and uses that education systems give to professional standards seem to have a defining influence on how these are structured and used. Professional standards can have many structural differences, such as the text's extension and detail or how they describe objectives. For example, they can be organised as extensive lists of competences or as more generic statements. They can also be part of a framework with different possible balances between formative and summative functions (Ingvarson and Kleinhenz, 2003; FIER, 2009; OECD, 2013b). There is some evidence however that shows some convergence in the content of professional standards. Ingvarson and Kleinhenz (2003) identified that most sets of professional standards today share common structural features, such as their articulation at taxonomical levels of specificity.

As part of the development of professional standards' across an increasing number of countries, an important amount of literature has discussed their effects, but the research is not conclusive. Some report that professional standards for teachers can lead to better student outcomes and can help identify effective teaching practice when used for certification purposes (Darling-Hammond, 2000; Darling-Hammond *et al*, 2012; Kleinhenz and Ingvarson, 2007). At the same time, there is concern that professional standards may restrain teachers' practice or that their use may actually enlarge learning gaps between students if these are not accompanied with the necessary resources to help teachers in socially disadvantaged contexts (Muller, 2009; Caena, 2011). As pointed out by Guerriero in this volume, researchers have tried to conceptualise and measure teacher quality through proxies, such as whether teachers have certification, the qualifications they possess or their years of experience. However, in order that such proxies become effective indicators of teacher quality, they need to reflect the actual competences underlying teaching itself.

General characteristics of teachers' professional standards

The selected cases for analysis come from Australia, England and Scotland (the United Kingdom), the standards developed by the National Board of Professional Teaching Standards (NBPTS) (the United States) and Ontario (Canada). These cases were selected because their professional standards have different extensions (e.g. the NBPTS vs. Ontario), they seem widely used within their system (England, Scotland and Ontario), have served as examples for the development of professional teacher standards in other countries

(e.g. Ontario, the NBPTS, England), or have recently adopted or revised professional standards (Australia and Scotland in 2013; England, 2012; the NBPTS, yearly revisions). In all the selected cases in this analysis, other documents or instruments in addition to professional standards complement the framework (Table 3.1).

Table 3.1. **Main elements composing the professional standards selected for analysis**

Country	Name	Main components
Australia	Australian Professional Standards for Teachers (AITSL, 2013a, 2016)	Professional teaching standards supported by the Self-Appraisal Tool (SAT) and the Australian Charter for the Professional Learning of Teachers and School Leaders (for continuous professional development). The standards are accompanied by videos that illustrate the practice in real life and other supporting material provide information on the accountability requirements for teachers at different career stages (initial teacher education, registration, teacher performance and development, and certification).
Ontario (Canada)	Professional standards (OCT, 2013, 2006, n.d.)	Standards of practice, ethical standards and the professional learning framework (for continuous professional development). There is also a Member's Handbook, a Casebook Guide for Teacher Education, and Cases for Teacher Development: Preparing for the Classroom.
England (United Kingdom)	Teachers' Standards (DfE, 2013; GTCE, 2015)	Teachers' Standards are divided into two parts: 1) Teaching and 2) Personal and Professional Conduct. Guidance to accompany the Professional Standards for Qualified Teacher Status and Requirements for Initial Teacher Training completes the framework. Master teacher standard (for advanced teachers) has been discussed as a possibility.
Scotland (United Kingdom)	Professional standards for teachers (GTCS, 2012a, 2012b)	Standards for Registration (for provisional registration at the end of initial teacher education and full registration), the Standards for Career-Long Professional Learning, and the Standards for Leadership and Management (Middle Leadership and Headship). There is also a Code of Professionalism and Conduct.
United States[1]	National Board of Professional Teaching Standards (NBPTS, 2012a, b, 2013)	Twenty-five sets of standards organised according to the student's developmental (grade) level and the subject area of the teacher. Among the supporting documents is the Guide to the National Board Professional Standards' Certification. Other sets of standards are being developed to address the teacher career continuum.

1. The United States have only recently developed a set of national standards (the Council for the Accreditation of Educator Preparation), but several states have developed their own standards (e.g. California, Colorado, Illinois, New York, Texas, Virginia, Washington and Wisconsin). The *National Board of Professional Teaching Standards* is an NGO that has developed standards for certification as advanced teachers.

Previous research has identified some general desirable characteristics of professional standards to promote good teaching (CEPPE, 2013; Ingvarson, 2002; Ingvarson and Kleinhenz, 2003; Ingvarson and Rowe, 2007; OECD, 2013a). These general characteristics can be summarised along three aspects: a) coverage and purpose, b) internal structure, and c) quality assurance tools. We use these aspects to conduct our analysis of the selected cases.

Coverage and purpose

Coverage and purpose refer to how the professional standards in the framework establish pathways for professional learning. Standards frameworks should provide a common basis to organise the key elements of the teaching profession, such as initial teacher education, teacher registration, teacher's professional development, career advancement, and teacher appraisal. These elements should be aligned to signal a logical improvement process at teachers' different career stages (OECD, 2005a; CEPPE, 2013; Bourgonje and Tromp, 2011). In terms of coverage, standards can be:

- generic (same professional standards for all the profession's branches)
- specific (distinctions among the profession's branches, such as grade level or subject taught).

As for their purpose, they can be distinguished by career stages (e.g. registration, certification) and proficiency stages (e.g. beginner, intermediate, advanced) levels, such as:

- basic core (one set of competences for all career or proficiency stages)
- roadmap (distinction from most basic to most advanced career stages)
- semi-roadmap (covers some professional stages only: typically registration and continuous development).

Table 3.2 summarises the coverage, the purposes and the main features of the selected cases for analysis.

Table 3.2. **Coverage, purpose and features of the professional standards selected for analysis**

Country, Professional Standards	Coverage	Purposes
Australia Australian Professional Standards for Teachers	Generic	Roadmap
Ontario (Canada) Professional standards	Generic	Basic core
England (United Kingdom) Teachers' Standards	Generic	Basic core
Scotland (United Kingdom) Professional standards for teachers	Generic	Semi-roadmap
United States National Board of Professional Teaching Standards	Specific	Roadmap

The coverage and purpose of teachers' professional standards, as well as their links to qualifications frameworks, can vary across countries. Literature mentioned earlier points to the preference of producing standards frameworks that clarify how teachers will improve along their professional careers. Some of the cases analysed here follow this approach (predominantly generic professional standards). Other cases establish at least a common core of quality for all teachers, while guidance for improvement is addressed through other process-oriented tools composing the framework.

Support and quality assurance

Researchers encourage combining different types of instruments for support and quality assurance, since teachers perform complex tasks that require a variety of competences. Kleinhenz and Ingarson (2007) point out that a framework of professional standards should be defined with quality assurance tools in mind. For example, instruments could include classroom observations, interviews with the teacher, teacher self-appraisal, student performance data, and feedback from parents and students, as well as teacher portfolios containing samples of student work, recorded lessons, among others (OECD, 2013b). The adequate use of these instruments requires capacity-building for teachers, school principals and evaluators in order to clarify the objectives of the standards and how success in achieving these tasks should be assessed. Furthermore, the evidence requested from teachers should not entail additional heavy workloads for them. Rather, this should be a "natural harvest" of their daily work in the classroom (e.g. samples of student work or class recordings) (OECD, 2005a; Santiago and Benavides, 2009; OECD, 2013b).

The professional standards in the cases analysed seem to comply in principle with what the literature notes on the desirable ways of appraising teachers previously mentioned. All frameworks analysed request evidence of practice from a variety of sources that draw from the teaching context (e.g. portfolios, meetings with appraisers, samples of student work). This evidence is based on professional judgement and the goal is to produce evidence of teacher practice drawn from the "natural harvest" of teachers' work. Additionally, a variety of actors can appraise teachers besides the school principal, such as other personnel from the school's leadership structure, other teachers or external personnel.

A detailed analysis on how the selected professional standards compare with regards to their coverage, purpose and quality assurance tools is beyond the scope of this chapter. Here we provide a summary on how the selected frameworks compare in terms of their internal structure.

Internal structure

Before turning to how standards formulate the requirements for teachers' knowledge, it is important to first understand how these documents frame the discourse about teaching. According to the literature (Ingvarson and Rowe, 2007; Bourgonje and Tromp, 2011; Santiago and Benavides, 2009), good teaching standards should be grounded on clear guiding conceptions of what good teaching actually means; be valid and specify the evidence to be gathered about what teachers know and do in order to promote learning and ensure it is authentic; and finally, identify the levels of performance and criteria to ensure reliability. They should also explain how and in what areas teachers should improve with time, and providing opportunities for this. Regarding the internal structure of standards frameworks, we will shortly summarise what standards should be like on the basis of literature and what we found in the selected professional standards.

In terms of teacher improvement, standards should motivate teachers to perform as professionals, promoting the teacher's capacity of empathy and self-efficacy. Concerning "growth and development" standards should align competencies from a perspective of gradual improvement that can take place at different stages of a teacher's career. Moreover, literature suggests that they should include domain specific and broader life skills, cultural and socio-emotional competence, as well as values (Ingvarson and Rowe, 2007; Bourgonje and Tromp, 2011; Santiago and Benavides, 2009). In the standards analysed, there seems to be some consistency in what teachers are expected to know as they progress in their professional careers. In general, the more experienced the teacher, the more adaptable they are expected to be (Australian, Scottish and the NBPTS [e.g. Middle Childhood-Generalist] professional standards). The selected standards tackle professional development in a variety of ways, with the support of documents aligned to professional standards, which goes from providing main guidelines, to specifying examples of activities.

Professional standards should allow teachers to understand the complexity of competences expected from them (e.g. by pointing to large "chunks" of the teachers' work, rather than only describing one task). They should refer to broad competences/complex sets of skills and avoid pointing at "micro-level" competencies or "personality traits", while at the same time paying attention to how personal and contextual factors (societal, school system, and school-level) are related to teachers' performance. (Ingvarson and Rowe, 2007; Bourgonje and Tromp, 2011; Santiago and Benavides, 2009). The statements of what a teacher should be able to do seem to require the use of complex resources that entail cognitive, personal, functional, or ethical competences. Most of these professional standards explain what the teacher should be able to do, and are supported by further developments of what these statements are (e.g. descriptors, illustrations of practice). Australian professional standards, for example, have developed a series of videos to illustrate how one or more professional standards or descriptors translate into real life practice (AITSL, 2013). The NBPTS professional standards, such as those for Middle Childhood Generalist (NBPTS, 2012a), also include broad explanations of how a specific statement applies to the classroom. Both the professional standards from Scotland and England contain lists of supporting bullet points that further elaborate the professional standards' scope, and are not intended to be considered individually, but as a group of statements that clarify further the complexity of the competence requested (Bourgonje and Tromp, 2011; GTCS, 2012a; 2012b) (Table 3.3).

Table 3.3. **Extract from Standards for Registration (Scotland)**

3.1.3 Employ a range of teaching strategies and resources to meet the needs and abilities of learners	
Professional Actions Student teachers:	**Professional Actions** Registered teachers:
• demonstrate that they can select creative and imaginative strategies for teaching and learning appropriate to learners as individuals, groups or classes; • demonstrate that they can select and use a wide variety of resources and teaching approaches, including digital technologies and outdoor learning opportunities; • demonstrate the ability to justify and evaluate professional practice, and take action to improve the impact on all learners.	• consistently select creative and imaginative strategies for teaching and learning appropriate to the interests and needs of all learners, as individuals, groups or classes; • skilfully deploy a wide variety of innovative resources and teaching approaches, including digital technologies and, where appropriate, actively seeking outdoor learning opportunities; • justify consistently and evaluate competently professional practice, and take action to improve the impact on all learners; • create opportunities for learning to be transformative in terms of challenging assumptions and expanding world views.

Source: GTCS (2012a), The Standards for Registration: Mandatory Requirements for Registration with the General Teaching Council for Scotland, GTCS.

Standards should furthermore stand as "context free" (or context transversal), which means that most teachers working in schools with different characteristics in the same education system should be able to follow them. Although by definition, standards prescribe what teachers should know and be able to do, they should at the same time allow for diversity and innovation instead of forcing teachers to follow a specific method, (Ingvarson and Rowe, 2007). All the professional standards analysed seem to allow diversity of practice in general. Some mention innovation expectations for teachers (although briefly), without specifying what is an innovation. This is a more interesting finding if we consider the TALIS 2008 survey results, where three-quarters of teachers reported that they would receive no recognition for being more innovative in their teaching (OECD, 2009). The Scottish professional standards request innovation as part of a continuing professional learning process, where Scottish teachers should "lead and collaborate with others to plan innovative curricular programmes" (GTCS, 2012a). In the Australian professional standards, innovation (understood in a broad sense) is encouraged indirectly from the highly accomplished level, where teachers are asked to "initiate" or "lead" strategies in different areas (AITSL, 2016). The Ontario and England professional standards do not explicitly address innovation in their content, but are in general broad enough to allow for diversity in practice.

Interactions/engagement with other actors, such as students or colleagues, is also an important component of professional teacher standards. For teachers, engagement with other actors refers to performing wider professional responsibilities or collaborative work with other teachers, parents, or school principals, as members of learning communities. The Australian Professional Standards for Teachers (AITSL, 2016), for example, encourage more experienced teachers to "lead" activities in different aspects of teacher practice, such as developing or evaluating the effectiveness of teaching programmes, or to extend the repertoire of teaching strategies. The English Teachers' Standards, encourage teachers to participate in professional learning activities.

Ethical practice is also raised as important in all the professional standards analysed. The professional standards for England (United Kingdom), Ontario (Canada) and Scotland (United Kingdom) have separate components or standards for ethics-related aspects, where ethics comprise values such as: social justice, national values, care, integrity, trust and respect, and professional commitment. The Australian Professional Standards for Teachers point to professional ethics and responsibilities as part of the teacher's engagement with other actors. The NBPTS professional standards do not explicitly mention ethics-related issues in the five core values, but these are discussed later in the document. For example, the Middle

Childhood Generalist teacher professional standards include a standard on professionalism, leadership, and advocacy.

To summarise, while the professional standards analysed have different structures, they show some similarities in their general characteristics. They all seem to handle professional growth and development in a systematic way: the more expert the teachers, the more adaptable they are expected to be across these frameworks. They expect professionals to have complex competencies intended to be used across different contexts, they encourage diversity in practice and, (at least vaguely) address innovation in teaching. The standards also illustrate the described broad competencies in various ways. Moreover, they all provide various tools for quality assurance. Here we examine the kinds of professional knowledge that these standards include.

The knowledge components of teachers' professional standards

Research has shown that teaching practice is related with the nature and depth of a teacher's understandings of what they are teaching and this is also reflected in student learning outcomes. There is evidence that teachers become more effective when they gain a better understanding of how students learn content (Ingvarson, 2002). Darling-Hammond (2000) cites strong evidence that a teacher's increased education coursework can improve student achievement more than subject matter knowledge alone. According to this evidence, when teachers have knowledge of how to teach the subject to various kinds of students, subject matter knowledge can bring greater benefits. (This is further covered in Chapter 4 by Guerriero, this volume.)

In an attempt to understand how teachers' knowledge is manifested in professional standards, we now look at the knowledge components that are detailed in the standards. "Professional knowledge" refers to the distinctive body of knowledge that defines a profession (Hargreaves, 1996; Hiebert, Gallimore and Stigler, 2002; Mehta and Teles, 2014). There are various typologies of professional knowledge (for more details about typologies, see Chapter 2 by Révai and Guerriero, this volume). In the following section, we explore:

1. how different types of knowledge components are described
2. specific elements of pedagogical knowledge.

Types of knowledge components

Two common types of knowledge components that professional standards identify as essential for the professional to be successful are:

1. Specific content knowledge (or declarative knowledge, *knowing that*) relates to the disciplinary or epistemic knowledge of the sciences, arts, humanities and social sciences that professionals acquire mainly through formal training at the beginning or throughout their careers (Rata, 2012). In Shulman's (1986, 1987) seminal work, content knowledge is defined as knowledge of subject matter and its organising structures.
2. Application knowledge (or practitioner knowledge, procedural knowledge, *knowing how*) relates to the knowledge that helps translate the specific content knowledge into the context of the profession. It is continuously gained and improved by experience or training in practice to address specific situations. It is therefore: a) linked with practice; b) detailed, concrete, and specific, and; c) integrated (i.e. usually composed of different elements) (French, 2007; Hiebert, Gallimore and Stigler, 2002). In Shulman's (1986, 1987) work, this is pedagogical content knowledge, defined as knowledge of content and pedagogy.

This classification of knowledge components can also relate to the different types of previously mentioned competences. For instance, specific content knowledge relates more to cognitive competences (use of theory, concepts, and tacit knowledge gained through experience), while application knowledge relates more to functional competences (know-how, what a person should be able to do when working in a certain area). Professional standards also contain personal competences (knowing how to conduct oneself in a specific situation) and ethical competences (possessing certain personal and professional values). While these are also important, their coverage is beyond the scope of this paper.

The two components identified above are manifested in various forms in the standards analysed. Some standards describe these two components in separate sections, while others combine them in the descriptions and do not explicitly distinguish between them. Among the selected standards it is only the Scottish one that has separate sections: a part called "Professional Knowledge and Understanding", which mostly relates to specific content knowledge and one called "Professional Skills and Abilities" concerned with application knowledge. In the other standards the two knowledge components can be identified through, for example, the use of verbs. Verbs and expressions such as "demonstrate knowledge", "have a secure knowledge", "informed by […] knowledge", "have a detailed understanding of" most often relate to specific content knowledge, while verbs such as "use", "design", "implement", "evaluate" or "select" are more application-oriented. Some sections of the English Teacher Standards describe these components in parallel as two facets of a certain content area, such as, in the statement "demonstrate an awareness of the physical, social and intellectual development of children, and know how to adapt teaching to support pupils' education at different stages of development".

On the whole, the professional knowledge components of standards seem to focus more on application knowledge, while specific content knowledge includes broad knowledge domains rather than an actual description of teacher knowledge in detail. Let us now analyse more closely what domains of knowledge the standards include.

Elements of pedagogical knowledge

All professional standards include references to content knowledge and mention, for example, that teachers should know the curricula or subjects taught, and keep this knowledge updated, such as the Teachers' Standards in England and the Ontario Standards of Practice for the Teaching Profession. The Australian Professional Standards for Teachers additionally refer to the "knowledge and understanding of concepts, substance and structure of the content". In the same way, the NBPTS professional standards' five core propositions request teachers to know how this knowledge is "created, organised, linked to other disciplines and applied to real-world settings". The Scottish Standards for Registration request teachers to know and understand the nature of the curriculum and its development, as well as of the relevant areas of curriculum at the specific grades taught (pre-school, primary or secondary). The Standards for Career Long Professional Learning ask to lead curriculum development, with a deep understanding of the place of subject knowledge.

For our analysis, we focus specifically on general pedagogical knowledge to explore the main domains that the selected standards contain. General pedagogical knowledge has been defined in various ways (see details in Chapter 4 by Guerriero in this volume), here we use the definition given earlier in this chapter (p. 55). Some countries (e.g. some states and districts in the United States, Chile, or the province of Quebec in Canada) have

used Danielson's (2013) Framework for Good Teaching as an example to develop their own professional standards (OECD, 2013b). This framework has four key domains (Planning and preparation, Classroom environment, Instruction, and Professional responsibilities) each of which consists of several components. Each domain describes four progressive levels of proficiency (unsatisfactory, basic, proficient and distinguished). In our analysis we used a grounded theory approach (Glaser and Strauss, 1967) to identify and describe elements of general pedagogical knowledge in the selected standards so as not to be biased or limited by any existing frameworks. As the analysis focuses on the professional standards or principles that apply to all teachers within a specific context, in the case of the NBPTS professional standards, the "Five Core Propositions" were selected since they are addressed to all teachers aiming to obtain a certification, regardless of the subject or grade/student age taught (although in some cases we also refer to the Middle Child Generalist standards).

Overall, the selected professional standards share several dimensions of pedagogical knowledge, although these are termed and organised in different ways. On the whole we identified the following as key areas that were covered in all or most of the standards:

- planning
- classroom environment
- instruction
  - student engagement and active learning
  - working with heterogeneous classes (adaptive teaching)
- theories about learning
- assessment
- using data and engaging in research.

In the following, we highlight some key expectations formulated in the selected standards within these areas.

Planning is part of all standards analysed. Some dedicate a separate section to this element (e.g. English, Scottish, and Australian standards) with details about the various components of planning such as planning learning goals, structuring, and sequencing learning programmes or selecting resources in the Australian standards. On the other hand, in the NBPTS Middle Child Generalist standards, planning appears as a more horizontal-type knowledge with mentions in several sections, while it is formulated within a more general statement as in the standards of Ontario.

Classroom environment is the broad concept used in the standards that encompasses classroom management as well as managing the social nature of learning. Knowledge of the classroom environment can have different objectives across professional standards such as student discipline and involvement (England), ensuring adequate physical conditions of the learning environment (Scotland and NBPTS core propositions), and supporting student participation, with discipline, safety and good use of ICT (Australia). The challenge in these professional standards seems to be balancing the expectation for teachers to shape environments where students are treated with respect, but engaging students at the same time to participate in learning. The Scottish professional standards seem to address directly a range of different elements within the classroom environment such as emotions, social, active learning and classroom management. The teacher is generally seen as the main generator of this environment.

Instruction is another key area in several standards. The NBPTS, for example, refers to knowing and being able to use diverse instructional strategies and techniques, and organise instruction. The English teachers' standards refer to using appropriate teaching strategies. A specific goal of knowledge on teaching methods, namely, being able to engage students and facilitate active learning is present across the different standards. All the selected professional standards require teachers to engage students. They encourage more explicitly the social interactions between the teacher and the classroom (known as "direct instruction"). The Ontario (Canada) professional standards, for example, talk about "learning communities", without specifying who is involved in these (teachers, students, or both). The Australian and Scottish professional standards expect teachers to construct learning interactions among students as well. In Australia, a proficient teacher should be able to establish and implement "inclusive and positive interactions" to engage and support all students. According to Scottish professional standards, all teachers should create opportunities to stimulate learner participation in debate.

Most of the professional standards promote active learning at least indirectly, focusing on the teacher, the student or both. Scottish professional standards, for example, encourage active learning by explaining what the student should be doing: they expect student engagement for the planning and enhancement of their own learning programmes. Australian professional standards encourage active learning by explaining what the teacher should be doing: identifying strategies to support inclusive student participation and engagement in classroom activities. English professional standards explain actions for both the student and the teacher. To promote good progress and outcomes from pupils, teachers should encourage pupils to take a "responsible and conscientious attitude to their own work and study (an action the student should perform)". Whereas, to ensure a good and safe learning environment, teachers should use approaches that address students' needs to involve and motivate them (this action is more centred on the teacher).

An important aspect of most standards is working with diversity in the classroom and adapting teaching methods to the individual differences and needs of children. One of the key terms is *differentiated instruction*, meaning instruction that meets the individual needs of all students (Tomlinson, 1999). Differentiated instruction accounts for student's prior knowledge, abilities and past experiences that affect the efficiency with which individual students will learn (Rock et al., 2008; Landrum and McDuffie, 2010) (includes issues of equity due to language, culture and socio-economic status). Adaptive teaching for classroom diversity is a strongly emphatic element in all standards and is the only component that all the professional standards analysed encourage directly. The emphasis is nevertheless different, as some emphasise more *the means* to teach in a context of student diversity (Ontario and Scotland), others emphasise the *different kinds* of student diversity (NBPTS core propositions, Australia), while another refers to *both* the kinds of student diversity and means to teach (England). Some examples are included below:

- **Ontario (Canada) (the means):** They refer to the teachers' capacity to use "appropriate pedagogy, assessment and evaluation, resources and technology in planning for and responding to the needs of individual students and learning communities".
- **Scotland (United Kingdom) (the means):** They refer to a range of teaching strategies and resources to meet the needs and abilities of students, such as: strategies appropriate to the needs of learners as individuals, groups and classes; innovative resources (from ICT to outdoor learning opportunities), professional practice evaluation, transformative learning that challenges assumptions and expands world views.

- **NBPTS- five core propositions (kinds of diversity):** They state that "teachers adapt their practice, as appropriate, on the basis of observation and knowledge of their students' interests, abilities, skills, knowledge, family circumstances, and peer relationships."
- **Australia (kinds of diversity):** They refer to adaptability through knowledge, design of activities or the teacher's capacity to lead other teachers in strategies to cater to differences such as: diverse linguistic, cultural, religious and socioeconomic backgrounds; the different student's learning abilities; or the specific case of the Aboriginal and Torres Strait Islander people.
- **England (United Kingdom) (both)**: They refer to the capacity to "adapt teaching to respond to the strengths and needs of all pupils" through an ability to know when to differentiate; understand the factors that inhibit learning; awareness of physical, social and intellectual development of children; and awareness of their different kinds of needs (e.g. special needs, high ability, non-English native speakers).

Another important element of the pedagogical knowledge contained in the standards is the knowledge and understanding of theories about *how children learn and develop* and how these theories relate to the teaching practice. All standards explicitly require teachers to have knowledge and understanding on learning and development. The Scottish, the Australian and the American (NBPTS – Middle Childhood Generalist) standards all dedicate a separate section to learning and development theories. These usually include knowledge and understanding of how students learn and of the stages of development, although these latter refer to slightly different things. The Scottish standards speak about cognitive, social and emotional development, the English and Australian standards about physical, social and intellectual development, while the American about social, physical, emotional, and intellectual development. The English teacher standards mention knowledge on how students learn and that related to their development in two different sections, while in the Canadian standards this is an integral part of the professional knowledge section. New research in the discipline of developmental cognitive neuroscience, which explores the underlying mechanisms of how learning can be improved, is increasingly being used for instructional practice. Box 3.1 illustrates how one aspect – attention – in the study of cognitive neurosciences appears in the standards.

How learning is assessed, what the various forms and procedures of evaluation are, including formative and summative assessment, also constitute a key component in the standards. All the professional standards refer to assessment and encourage providing feedback to students. Feedback, broadly defined as "information provided to learners about their knowledge and/or performance" (Kahu, 2008: 187), is a key term regarding formative assessment. For example, the English professional standards expect teachers to provide feedback to their students, help them reflect on their performance and encourage pupils to respond to feedback. An interesting feature of the Scottish professional standards is that they promote students' self-evaluation and peer-assessment. Therefore, students would also become their own motors of assessment. In the same way, only Scottish professional standards ask teachers to question students as part of a learning process, with varied questioning strategies that tackle the different learning needs of students.

Box 3.1. **How standards reflect knowledge about how the brain learns**

There are a number of recent findings in the field of developmental cognitive neuroscience that are relevant to teaching (for example, see the chapter by Ansari, et al., this volume). To illustrate the extent to which these are incorporated in teaching standards, we looked at how the concept of attention is covered in the standards.

The professional standards analysed do not provide a definition of attention, but overall they consider that students' *attention* can be enhanced through strategies such as adequate lesson design, use of learning materials, and classroom communication. Australian professional standards request teachers to stimulate students' attention through teachers' capacity to plan, structure, and sequence learning programmes, use effective classroom communication, support student participation, and manage classroom activities.

For the most part however, the standards do not make direct reference to how attention can be stimulated specifically. For example, the Scottish professional standards refer indirectly to attention through teachers' capacity to "use, design, and adapt materials for teaching and learning which stimulate, support and challenge students." English teachers are also expected to engage students' attention through the planning and teaching of well-structured lessons that "promote love of learning and children's intellectual curiosity."

Teachers' knowledge about how to *use data and research* to help assess, evaluate, and improve teaching is again an important aspect in the standards analysed. This appears essentially in two forms: either generally as critical reflection and inquiry or specifically as engaging in/with research and data. Ongoing inquiry, dialogue, and reflection is expected from teachers in Ontario, while Scottish teachers are expected to "systematically investigate, analyse, and evaluate the impact of practice", and both of these standards also expect teachers to engage with educational literature, research, and policy. Critical reflection on the practice is also a requirement in the US NBPTS Core Propositions and the English standards as well. In the latter teachers should take responsibility for improving teaching through professional development, advice and feedback from colleagues. However, there is no explicit reference to engaging with or in research. On the other hand, the Middle Childhood Generalist Standards of the NBPTS include a number of forms of engagement with research: e.g. collaborating with universities, using research, and conducting action research. In Australia, teachers need to engage with research to different extents according to their level of career. Teachers in Scotland are also required to do research on pedagogical theories and practice.

To summarise, the analysis carried out in this section shows that standards share a few main components of teachers' pedagogical knowledge, although the specific elements of these components are described in different ways and to varying extents. Differentiated instruction, engagement, student feedback and classroom management are the aspects most shared across the teacher professional standards analysed. Differentiated instruction seems to be the element that is most strongly present across all the professional standards analysed, possibly requesting teachers to adapt their practice to the various ways in which students can be different (socio-economically, culturally, ability levels, having special needs, etc.). This is consequent with the previous section's findings that professional standards expect teachers to adapt more easily as they gain experience. This suggests an important emphasis on equity issues in the definition of teacher competence in the frameworks analysed. We have also seen that while reflecting on one's own teaching practice is required in all documents analysed, explicit expectations on engaging with or in research are not part of all standards.

Conclusions

To explore how teachers' professionalism and teachers' knowledge are manifested in key documents, namely, qualifications frameworks and professional standards, this chapter followed two pathways of analysis. The first pathway aimed to understand what these documents are by summarising the definitions of the main concepts related to standards and qualifications frameworks, and exploring how these frameworks relate to each other to guide teachers' professionalism. This pathway found that competences, competencies, qualifications, skills and other related terms still lack clarity on what they mean. Nevertheless, there seems to be a growing consensus on the objectives these concepts should be able to fulfil, for example, being broader to comprise the complexity of an action, and increasingly flexible to recognise that learning can happen in different contexts and be able to capitalise learning opportunities from them. This is relevant for the recognition and valorisation of professional training opportunities in practice.

The second pathway aimed to compare the content of professional standards' in terms of key areas of teachers' knowledge focusing in particular on pedagogical knowledge, such as planning, instruction, learning theories and assessment. We found that professional standards share a number of elements, of which the most strongly accentuated is differentiated instruction.

The knowledge content that the standards identify as characterising a successful professional show some similarities in their general characteristics, such as a broad description of competences/competencies, encouraging diversity in practice and addressing innovation in teaching. The more expert the teachers, the more adaptable they are expected to be across these frameworks. This is a more interesting finding if we consider that "competence" relates to the ability of an individual to deal with complexity, unpredictability, and change. Hence, as shown in this paper, professional standards understand competence as the *capacity to use and to adapt knowledge*. A higher level of competence would lead to more evidence of self-directedness and critical reflection (meta-competence) across domains (Sultana, 2008). At the same time, the emphasis put on the teacher's capacity to adapt (through the use of different teaching strategies, by focusing on the possible differences of students, or both) also suggests a shared importance that these frameworks place on equity.

An analysis of the components that comprise "professional knowledge" shows that the professional standards focus on helping professionals translate knowledge into practice. Professional standards do not always clarify what comprises the "specific content knowledge" expected from a professional, but explain instead what implies mastering this knowledge component. The "application knowledge" refers to the knowledge needed by the professional to accomplish a successful use of specific content knowledge during practice. Both specific content knowledge and application knowledge are crucial to distinguish a profession. They both answer the key questions: what kind of knowledge distinguishes this profession from other professions; and what specific purpose does this body of knowledge serve that makes it distinct.

This chapter shows that adaptability to different students and the environment is a key element of professional competence, as identified by standards. As a consequence, it seems important that continuing professional development as a wide concept encompassing all forms of formal and non-formal learning opportunities also have a greater flexibility to offer teachers not only to acquire but also to create and adapt knowledge from and through research on learning. This approach would help better reflect the complexity of the teaching profession and better address the needs of its professionals.

Notes

1. TALIS is the international survey that collects data from teachers and school leaders in various areas related to the teaching and learning. More on the project is available on its website: www.oecd.org/edu/school/talis.htm.
2. Improving Schools is a series of reviews of national policies for education. Reviews and other related material are available for Iceland, Mexico, Norway, Sweden and the UK (Scotland and Wales) at www.oecd.org/edu/bycountry/.

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PART II

Measuring teacher knowledge and professional competence: Opportunities and challenges

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Chapter 4

Teachers' pedagogical knowledge: What it is and how it functions

by
Sonia Guerriero
OECD

This chapter gives an overview of the literature on teachers' knowledge and how it relates to teacher quality and student outcomes. First, we illustrate the complexity of the teaching and learning process through some models. Second, we review how teachers' knowledge has been conceptualised and what specific content it is composed of in the different models, focusing in particular on pedagogical knowledge. Third, we summarise the empirical evidence on the relationship between teachers' knowledge and student learning outcomes. We then describe how pedagogical knowledge is used in decision-making, how it is learned and how it is developed into expertise. We conclude with some implications on teacher education.

Introduction and policy context

The imperative in recent years about improving student outcomes is also about improving the quality of the teaching workforce. In recent years, however, recruiting and retaining quality teachers have become challenges among some OECD countries. In addition to the ageing of the teaching workforce, some countries experience high rates of attrition among new teachers and a shortage of quality teachers in high-demand subject areas and disadvantaged schools. There is also concern about attracting high-achieving and motivated candidates into teacher education programmes and the lowering of qualification requirements in the certification and licensing of new teachers (OECD, 2005).

Issues such as these have an impact on the quality of the resulting teaching workforce that is tasked with improving student outcomes. For example, the ageing of the teacher workforce entails the loss of experienced teachers. High attrition rates among new teachers are costly to the system and may prompt education authorities to fill teacher shortages by lowering qualification requirements for the certification of new teachers or by assigning teachers to teach subjects or grades for which they are not trained (for a review, see Santiago, 2002). In such cases, the quality of the teaching workforce is negatively affected.

The quality of the teaching workforce has implications for student outcomes, as empirical research has shown that teacher quality has an impact on student achievement. Research studies using econometric approaches have shown that teacher quality is an important factor in determining gains in student achievement, even after accounting for prior student learning and family background characteristics (e.g. Darling-Hammond, 2000; Hanushek, Kain and Rivkin, 1998; Muñoz, Prather and Stronge, 2011; Wright, Horn and Sanders, 1997). In these types of studies, predictors of teacher quality have included factors such as class size, certification, type of qualification, degrees earned or years of experience. However, findings have been inconsistent (e.g. Darling-Hammond, Berry and Thoreson, 2001; Muñoz and Chang, 2007; Wayne and Youngs, 2003) or minimal when teacher characteristics are examined independently of overall teacher effects (e.g. Goldhaber and Anthony, 2007; Hanushek, Kain and Rivkin, 1998; Rivkin, Hanushek and Kain, 2005).

It is not surprising that such studies have shown inconsistent results. Factors such as teacher certification, qualifications or years of experience are proxies assumed to measure quality. In these studies, it is hypothesised that such proxies will differentiate quality teaching (Hill, Rowan and Ball, 2005). But in actuality, teachers' competency in the classroom, such as the quality of the instructional skills employed, are not directly examined. In the same way, any policy changes directed at certification or qualification requirements that do not target the actual competences underlying teaching itself risk of being unsuccessful.

In a different set of studies, a more direct indicator of teacher quality has been explored by investigating the substance of teachers' knowledge. In this approach, the study of teacher quality goes beyond an investigation of distal indicators, such as qualifications, degrees earned or years of study, to a more conceptual investigation of quality by studying the knowledge base of teachers presumed to underlie competent teaching (Hill, Rowan and

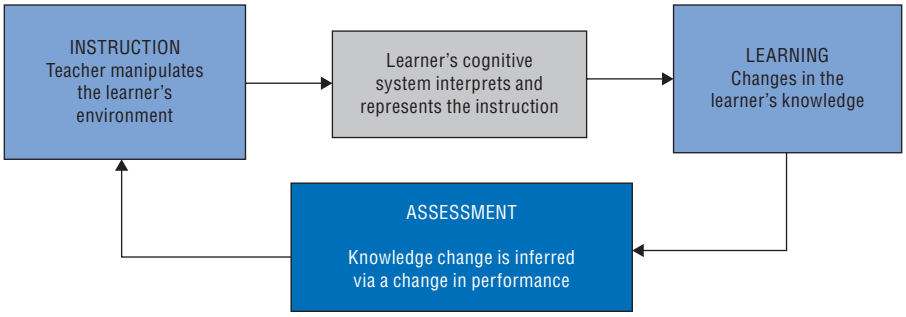
Ball, 2005). Studies of teacher knowledge hypothesise that differences in the conceptual quality of teachers' knowledge can better differentiate quality teaching because (competent) performance is based on an underlying pedagogical knowledge base. This approach to understanding teacher quality is more complex, but it is more likely to lead to policy changes that can have an impact on student learning, for example, by exerting a direct influence on the content of teacher education programmes. In fact, as will be discussed later, research shows that teacher knowledge is a better predictor of student outcomes than distal factors.

In this chapter, we review the research on how teachers' knowledge has been conceptualised in the literature in order to gain a better understanding of what it is and how it relates to teacher quality and student outcomes. This review resulted as part of the development of the *Innovative Teaching for Effective Learning* project introduced in Chapter 1. But before beginning the review, we start with a brief overview of the teaching-learning process. It would not be possible to investigate the knowledge base of teachers (a psychological concept) without first understanding how the teaching-learning process works (a cognitive concept). As a result, this paper adopts a cognitive-psychological view of teaching and learning where "learning" is a cognitive process and defined as a change (i.e. growth) in student knowledge. Under this approach, the learner is the focus of the teaching-learning process and teaching is viewed from the perspective of the learner. In other words, (effective) teaching is interpreted from the perspective of its effect on student learning growth. Implications for teacher education are discussed at the end.

The teaching-learning process

The teaching-learning process is complex, and to this day, not yet fully understood. A simplistic view in diagram form is given below, adapted from Mayer (2011):

Figure 4.1. **The teaching-learning process**



Source: Adapted from Mayer (2011), *Applying the Science of Learning*.

Under a cognitive view, instruction is defined as the manipulation of the learner's environment to cause a change in the learner's experience. A change in the learner's experience is interpreted as new knowledge and is, thus, a learning process. These are represented in the light blue boxes. The grey box represents the hypothesised cognitive changes in the learner's mind as the learner interprets and represents the instruction. Evidence of the change in the learner's knowledge is inferred via a change in the learner's performance in an assessment test. Assessment is a crucial component of the teaching-learning process as this is how the effectiveness of the instructional manipulation is determined. In this simplistic diagram, Mayer has nicely captured the complexity of the cognitive processes underlying teaching and learning.

An example of a more sophisticated model of teaching and learning is one proposed by Seidel and Shavelson (2007) who built on a previous model of teaching and learning developed by Bolhuis (2003). Seidel and Shavelson conceptualise learning as the intentional construction of knowledge in a specific subject domain, in a regulated, goal-directed and social learning environment, with continuous monitoring and assessment of learning. Effective teachers employ teaching practices that best exploit the learning process. For example, effective teachers are those who differentiate teaching in different content areas (maths vs. reading), allow sufficient learning time for students to actively construct their knowledge, structure learning by setting and orienting students towards goals, establish a social learning climate in the classroom, and provide feedback and support for continuous monitoring and evaluation of student learning. Although teaching effects are differentiated through measures of outcomes in student learning, motivational-affective and cognitive components, the model is based on the perspective of teaching and the student's contribution to the teaching-learning process is not made explicit.

In a different set of models, the student's contributions to the teaching-learning process are made explicit and taken into account as inputs to the process of effective teaching. Carroll (1963) proposed a model that is comprised of five elements that contribute to effectiveness of instruction: students' general ability, prior knowledge, motivation to learn, opportunity to learn (i.e. amount of time allowed for learning) and quality of instruction. Three of these five elements (general ability, prior knowledge and motivation to learn) are student inputs to the teaching-learning process, while the other two (opportunity to learn and quality of instruction) are under the control of the teacher. Carroll's model introduces the concepts of "learning differences" and "adaptive instruction" in the teaching-learning process. Teachers need to balance the time needed for instruction with the time available for instruction, given that students within a classroom will vary in ability, knowledge and motivation. For example, students with lower abilities or motivation will require more time for instruction. At the same time, the higher the instructional quality (e.g. ensuring students have the requisite prior knowledge for successfully learning a new lesson), the less time will be needed for a lesson. Thus, student and teacher are interconnected and interdependent in the teaching-learning process.

Slavin (1984) built upon Carroll's (1963) model by concentrating on the alterable components of effective instruction that are under the teacher's control: quality of instruction, appropriate levels of instruction, incentive (i.e. motivating students) and time allocated for learning. According to Slavin's model, the alterable components under the teacher's control combine with student inputs (student aptitude and student motivation) to result in student achievement. Although student inputs are considered fixed in the short-term, they are not immutable and can be affected by classroom practices in the long-term. Slavin also proposed two mediating variables: instructional efficiency (a product of quality of instruction, appropriate levels of instruction and incentive) and engaged time on task (a product of incentive and time allocated for learning). Like in Carroll's model, Slavin views students and teachers as interconnected and interdependent in the teaching and learning process. For example, student aptitude and student motivation contribute to instructional efficiency and engaged time, which ultimately affect student achievement.

This brief overview is meant to illustrate the complexity of the teaching-learning process and the complex relationship between students and teachers. This contrasts with econometric models that attempt to predict effective teaching by controlling for student factors. While it makes sense to control for differences in student characteristics that are beyond the control

of teachers or schools in value-added models of accountability, the above review indicates that student factors are part of, and interdependent with, the teaching-learning process. A model of effective teaching would need to account for these.

More importantly, these models presuppose that a teacher's knowledge goes beyond mere knowledge of content (e.g. of maths, science or reading) and classroom management, but should also include knowledge of learners and learning. In the next section, we review various conceptualisations of teacher knowledge and how it functions in the teaching-learning process. We begin with definitions.

Teacher knowledge: Theoretical/scientific knowledge and practice-based knowledge

Verloop, Van Driel and Meijer (2001) define the pedagogical "knowledge base" of teachers to refer to all the pedagogical-related knowledge that is relevant to teachers' activities in a teaching-learning situation. This would include both theoretical or scientific knowledge (e.g. theories of learning and of teaching-learning processes, as described above) and practical or practice-based knowledge (e.g. situated knowledge), but it is not meant to refer to guidelines or prescriptions for practice. Essentially, this knowledge base would comprise all the required cognitive knowledge for creating effective teaching and learning environments. Identifying what specifically is the content of this knowledge is the purpose of this paper. As proposed by Verloop, Van Driel and Meijer, teachers' knowledge base can be made explicit and studied.

But what exactly is meant by "knowledge"? In cognitive psychology, "knowledge" does not refer to a single concept – a distinction is made between "declarative" knowledge and "procedural" knowledge. This distinction is important because it forms the basis for understanding how knowledge is acquired and developed into mastery, such as in expert teaching. Research from cognitive psychology is of particular relevance here because of the focus on understanding how knowledge is related to behaviour (e.g. as in teaching performance). Simplistic conceptualisations of declarative and procedural knowledge define these as "knowing that" (e.g. knowledge of facts) and "knowing how" (e.g. knowledge of how to ride a bike), respectively. But the issue is actually more complex, and essentially has to do with how knowledge of skills is stored and organised in memory and how it is used and developed into mastery performance (Anderson, 1982).

Based on the work of Anderson (1982, 1987; also Corbett and Anderson, 1995), declarative knowledge can be either factual or experiential knowledge, whereas procedural knowledge is goal-oriented knowledge that mediates problem-solving behaviour. Knowledge starts out in declarative form, which is then converted to procedural form and embodied as performance of a skill. For example, knowledge of a skill such as teaching is initially encoded in memory in declarative form through experiences such as listening to lectures or reading a textbook (e.g. facts about instruction or classroom management). Through practice, declarative knowledge is interpreted into procedural knowledge to generate behaviours (e.g. knowing when and how to use a particular instructional strategy). Performance improves through subsequent practice as both declarative and procedural knowledge is strengthened.

These distinctions are relevant to the work on teacher knowledge as they explain how novice teachers develop into expert teachers. Specifically, a novice teacher starts with the acquisition of declarative knowledge and then begins to apply that knowledge to teaching students. Research on teacher expertise shows that novice and expert teachers differ in their

ability to apply their knowledge (i.e. procedural knowledge), which suggests differences in the quality of pedagogical knowledge based on experience.

When applying their pedagogical knowledge, teachers are making a "professional judgement". Shalem (2014) argues that teachers' professional judgement derives from theoretical knowledge and from practice-based knowledge, which she defines as working knowledge of contextually-specific experiences. According to Shalem, teachers' professional judgement depends on their theoretical knowledge, which is what binds the judgement to a specific situation. Importantly, Shalem argues, it is the theoretical or scientific knowledge that makes teaching a true profession. In other words, placing teachers' judgement primarily on situated knowledge or knowledge that is acquired primarily experientially is what contributes to de-professionalising teaching. This discussion is picked up again later in the chapter in the discussion on teacher decision-making and expertise.

General pedagogical knowledge

The study of the structure and content of teacher knowledge began in earnest with Shulman (1986, 1987) who proposed that teacher knowledge was comprised of the following categories:

- general pedagogical knowledge (principles and strategies of classroom management and organisation that are cross-curricular)
- content knowledge (knowledge of subject matter and its organising structures)
- pedagogical content knowledge (knowledge of content and pedagogy)
- curriculum knowledge (subject- and grade-specific knowledge of materials and programmes)
- knowledge of learners and their characteristics
- knowledge of educational contexts (knowledge of classrooms, governance and financing of school districts, the culture of the school community)
- knowledge of educational ends, purposes, values, and their philosophical and historical grounds.

In this seminal work, Shulman formally proposed the concept of "pedagogical content knowledge", in which he referred to knowledge that integrates the content knowledge of a specific subject and the pedagogical knowledge for teaching that particular subject. Specifically, pedagogical content knowledge "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987: 8). This category would also include knowledge of strategies for reorganising the understandings of learners because students of different ages and backgrounds bring with them prior knowledge, some of which may include misconceptions (Shulman, 1986). According to Shulman, this is the category of knowledge that is fundamental to teachers' knowledge of teaching. This conceptualisation, in fact, fits well with models that take account of student individual differences in the teaching-learning process as described in the previous section.

The concept of "pedagogical content knowledge" became the focus of study for many educational researchers because it gave rise to the idea that teachers held a unique form of "technical" knowledge available only to the profession of teachers (Ball, Thames and Phelps, 2008; Depaepe, Verschaffel and Kelchtermans, 2013). For example, Ball, Thames and Phelps (2008) proposed that pedagogical content knowledge, as defined by Shulman (1986, 1987),

is actually comprised of two categories: "knowledge of content and students" (knowledge of students' (mis)conceptions) and "knowledge of content and teaching" (knowledge of instructional strategies). They further proposed that Shulman's concept of "content knowledge" is comprised of "specialised content knowledge" (knowledge unique to the work of teachers) and "common content knowledge" (knowledge common to teachers and non-teachers). With the addition of two more categories ("horizontal content knowledge" and "knowledge of content and curriculum"), these six categories were hypothesised to contribute to teachers' knowledge of teaching specific subject content. In Ball, Thames and Phelp's research, the domain of study is mathematics teaching. Most investigations of pedagogical content knowledge have focussed on mathematics (e.g. Baumert et al., 2010; Hill, Schilling and Ball, 2004; Depaepe, Verschaffel and Kelchtermans, 2013) or science teaching (e.g. Abell, 2008; Kind, 2009; Schneider and Plasman, 2011).

For the purposes of this review, the focus is on "general pedagogical knowledge", originally defined by Shulman (1986, 1987) as principles and strategies of classroom management and organisation that are cross-curricular. While research on pedagogical content knowledge proliferated the field after Shulman's seminal work, empirical studies of general pedagogical knowledge are still few in number.

However, research is beginning to show that general pedagogical knowledge is just as essential as content knowledge and pedagogical content knowledge for developing quality teachers. First, it is clear that content knowledge alone is insufficient. For example, when teachers' content knowledge is controlled (via a direct assessment), higher levels of knowledge do not predict better student scores (this study, Baumert et al. (2010), is further described below). This result should not be confused with those from effectiveness studies that have reported a relationship between indicators of teacher knowledge and student learning gains (e.g. Wayne and Youngs, 2003). Those studies used distal indicators (i.e. the measures used are coursework or degrees in a subject) and have not directly assessed teachers' content knowledge. This lack of control could likely explain the mixed findings in these types of analyses.

As more and more researchers are beginning to conduct empirical studies of teacher professionalism, the concept of general pedagogical knowledge as part of professional competence is becoming more relevant (e.g. Blömeke et al., 2008; Kunter et al., 2013; Voss, Kunter and Baumert, 2011). Finally, on a theoretical level, the study of teachers' general pedagogical knowledge might help the field move towards a common framework that can bridge the gap between research on teaching and research in teacher education, which, as argued by Grossman and McDonald (2008), has developed in isolation from research on teaching in general. Such a framework would be useful in informing the content of teacher education and making the existing body of knowledge available to novice teachers. Grossman and McDonald propose a framework that is common across subjects, grade levels, students and school contexts, independent of teaching methods, that identifies the key underlying components involved in successful teaching. For example, establishing student-teacher relationships or engaging students in the learning process are common factors across teaching domains.

Shulman's (1986, 1987) original definition of general pedagogical knowledge was restricted to classroom management and organisation that are cross-curricular. Recent conceptualisations have become more refined to integrate components of the teaching-learning process. For example, Voss, Kunter and Baumert (2011) proposed a model of general pedagogical knowledge that combines aspects of pedagogy and psychology to

account for the social environment of the classroom and heterogeneity of individual student learning. Their model of "general pedagogical/psychological knowledge" is comprised of five sub-dimensions:

- knowledge of classroom management (maximising the quantity of instructional time by having awareness of what is going on in all parts of the classroom, handling two or more classroom events at the same time, teaching at a steady pace throughout the lesson to maintain momentum, maintaining clear direction in lessons and keeping the entire group of students alert)
- knowledge of teaching methods (making productive use of instructional time by having a command of various teaching methods [e.g. direct instruction, discovery learning, etc.] and knowing when and how to apply each method in promoting students' conceptual involvement with learning tasks)
- knowledge of classroom assessment (knowledge of different forms and purposes of formative and summative classroom assessments and knowledge of how different frames of reference [e.g. social, individual, criterion-based] impact students' motivation)
- knowledge of learning processes (supporting and fostering individual learning progress by having knowledge of various cognitive and motivational learning processes, including learning strategies, impact of prior knowledge, memory and information processing, causal attributions and how they foster student engagement, effects and quality characteristics of praise, and opportunities for increasing student engagement)
- knowledge of individual student characteristics (meeting individual student needs by having knowledge of the sources of student cognitive, motivational and emotional heterogeneity, such as test anxiety, ADHD, dyslexia, mental abilities and giftedness, and influence of ethnic background).

In contrast to knowledge of classroom management, teaching methods and classroom assessment, which are pedagogical components, knowledge of learning processes and individual student characteristics are "psychological" components. Psychological components are included in this model because learning occurs in a social context and learning success depends on the general cognitive and affective-motivational characteristics of individual students. In other words, psychological aspects such as general cognitive abilities, motivational and affective characteristics, and prior knowledge will differ among students and thus impact on individual learning success. As such, teachers need to know how to deal with what the authors refer to as "heterogeneity" in student learning, which is subsumed in the sub-dimensions of "learning processes" and "individual student characteristics". In this manner, Voss, Kunter and Baumert's (2011) model is similar to those of Slavin (1984) and Carroll (1963) where students and teachers are considered interconnected and interdependent in the teaching and learning process. According to Voss, Kunter and Baumert (2011), their model is domain-general and necessary for "creating and optimising teaching-learning situations" (p. 953). This model also addresses an important issue brought up by Grossman and McDonald (2008) about the centrality of relationships in teaching and the lack of research investigating this pedagogical relationship and how it influences student engagement. Voss, Kunter and Baumert's model, "knowledge of learning processes", which encompasses factors involved in the teacher-student relationship, can begin to address this issue.

Another cognitive model also based on student learning is proposed by König et al. (2011). König et al. used a task-based framework of teacher competence to define and operationalise "general pedagogical knowledge" by adopting Slavin's (1994) model of effective teaching

as a theoretical framework. According to König et al., general pedagogical knowledge is comprised of four dimensions:

- structure (structuring of learning objectives, lesson planning and structuring the lesson process, and lesson evaluation)
- motivation and classroom management (achievement motivation, strategies to motivate a single student or a whole group, strategies to prevent and counteract interferences, and effective use of allocated time and routines)
- adaptivity (strategies of differentiation and use of a wide range of teaching methods)
- assessment (assessment types and functions, evaluation criteria and teacher expectation effects).

Within this framework, effective teachers are proposed to have acquired general pedagogical knowledge if they showed competency in tasks requiring them to prepare, structure and evaluate lessons; to motivate and support students and make effective use of time to manage the classroom; to deal with heterogeneous learning groups in the classroom by making use of differentiated strategies and methods of instruction; and to assess students. This model is similar to Voss, Kunter and Baumert's (2011) model, except that König et al.'s model does not make the existence of psychological factors underlying learning processes and student characteristics explicit as their model is based on the alterable elements of instruction that are under the control of the teacher (as per Slavin, 1994).

One of the reasons for the dearth of empirical studies investigating general pedagogical knowledge could be due to the difficulty in defining this concept. For instance, some such as König et al. (2011) and Blömeke et al. (2008) suggest that cultural differences in perspectives on the role of teachers and schooling contribute to difficulties in defining a construct like general pedagogical knowledge. By contrast, a construct such as "mathematics" is relatively universal. Despite this, researchers such as König et al. (2011) and Blömeke et al. (2008) have shown that it is possible to develop a standardised assessment instrument to investigate general pedagogical knowledge across different countries. These studies show that such an instrument is valid cross-culturally, namely, across Germany, United States, South Korea, Chinese Taipei and, thus, give support to the existence of a culturally-independent fundamental knowledge base for teaching.

Relationship to student learning outcomes

A positive relationship between teacher knowledge and student learning outcomes would indicate that efforts aimed at improving the quality of teacher knowledge should lead to improvements in learning outcomes. However, like investigations of the (theoretical) components of teacher knowledge, most studies of the impact of teacher knowledge on student learning outcomes are restricted to investigations of pedagogical content knowledge or simply content knowledge. We review this evidence here.

In a study investigating the quality of teachers' content knowledge of mathematics, Hill, Rowan and Ball (2005) reported a significant relationship to student achievement gains. In this study, the knowledge category of interest was conceptualised as "content knowledge for teaching mathematics" and comprised two components: (1) common knowledge of content (the knowledge of the subject that most adults would have); and (2) specialised knowledge used in teaching mathematics to students (the knowledge needed for evaluating solutions, at the level of a mathematician). Results showed that for every standard deviation difference in teachers' knowledge, students gained about one-half to two-thirds of a month

of growth. Data was also collected on the number of mathematics and mathematics methods courses taken as reported by the teachers and whether teachers were certified. Results revealed that neither certification nor courses taken were significantly related to student achievement gains. Furthermore, neither variable showed a strong significant relationship with mathematical content knowledge for teaching as assessed in this study, indicating that these approaches to improving teacher quality do not target the necessary knowledge underlying quality instruction. One limitation of this study, however, is that "pedagogical content knowledge", conceptualised as the specialist or technical knowledge of both content and pedagogy that is in the professional domain of teachers, was not assessed.

Baumert et al. (2010) investigated the specific impact of pedagogical content knowledge (of mathematics) on student achievement. Pedagogical content knowledge was operationalised into three assessment dimensions: (1) a "tasks" dimension, which assessed teachers' ability to identify multiple solution paths; (2) a "student" dimension, which assessed teachers' ability to recognise students' misconceptions, comprehension difficulties and solution strategies; and (3) an "instruction" dimension that assessed teachers' knowledge of different representations and explanations of standard mathematics problems. In their model, "instructional quality" was used as a mediator and operationalised into three components: (1) cognitively challenging and well-structured learning opportunities, for example, by drawing on students' prior knowledge and ensuring alignment between the cognitive demands of the tasks and materials chosen by the teacher and curricular demands; (2) learning support through monitoring of the learning process, individual feedback (including motivating students) and adaptive instruction for addressing student difficulties; and (3) efficient classroom and time management, for example, preventing disruptions and using classroom time effectively. All student tests, examinations, tasks and homework assignments given by the teachers were collected and analysed for the level of cognitive activation demanded and level of alignment with the curriculum. For measuring individual learning support and classroom management, students and teachers completed rating scales. Finally, student achievement was assessed via a German national mathematics exam in combination with the Programme for International Student Assessment (PISA) 2003 results in mathematics and reading literacy.

Multilevel analyses showed that teachers' pedagogical content knowledge was a significant predicator in explaining differences in student achievement between classes. Moreover, the relationship between pedagogical content knowledge and mathematics achievement was linear. Analyses of instructional quality showed that the cognitive level of tasks, the curricular level of tasks and effective classroom management were significant predictors of mathematics achievement. However, individual learning support and classroom management were not found to have a specific effect on mathematics achievement. The mediation model revealed that pedagogical content knowledge influenced the cognitive level, curricular level and learning support dimensions of instructional quality, suggesting the important contribution of pedagogical knowledge specifically.

There is still a debate in the teacher knowledge literature in connection with whether content knowledge, that is, knowledge of subject matter, falls within the concept of pedagogical content knowledge or is independent of it. According to Shulman (1986, 1987), pedagogical content knowledge and content knowledge are separate categories, but not all agree to this separation (see Depaepe, Verschaffel and Kelchterman, 2013 for a review). Under Baumert et al.'s (2010) model, these two constructs represent distinct knowledge

categories, which were empirically tested in their study as the teachers also completed a mathematics test assessing their conceptual understanding of mathematics topics taught in Grades 5 through 10. Results revealed that teachers' pedagogical content knowledge has more of an impact on student achievement than content knowledge. In regards to measures of instructional quality, teachers' content knowledge predicted the curricular level of tasks (i.e. teachers with higher levels of content knowledge were better able to align the material with the curriculum). However, higher levels of content knowledge had no direct impact on cognitive activation or on the individual learning support that teachers are able to provide when learning difficulties occurred. Only pedagogical content knowledge seems to have an impact on the quality of instruction, suggesting that it is a separate category of knowledge, and an important component of teachers' knowledge required for impacting student learning.

Empirical investigations of the relationship between teacher knowledge and student outcomes are also few in number, and these have focused on pedagogical content knowledge. One study has attempted to investigate teachers' general pedagogical knowledge, and this study, by Voss, Kunter and Baumert (2011), also discussed above, has investigated this relationship empirically by examining student perceptions of instructional quality.

Based on their conceptualisation of teachers' "general pedagogical/psychological knowledge", Voss, Kunter and Baumert (2011) developed an assessment instrument to investigate the impact of this knowledge on instructional quality. As part of their validation work, a sample of students was asked to rate their teachers on five aspects of instructional quality: (1) cognitive activation (giving students cognitive autonomy, such as comparing and evaluating different ways of solving a problem); (2) pace of instruction (giving students sufficient time to think before responding to a question); (3) classroom management (managing disruptions during lessons); (4) student-teacher relations (the caring nature of the teacher); and (5) awareness of students' comprehension problems during a lesson. Results showed that student perceptions of instructional quality were related to teachers' general pedagogical/psychological knowledge: Students of teachers with higher general pedagogical/psychological knowledge reported higher cognitive activation, better instructional pacing, better student-teacher relationships, fewer disruptions and higher teacher awareness of students' comprehension problems.

Regrettably, this is the only study that has conducted an empirical investigation of the relationship between teachers' general pedagogical knowledge and student learning outcomes, where teachers' knowledge is properly operationalised and controlled. Although there is a long history of discussion and debate around the connection between teacher knowledge and quality instruction, there is a lack of empirical research testing this hypothesis or even connecting knowledge to student learning. The studies reviewed here show that while much research is still needed to fully support this relationship, as well as to test a cross-cultural conceptualisation of general pedagogical knowledge, research thus far is beginning to show that teachers' general pedagogical knowledge is relevant to understanding quality teaching as understood by its impact on student learning outcomes.

A related area of work to understanding teacher knowledge is the work on teacher decision-making. Research on teacher decision-making addresses the question of how teacher knowledge functions in the teaching-learning process. This research is reviewed next.

How is teacher knowledge used in decision-making?

For most, teaching is viewed as a profession similar to the professions of medicine or engineering and, just like doctors and engineers hold knowledge specific to their professions, teachers hold specialist knowledge of learning. As "learning specialists", teachers are assumed to have the requisite pedagogical knowledge for decision-making and judgement as required by the profession, for example, for deciding on how to design a lesson for a diversity of learners or making on-the-spot judgements while the classroom dynamics are unfolding. A similar view is proposed by Alter and Coggshall (2009) who conceptualise teaching as a "clinical practice profession" because of its similarity to the professions (as opposed to crafts) of clinical psychology and medicine (also McLean Davies et al., 2013).

Based on a systematic review of the teacher and medical education literature, Alter and Coggshall (2009) identified five key characteristics of a clinical practice profession: (1) centrality of clients; (2) knowledge demands; (3) use of evidence and judgement in practice; (4) community and standards of practice and (5) education for clinical practice. Our view of the learner (student) as the central focus of the teaching-learning process is in accordance with the "centrality of clients" in a clinical practice profession such as medicine or clinical psychology. "Knowledge demands" refers to the various knowledge domains held by the professional, which for teaching would include general pedagogical knowledge, pedagogical content knowledge, content knowledge, and so on. "Community and standards of practice" and "education for clinical practice" refer to the use of evidence-based standards for accountability and evaluation, how knowledge is codified in the profession, how knowledge is transformed into practice and professional responsibility for continued learning. In this section, we are concerned with the "use of evidence and judgement in practice" as this addresses how teacher knowledge is used in decision-making.

If we take the view of teachers as learning specialists who hold profession-specific technical knowledge of teaching and learning, we also assume that teachers must use their professional knowledge for judgement and decision-making. This idea is not new. Shavelson (1973) argued that decision-making is actually a basic teaching skill. According to Shavelson, decisions are regularly made by teachers during teacher-student interactions while processing cognitively complex information about the student (e.g. the prior or current knowledge available to the student) in order to decide alternatives for increasing the student's understanding.

Others have made similar arguments, and more recent research has refined our understanding of the complexity involved in teaching (e.g. Kagan, 1988; Leinhardt and Greeno, 1986; Shavelson and Stern, 1981; Westerman, 1991). For example, Leinhardt and Greeno (1986) characterise teaching as a complex cognitive skill that requires making rapid decisions in an ill-structured and constantly changing environment, where information that arises while in the performance of teaching must be used to inform performance as it is occurring. In this line of research, teachers' decision-making is analogous to that of physicians who engage in clinical problem-solving (in the case of physicians, for diagnosing and treating physical dysfunctions). In a US National Institute of Education review reported in Kagan (1988), teachers are compared to physicians because teachers are professionals who diagnose and treat learning dysfunctions using clinical problem-solving strategies similar to physicians, such as collecting and interpreting information about the client (the student), applying new research findings to the current (classroom) situation and using data to make judgements.

All decisions taken by a teacher interact to create a learning environment (Clough, Berg and Olson, 2009). Clough, Berg and Olson (2009) developed a "decision-making framework" to illustrate how teacher decisions about content and activities, as well as decisions about teaching strategies and behaviours, interact with teaching goals and how students learn. Key teacher decisions rest on the centrality of assessment that is part of a continual feedback loop within the learning environment. For example, teachers are continually assessing the learner (e.g. collecting information about the student's thinking, self-efficacy, prior knowledge, developmental level, etc.) to inform their decisions on selecting the strategies, tasks and activities, as well as how to behave and interact with the student, in order to move the student forward in their learning. Clearly, in this highly interactive, continually changing environment, teaching is complex and cognitively demanding.

In an earlier and more comprehensive model of teacher decision-making, Shavelson and Stern (1981) included factors beyond the classroom as variables influencing teachers' decisions, as well as characteristics of the teacher themselves. Based on their review of the research, teachers' decisions, judgements and behaviours are influenced by:

- the students (e.g. general ability, gender, self-concept, social competence, behaviour problems, work habits)
- the nature of the instructional task (e.g. subject matter, learning goal(s), availability of materials, student characteristics that impact decisions about the task such as how to group students)
- the classroom environment (the social and physical context of the classroom influence teachers' decisions as part of a continual process of negotiating learning goals with students; e.g. decisions around establishing a sense of community, reward structures, routines)
- the school environment (e.g. school policies around evaluation, curriculum, content, parents and community)
- teacher characteristics (e.g. teachers' beliefs about teaching (traditional vs. progressive) and conceptions of subject matter influence decisions about instructional methods and strategies)
- teachers' cognitive processes used in selecting and integrating information for decision-making (e.g. heuristics, attributions of student abilities and inferences).

Information about the students, the nature of the instructional task, and the classroom and school environments serve as antecedent conditions that influence teachers' judgements. Antecedent conditions combine with teachers' characteristics and cognitive processes to impact the pedagogical decisions that guide teaching behaviours, such as planning instruction and interacting with students. Pedagogical decisions in turn impact antecedent conditions and the decision-making cycle continues as such (Shavelson and Stern, 1981).

How teacher knowledge is used in decision-making is not an easy question to investigate. Kersting et al. (2012) conducted a study to investigate how teachers use mathematical pedagogical knowledge by asking teachers to analyse videotaped episodes of classroom instruction. It was hypothesised that teachers' analyses of videotaped events might explain how teachers access and apply knowledge in a classroom situation and thus reveal their pedagogical thinking. To measure the degree of teachers' knowledge, teachers' written analyses of the videotaped instructional episodes were coded for evidence of content knowledge, whether they made suggestions for improvement, depth of interpretation of

the instructional event, and awareness of student thinking. Results showed that more knowledgeable teachers were those who were able to connect content knowledge (in this case, of mathematics) with student thinking, which in turn informed their choice of teaching strategies (by making suggestions for improvement). Further analyses revealed that teachers who provided more sophisticated analyses of the videotaped events were judged to exhibit higher quality teaching in their classrooms and that higher instructional quality was a significant predictor of student learning gains (also Kersting, 2008; Kersting et al., 2010).

Other researchers have studied how teacher knowledge is used in decision-making by investigating teachers' ability to notice and reason about classroom events (Sherin and van Es, 2009; van Es, 2009; van Es and Sherin, 2008). "Noticing" refers to teachers' ability to direct their attention to relevant classroom situations as they are occurring. "Reasoning" refers to teachers' cognitive processing and interpreting of the instructional events to which their attention is directed based on their knowledge of teaching and learning. Research has identified three aspects to this reasoning process: (1) the ability to describe what has been noticed; (2) higher-order processes to connect the observed classroom event to prior knowledge and understanding of teaching and learning; and (3) knowledge-based reasoning processes to evaluate and predict what might happen as a result of connecting the observed situation to prior knowledge of teaching and learning (Seidel et al., 2011). Together, noticing and reasoning about classroom events interact in a dynamic manner and require (1) a high level of domain general pedagogical knowledge about effective teaching and how it relates to students' learning processes and (2) the ability to apply such knowledge for the planning and implementation of instruction to the current situation (Stürmer, Könings and Seidel, 2013). Thus, teachers make (and implement) decisions as a result of identifying and interpreting important events in the midst of instruction based on their pedagogical knowledge.

In sum, empirical research seems to be suggesting that in order to make informed pedagogical decisions, teachers must be able to analyse and evaluate specific learning episodes, in combination with contextual and situational factors (e.g. students' prior knowledge, ability levels, motivational factors, lesson objectives, curriculum goals, etc.) and to be able to connect all this information to their specialist knowledge of the teaching-learning process in order to guide subsequent teaching actions. Thus, making good pedagogical decisions hinges on the quality of the pedagogical knowledge held by the teacher.

It should be clear at this point that complex knowledge is involved in effective teaching, which begs the question about how pedagogical knowledge is learned and developed. A related area of work on teacher knowledge is the field of research on teacher expertise and how teachers acquire their knowledge. This is reviewed next.

How is pedagogical knowledge learned and developed into expertise?

Defining expert teaching and identifying expert teachers are complex issues given that conceptualisations of "expert teaching" are culturally-dependent and often lack objective criteria (Berliner, 2001). Based on a review of the literature reported in Berliner (2001, 2004), expert teachers are characterised as having the following features: better use of knowledge; extensive pedagogical content knowledge, including deep representations of subject matter knowledge; better problem-solving strategies; better adaptation and modification of goals for diverse learners; better skills for improvisation; better decision-making abilities; giving students more challenging objectives; better classroom climate; better perception of classroom events; better ability to read cues from students; greater sensitivity to context;

better monitoring of learning and providing feedback to students; more frequent testing of hypotheses; greater respect for students; and display of more passion for teaching. Many of the features reported by Berliner have been discussed in preceding sections of this paper, for example, teachers' use of pedagogical knowledge.

Sternberg and Horvath (1995) used findings from psychological research on expert performance to characterise the features of the prototypical expert teacher and identified three basic ways in which experts differ from novices: (1) experts bring more knowledge to bear in solving problems than do novices; (2) experts are able to solve problems more efficiently than are novices; and (3) experts are more able to arrive at insightful solutions to problems than are novices. The main driver behind expert teachers' ability to solve problems more efficiently and to arrive at more insightful solutions than novices is the knowledge they hold, which Sternberg and Horvath propose to be the most important feature of expertise. Westerman (1991) investigated development of teacher decision-making and reported that integration of knowledge (e.g. combining new subject content knowledge with prior knowledge) was one of the notable differences between novices and experts.

Empirical studies on the nature of expertise have revealed that teaching expertise is developed over time and that it takes about five to seven years for new teachers to learn the knowledge and skills to a sufficient degree where they can have an impact on student outcomes (e.g. Berliner, 2004). It has been proposed that learning to teach is more complex and different from other forms of learning, because the learning growth of student teachers goes beyond simply assimilating new academic knowledge; it must also incorporate the new knowledge derived from experiential and practical experiences in the classroom (Calderhead, 1991). This is consistent with the view of teaching as a clinical practice profession as proposed by Alter and Coggshall (2009).

A new body of research is investigating "opportunity to learn" as a measure of the quality of teachers' knowledge by looking at the types of pedagogical content that teachers are exposed to in teacher preparation programmes and the extent to which teachers have opportunities to learn the various content (Schmidt, Cogan and Houang, 2011; Schmidt et al., 2008; Schmidt et al., 2007). These studies are beginning to show that variations in opportunities to learn in teacher preparation are related to differences in student achievement as assessed by international studies such as PISA and Trends in International Mathematics and Science Study (TIMSS). More specifically, teachers from countries that are top performers in PISA and TIMSS tend to have more opportunities to learn mathematical content (content knowledge), mathematical pedagogy (pedagogical content knowledge), and general pedagogy.

In sum, empirical studies are beginning to show that teacher knowledge is related to quality teaching, and that pedagogical knowledge can be leaned and developed over time given the right opportunities. This has implications for teacher education, discussed next.

Implications for teacher education

The purpose of this chapter was to review the theoretical and empirical research on teacher knowledge, specifically teachers' general pedagogical knowledge, and to give an overview of how it functions in the teaching-learning process. The research studies reviewed indicate that teachers' pedagogical knowledge is related to higher student achievement and better instructional quality. This research also suggests that while content knowledge and pedagogical content knowledge are necessary for improved student achievement, they are not sufficient. General pedagogical knowledge is another key factor underlying teacher quality.

In reviewing how teacher knowledge functions in the teaching-learning process, it becomes clear that teaching is a complex and cognitively-demanding activity and that improving teaching so as to improve learning outcomes will require more than just superficial reforms to certification requirements, qualifications or programme durations. Expert teachers are capable of enacting informed professional judgements that integrate extensive theoretical and practice-based knowledge. Becoming an expert teacher takes time and requires years of deliberate practice. The research shows that expert teachers are effective at helping their students learn successfully because of quick decision-making that hinges on a well-developed foundational pedagogical knowledge base. Improving teaching so as to have a corresponding improvement in learning outcomes will thus require substantive reforms to the scope and depth of the knowledge that teachers are meant to acquire in initial teacher education and throughout their professional careers.

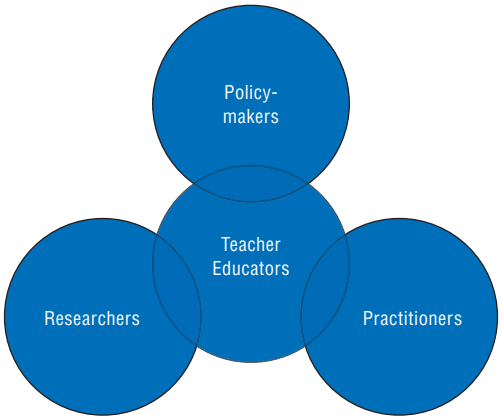
This has implications for how teachers can be more effectively trained. The research reviewed above indicates that the quality of teachers' knowledge is related to having access to opportunities to learn a range of pedagogical content and scope. For example, research by Blömeke et al. (2008) indicates that teacher education courses in high-achieving Asian countries are more focused on the processes of student thinking and cognitive development in comparison to the USA and European countries. Access to such "opportunities to learn" will have differential effects on teacher quality.

Another, generally overlooked, factor related to variation in opportunities to learn in initial teacher education is teacher educators. According to a report published by the European Commission (2013), teacher educators are key players in improving education quality, but the roles and responsibilities of teacher educators are not well understood. For example, variation exists in the level of qualifications required of teacher educators (e.g. Bachelor, Master or PhD), area of expertise (e.g. pedagogical or subject-matter experts) or professional profile (university lectures, researchers or school teachers). This variation in the "profession" of teacher educator also affects opportunities to learn, not only in initial teacher education institutions, but also in the provision of professional development.

Teacher educators are key to teaching students how to link theory to practice (European Commission, 2013), which, as argued above, is how professional judgements are made. Teacher education is the mechanism through which teachers are trained and inducted into the profession (Berliner, 2004), and it is through these formal learning opportunities that profession-specific knowledge is learned (Kunter et al., 2013). However, as some have argued (e.g. Révai and Guerriero, this volume), it is not clear whether the profession's knowledge base is up-to-date due to the complexity of the knowledge dynamics in the teaching profession.

To this end, teacher educators can play a crucial role in contributing to the development of the profession's pedagogical knowledge base through knowledge production, knowledge use, knowledge management and knowledge translation. Engaging with research would enable the profession to become better consumers of research, and by consequence, enable the profession to be informed by research-based knowledge in a more systematic way (BERA, 2014). Teacher educators, holding specialist knowledge of both theory and practice, are well-positioned to undertake research to further understanding of teaching and learning. In fact, teacher educators can be seen as sitting at the nexus of practice, research and policy, as exemplified by the figure below. Teacher educators are also well-positioned to inform policy with evidence-based recommendations.

Figure 4.2. **Building a pedagogical knowledge base and a teaching profession through teacher educators**



The debate around teachers' knowledge and its role in the teaching profession continues. It has been argued that access to a specialist knowledge base will elevate teaching to a status that is afforded to other professions with a rich knowledge base, such as medicine or law (e.g. Calderhead, 1991). In this chapter, we argue that teacher educators can play a key role in building the profession's knowledge base. But it is not so simple. As made clear by the European Commission (2013) report, despite acknowledging the important role of teacher educators to improving learning outcomes, national policies to promote the development of the profession are lacking. More importantly, professionalising teacher educators is likely to have a positive impact on the profession as a whole.

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Chapter 5

Modelling teachers' professional competence as a multi-dimensional construct

by
Sigrid Blömeke
University of Oslo, Norway

This chapter presents a framework for comparative studies that explains student achievement by teacher competence. Teacher competence is modelled as a multi-dimensional construct that includes cognitive and affective-motivational resources necessary to master classroom demands. Lesson planning, motivating students, classroom management and diagnosing student achievement can be regarded as crucial demands teachers have to master in many countries. Processes mediating the transformation of teacher's cognitive and affective-motivational resources into classroom performance in terms of teachers' situational skills are included in the framework as well. Perception, interpretation and decision-making are highlighted in this respect. Competence profiles describe the patterns how all teacher resources (cognition, affect, motivation, situational skills) play together. In this chapter, we pay attention particularly to teachers' general pedagogical knowledge and skills which are facets all teachers need to deal successfully with classroom demands. Empirical results from the international "Teacher Education and Development Study in Mathematics (TEDS-M)" are presented, which examined teacher knowledge in 16 countries at the end of their programmes. In addition, results on mediating situated skills such as teachers' perception or decision-making are presented.

Introduction

Student achievement in school subjects like mathematics or reading depends on a range of preconditions such as students' demographic background or their knowledge gained prior to schooling. The education system cannot do much about these characteristics but to accept and work with them. In contrast, teacher quality is an important factor that has a proven effect on student achievement and is at the same time prone to change by educational policy. Far-reaching consensus exists that – if student achievement shall be improved – teacher quality is one of the factors to be addressed.

Strangely enough, not much evidence exists about the level of teacher quality from an international comparative perspective. Even less cross-country evidence exists about how teacher quality can be influenced, in particular improved, and how precisely teacher quality is related to student achievement. Such evidence is a necessary precondition if reforms shall take place. Baumert, Blum and Neubrand (2002) critiqued therefore work that is international yet ignores teacher quality. They described this as a conceptual "gap" in OECD's Programme for International Student Assessment (PISA): "No account is taken of teachers' professional background, declarative knowledge, belief systems or motivation, or indeed of their procedural knowledge and professional action" (p. 8). The present chapter outlines how to frame an international study that intends to overcome current shortcomings of large-scale assessments such as PISA.

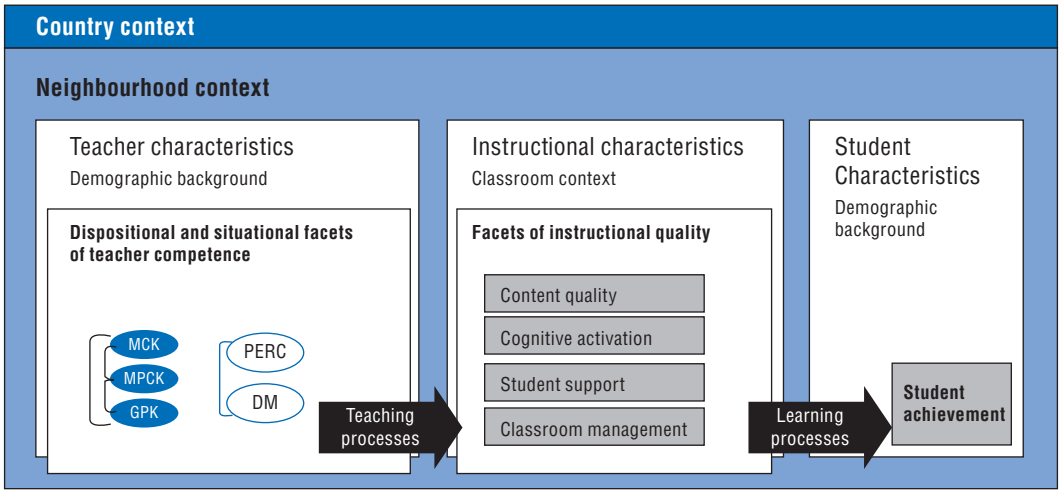
The complex role of teacher characteristics

Evidence suggests that the instructional quality in a classroom and student achievement depend on different types of teacher characteristics, in particular on their knowledge, skills, beliefs, values, motivation and metacognition (Baumert et al., 2010; Schoenfeld, 2010). Even if all other classroom characteristics such as the composition of students in terms of their prior knowledge and demographic backgrounds, school resources and climate or neighbourhood characteristics are held constant, it is not enough just to refer to, for example, teachers' content knowledge or their job motivation to explain instructional quality and student achievement. Such direct single relations do rarely exist; a broad range of cognitive and affective-motivational teacher characteristics has to be examined to make valid conclusions.

The reason for this complexity, which represents a challenge for the examination of teacher characteristics, is twofold. On the one hand, different types of instructional quality and student achievement are related to different types of teacher characteristics. If we want to explain student achievement – for example – in mathematics, not only teachers' mathematical content knowledge (MCK) but also their mathematics pedagogical content knowledge (MPCK) is important (Baumert et al., 2010). If we want to explain instructional quality in terms of classroom management, teachers' general pedagogical knowledge (GPK) is important (König et al., 2014). On the other hand, it is not sufficient for explaining instructional quality and student achievement to look at teacher knowledge only even if its broad range of content knowledge, pedagogical content knowledge and general pedagogical knowledge is covered in a study. These dispositional teacher characteristics, to a large

extent acquired during formal teacher training, have to be applied in the practical context of classrooms. Given the multidimensionality and speed of teacher-student interaction (Sabers, Cushinger and Berliner, 1991), teachers' situational skills are relevant. Perception of classroom situations, interpretation and decision-making are crucial here (Blömeke, Gustafsson and Shavelson, 2015).

Figure 5.1. **Modelling teacher competence as a multi-dimensional construct and linking it to student achievement via instructional quality**



Note: MCK = mathematics content knowledge, MPCK = mathematics pedagogical content knowledge, GPK = general pedagogical knowledge, PERC = perception and interpretation skills, DM = decision-making skills.
Source: Kaiser, G. et al., (2016), "Professional competencies of (prospective) mathematics teachers: Cognitive versus situated approaches", *Educational Studies in Mathematics*, Vol. 92.

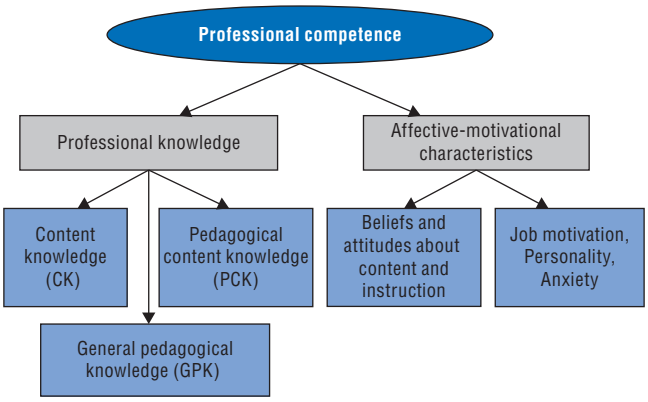
Developing a framework for a comparative study that intends to explain student achievement by teacher characteristics means therefore to model teachers' professional competence as a multi-dimensional construct that includes different types of resources necessary to master different job-related tasks (Weinert, 2001) on the one hand, and to be aware of mediating processes in terms of situational skills and instructional quality on the other hand (Baumert et al., 2010; Blömeke, Gustafsson and Shavelson, 2015). Furthermore, in a comparative study, the context characteristics play an important role and need to be considered because they vary strongly across countries. Otherwise, the link between teacher quality and student achievement cannot be established. Figure 5.1 displays the basic idea of this complexity, restricted on the teacher side to their cognitive dispositions and skills to facilitate the reading. This does not mean that teachers' affective-motivational characteristics can be neglected.

In this chapter, the idea of modelling teacher competence as a multi-dimensional construct is elaborated on in more detail. We will pay particular attention to teachers' GPK which is a facet all teachers need to successfully deal with generic classroom demands, no matter whether they teach mathematics, mother tongue or history. In a next step, results from the international "Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M)" are presented, which examined for the first time teachers' MCK, MPCK and GPK with representative samples of future teachers at the end of their teacher education programme in 16 countries. Finally, an approach is presented on how to assess mediating situated skills such as teachers' perception or decision-making in a standardised way.

Facets of teachers' professional competence

Teachers' cognitive and affective-motivational characteristics can be subdivided into content knowledge (CK), pedagogical content knowledge (PCK) and GPK (Shulman, 1987) as well as into beliefs about the nature of the content taught and the nature of teaching and learning (Richardson, 1996), job motivation and personality traits. "Competence profiles" describe the patterns of how these resources play together (Blömeke et al., 2013). The level and quality of teachers' professional competence is influenced by their preconditions before entering teacher education and their opportunities to learn during it (Blömeke, Suhl and Kaiser, 2011; Blömeke et al., 2012). Teacher education programmes in this sense reflect a country's vision of what teachers are supposed to know and be able to do in class and how teacher education and professional development should be organised to provide the knowledge and skills necessary for successful accomplishment of teachers' professional tasks. Whereas moderate differences exist across countries on how to define teachers' CK, more controversies are seen with respect to PCK (Döhrmann, Kaiser and Blömeke, 2014) and GPK, as well as with affective-motivational facets of teacher competencies, how they are to be defined or whether they are to be included at all. Affective-motivational facets such as orientations and goals, and meta-cognitive facets like self-regulation are in some studies supposed to be decisive facets of teachers' competencies, whereas in others they do not get recognised at all.

Figure 5.2. **Dimensions and facets of teachers' professional competence**



Source: Döhrmann, M., G. Kaiser and S. Blömeke (2012), "The conceptualization of mathematics competencies in the international teacher education study TEDS-M. ZDM", – *The International Journal on Mathematics Education*, Vol.44/3, pp. 325–340.

Despite such differences, many recent national large-scale assessments roughly followed the framework displayed in Figure 5.2. Some examples are the "Cognitive Activation in the Classroom (COACTIV)" study (Baumert et al., 2010), the different national TEDS studies that followed TEDS-M (Blömeke et al., 2013, 2014) and the funding initiative "Modelling and measuring competencies in higher education (KoKoHs)" in Germany (Blömeke and Troitschanskaia, 2013). A similar framework has been used in the context of the "Learning Mathematics for Teaching (LMT)" studies which originated in the US (Delaney et al. 2008; Hill, Ball and Schilling, 2008), but have in the meantime been applied in many other countries.

The only comparative studies that examined teacher knowledge on a large scale across countries are the "Mathematics Teaching in the 21st Century (MT21)" study (Schmidt, Blömeke and Tatto, 2011) carried out in 2006 and the already mentioned TEDS-M study carried out in 2008 under the supervision of the International Association for the Evaluation of Educational

Achievement (IEA) (Tatto et al., 2012). Currently, TEDS-M represents the largest comparative dataset that provides empirical evidence on the level, structure and predictors of teacher competencies at the end of teacher education. As an IEA study it was required to follow common high-stakes methodological quality criteria so that its results would be highly reliable. Random samples of future teachers were drawn; test monitoring and control of response rates took place, as well as weights and sophisticated statistical procedures were applied.

The development of TEDS-M, focusing on outcomes of primary and lower-secondary teacher education, reflects the growing effort to study teacher quality internationally:

> *The impetus for TEDS-M … was recognition that teaching mathematics in primary and secondary schools has become more challenging worldwide as knowledge demands change and large numbers of teachers reach retirement age. It has also become increasingly clear that effectively responding to demands for teacher preparation reform will remain difficult while there is lack of consensus on what such reform should encompass and while the range of alternatives continues to be poorly understood let alone based on evidence of what works. In the absence of empirical data, efforts to reform and improve educational provision in this highly contested arena continue to be undermined by tradition and implicit assumptions. (Tatto et al., 2012: 17)*

While TEDS-M provided empirical data that informs policy and practice related to recruiting and preparing a new generation of teachers, data that allows to look not only within but also across countries with respect to the quality of practicing teachers and its link to student achievement is still missing. In this sense, TEDS-M illustrates how to frame such studies so that it is worthwhile to look at its instruments and results (see below), but it cannot cover the research gap regarding the urgent question how teacher quality and student achievement are linked to each other.

General pedagogical knowledge of teachers as a core competence facet

Two tasks of teachers can be regarded as crucial in all countries: instruction and classroom management (König and Blömeke, 2012). Generic theories and methods of instruction and learning as well as of classroom management can therefore be defined as essential parts of teachers' GPK. According to Shulman (1987: 8), GPK involves "broad principles and strategies of classroom management and organization that appear to transcend subject matter" as well as knowledge about learners and learning, assessment and educational contexts and purposes. Similarly, and extending this definition, Grossman and Richert (1988: 54) stated that GPK "includes knowledge of theories of learning and general principles of instruction, an understanding of the various philosophies of education, general knowledge about learners, and knowledge of the principles and techniques of classroom management." Future teachers need to draw on this range of knowledge and weave it into coherent understandings and skills if they are to become competent to deal with what McDonald (1992) called the "wild triangle" that connects learners, content and teachers in the classroom.

In order to define what these broad teacher tasks include, a reference to the state of instructional research is helpful because it provides evidence-based models of teaching and learning (Carroll 1963; Bloom 1976). In particular, the QAIT model by Slavin (1994) describes crucial teacher tasks in more detail. The QAIT model is one of effective instruction that focuses on four elements. "Quality of Instruction" (Q) refers to activities of teaching that facilitate the learning of students, for instance presenting information in an organised way or announcing transitions to new topics. "Appropriate Levels of Instruction" (A) is an element that refers to dealing with a heterogeneous class. For teachers, it is challenging

to adapt instruction to students' diverse needs. Adaptivity includes, for instance, different methods of within-class ability grouping. "Incentives" (I) covers teaching activities meant to enhance the motivation of students to pay attention, to study, and to perform the tasks assigned. For a teacher, this may mean, for instance, to relate the content of a lesson to students' experiences. "Time" (T), finally, refers to the quantitative aspect of instruction and learning, for example, strategies of classroom management enabling students to spend a high amount of time on tasks. According to Slavin (1994), all elements have to be linked to each other and instruction is only effective if all of them are applied. The four elements of the QAIT model correspond to elements of other models of effective teaching (Good and Brophy, 2007) so that they can be regarded as basic dimensions of teacher quality.

Pedagogical content knowledge and content knowledge of teachers

PCK is a teacher's subject-specific knowledge for teaching. Shulman (1987: 9) characterises it as an "amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding." A teacher has to know about typical preconditions of his or her students and how to present a topic to them in the best possible way. Teachers should ask questions of varying complexity, identify common misconceptions, provide feedback and react with appropriate intervention strategies. Lesson planning knowledge is essential before instruction in the classroom can begin because the content must be selected appropriately, simplified and connected to teaching strategies. Curricular knowledge is also part of PCK and includes knowledge about teaching materials and curricula. Teachers have to consider issues such as the consequences for future lessons if a key topic in the curriculum were removed or taught in a different context.

The state of research is most elaborated with respect to mathematics teachers, which means that we are talking about MPCK. This form of knowledge includes mathematics-related curricular knowledge, knowledge about how to present fundamental mathematical concepts to students, and knowledge about typical learning difficulties of students in the field of mathematics. These sub-dimensions were used in TEDS-M as well as in other studies such as LMT.

CK includes not only basic factual knowledge of a subject but also the conceptual knowledge of structuring and organising principles of the corresponding academic discipline (Shulman 1987): why a specific approach is important and where it is placed in the universe of approaches to this discipline. Ball et al. (2008) distinguished between common CK that also other professions would have, specialised CK of teachers, and horizon CK. Both CK and PCK of teachers deal with subject-specific knowledge but from different perspectives. Studies by Schilling, Blunk and Hill (2007) and Krauss et al. (2008) demonstrate with respect to mathematics that while it is possible to distinguish between MCK and MPCK, the two are highly correlated.

The particular focus on mathematics teachers' knowledge is related to warnings that their proficiency level may not be strong enough, given the marginalised role mathematics had been playing in teacher education in many Western countries. Mathematics educators (e.g. Schoenfeld 1994; Kilpatrick et al. 2001) and mathematicians (e.g. Cuoco 2001; Wu 1999) have repeatedly pointed to the risks of weak training in mathematics: teachers' limited understanding of what mathematics is, a fragmented conception with vertical and horizontal disconnects, less than enjoyable teaching routines and an inability to implement modern mathematical ideas in school. However, systematic evidence supporting these claims is still missing.

TEDS-M instruments and major results

General pedagogical knowledge of future teachers at the end of their training

The TEDS-M test of general pedagogical knowledge, applied in three countries as a national option in addition to the core study (Germany, Chinese Taipei and the United States), was based on the above-mentioned theoretical framework. Four tasks of teachers were addressed: planning and structuring lessons, motivating students and classroom management, diagnosing student achievement and adaptivity (see Table 5.1 for more details).

Table 5.1. **Theoretical framework of the TEDS-M test of teachers' general pedagogical knowledge**

GPK dimensions	Covered by the TEDS-M test (national option applied in three countries)
Structuring lessons/lesson planning	components of lesson planning and lesson process
	lesson evaluation
	structuring of learning goals
Motivating students/Classroom management	achievement motivation
	strategies to motivate single students / the whole group
	strategies to prevent and counteract interferences
	effective use of allocated time / routines
Adaptivity	strategies of differentiation
	variety and use of teaching methods
Diagnosing student achievement	assessment types and functions
	central criteria
	teacher expectation effects

Source: König and Blömeke (2012), "Future teachers' general pedagogical knowledge from a comparative perspective: Does school experience matter?", *ZDM Mathematics Education*, Vol. 44, pp. 341–354.

A conceptual framework of cognitive processes describing the demands on future teachers when they respond to test items was part of the study as well so that the item development was based on a two-dimensional matrix of teacher tasks and cognitive processes (see Table 5.2). Following Anderson's and Krathwohl's elaborate and well-known model (2001), three cognitive processes were distinguished that summarised the original six processes: recalling, understanding/analysing and creating/generating. Future teachers had to retrieve information from long-term memory to respond to a test item. They had to understand or analyse a concept, a specific term or a phenomenon outlined by a specific test item. And they were asked to create or generate strategies on how they would solve a typical classroom situation problem which included evaluating the situation.

Table 5.2. **Conceptual matrix that led the item development in the national GPK option of TEDS-M**

GPK dimensions	Cognitive processes involved		
	Recalling	Understanding/analysing	Creating/generating
Structuring			
Motivating and classroom management			
Diagnosing student achievement			
Adaptivity			

Source: König, J. and S. Blömeke (2012), "Future teachers' general pedagogical knowledge from a comparative perspective: Does school experience matter?", *ZDM Mathematics Education*, Vol. 44, pp. 341–354.

About 80 multiple-choice (MC) and constructed-response (CR) (also called open-response items [OR]) were developed as a national option in TEDS-M to assess the GPK of future

primary and lower-secondary teachers from Germany, Chinese Taipei and the United States. Test validity could be confirmed in all three countries (König and Blömeke, 2012). Figure 5.3 presents an MC and an OR item example with a genuine response from the United States. The first item measured knowledge about motivating students. Future teachers had to recall basic terminology of achievement motivation ("intrinsic motivation" and "extrinsic motivation") and they were asked to analyse five statements against the background of this distinction. Statement C represented an example of "intrinsic motivation" whereas A, B, D and E were examples for "extrinsic motivation." In the second item example, future teachers were asked to support another future teacher and evaluate his or her lesson. This is a typical challenge during a peer-led teacher education practicum, but practicing teachers are also regularly required to analyse and reflect on their own as well as their colleagues' lessons. The item measured knowledge of "structuring" lessons. The predominant cognitive process was to generate fruitful questions. For the open-response items, coding rubrics were developed and reviewed by experts on teacher education in Germany, Chinese Taipei and the US to prevent culturally-biased response coding and scoring.

Figure 5.3. **Item examples from the TEDS-M GPK test applied in Germany, Chinese Taipei and the United States**

Which of the following cases represents an example of intrinsic motivation, and which represents an example of extrinsic motivation?

Check one box in each row.

A student learns before a test in mathematics, because he/she…	**Intrinsic motivation**	**Extrinsic motivation**
A. expects a reward for a good grade.	☐ 1	☐ 2
B. wants to avoid the consequences of a bad grade.	☐ 1	☐ 2
C. is interested in problems of mathematics.	☐ 1	☐ 2
D. does not want to disappoint his/her parents.	☐ 1	☐ 2
E. wants to maintain his/her relative rank in the class.	☐ 1	☐ 2

Imagine you are helping a future teacher to evaluate his or her lesson because he or she has never done this before. To help him or her adequately analyse his or her lesson, what questions would you ask? Formulate ten essential questions and write them down.

Example questions:

1) Do your students have prior knowledge about the subject?
2) What are your objectives?
3) Are the students working individually or in groups?
…
10) Have your students gained the knowledge from the lesson?

Source: König et al. (2011), "General pedagogical knowledge of future middle school teachers: on the complex ecology of teacher education in the United States, Germany, and Taiwan", *Journal of Teacher Education*, Vol. 62/2, pp. 188-201.

This GPK test was administered as a national TEDS-M option in Germany, Chinese Taipei and the United States after the TEDS-M MCK and MPCK tests had been applied. The data revealed that – on the primary school level – future teachers from the US were significantly outperformed by future teachers from Germany. The difference of nearly 1.5 standard

deviations was very large. It meant that there was almost no overlap between US teachers on the one side and German teachers on the other side. Most of the worst achieving teachers from Germany still did better than most of the best achieving teachers from the US. Similar results were reported from the TEDS-M survey of future secondary teachers (for more details see König et al., 2011).

Table 5.3. **Mean (M), standard error (SE) and standard deviation (SD) of future primary and lower-secondary teachers' GPK in Germany and the United States or Germany, Chinese Taipei and the United States respectively**

Elementary	M	SE	SD
Germany	601	3.7	95
international	500	0.7	100
US	462	2.7	72
Middle School	M	SE	SD
Germany	576	4.9	85
Chinese Taipei	572	3.2	52
International	500	2.2	100
US**[1 3]	440	3.0	66

Pedagogical content knowledge and content knowledge at the end of teacher education

To measure future primary and lower-secondary teachers' MCK and MPCK, two 60-minute paper-and-pencil tests were developed and applied in 2008 to approximately 13 000 future primary and 9 000 future lower-secondary mathematics teachers during standardised and monitored test sessions in 16 countries. An overview of participating countries is provided in Table 5.4. The items were intended to depict knowledge demands of classroom performance as closely as possible (National Council of Teachers of Mathematics, 2000). The primary assessment consisted of 106 items (74 MCK and 32 MPCK items); the lower-secondary assessments consisted of 103 items (76 MCK and 27 MPCK items). The items were assigned to booklets following a balanced incomplete block design to capture the desired breadth and depth of teacher knowledge.

Table 5.4. **Participating countries in the TEDS-M primary and lower-secondary studies**

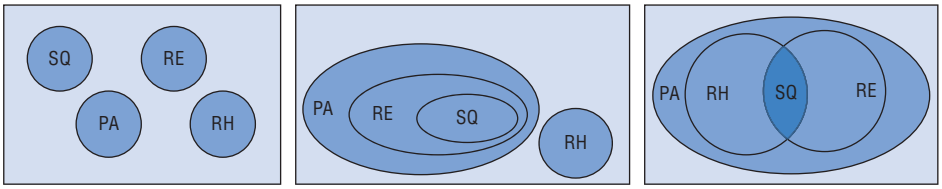
Botswana	Chile	Germany	Georgia
Malaysia	Norway	Oman (lower-secondary school only)	Philippines
Poland	Russia	Spain (primary school only)	Switzerland
Singapore	Chinese Taipei	Thailand	USA

The mathematics items included the content areas of number (as that part of arithmetic most relevant for teachers), algebra and geometry, with each set of items having roughly equal weight, as well as a small number of items about data (as that part of probability and statistics most relevant for teachers). The mathematics pedagogy items included aspects of curricular and planning knowledge and knowledge about how to teach mathematics. These two sets of items were given approximately equal weight. The items relating to curricular and planning knowledge covered areas such as establishing learning goals, knowing different assessment formats or linking teaching methods and instructional designs, and identifying different approaches for solving mathematical problems. The items relating to knowledge about how to teach mathematics covered, for example, diagnosing typical student responses, including misconceptions, explaining or presenting mathematical concepts or procedures, and providing appropriate feedback.

The majority of items were complex multiple-choice items. Some were partial-credit items. In addition and comparable to the GPK test, both the MCK and the MPCK tests covered three cognitive dimensions: knowing (recalling and remembering), applying (representing and implementing) and reasoning (analysing and justifying). Another feature that led the development of the items was their expected level of difficulty (novice, intermediate and expert). The items were developed benefitting from the experiences and items of the MT21 study mentioned at the beginning of this chapter (Schmidt, Blömeke and Tatto, 2011), as well as the "Knowing Mathematics for Teaching Algebra" study (Ferrini-Mundy et al., 2005) and the LMT study already mentioned (Hill, Loewenberg Ball and Schilling, 2008).

Figure 5.4. **Item examples from the TEDS-M MCK test for future primary and lower-secondary teachers**

Three students have drawn the following Venn diagrams showing the relationships between four quadrilaterals: Rectangles (RE), Parallelograms (PA), Rhombuses (RH) and Squares (SQ).



[Tian] [Rini] [Mia]

Which student's diagram is correct?

Check one box.

A. [Tian] O_1
B. [Rini] O_2
C. [Mia] O_3

Prove the following statement:
If the graphs of linear functions
$f(x) = ax + b$ and
$g(x) = cx + d$
Intersect at a point P on the x-axis, the graph of their sum function
$(f + g)(x)$ must also go through P.

Figure 5.5. **Item example from the TEDS-M MPCK primary school test**

When teaching children about length measurement for the first time, Mrs. [Ho] prefers to begin by having the children measure the width of their book using paper clips, and then again using pencils.

Give **TWO** reasons she could have for preferring to do this rather than simply teaching the children how to use a ruler.

Source: Brese, F. and M.T. Tatto (eds.) (2012), *User Guide for the TEDS-M International Database*. Amsterdam, Netherlands, IEA.

The descriptive TEDS-M results revealed significant country differences in teacher education outcomes in terms of MCK and MPCK. Future primary teachers from Chinese Taipei achieved the most favourable MCK result of all of the countries participating (Table 5.5; Blömeke, Suhl and Kaiser, 2011). The difference from the international mean (of 500 test points) was large – more than one standard deviation, which is a highly relevant difference according to Cohen (1988). The achievement of primary teachers from the US was slightly above the international mean and roughly on the same level as the achievement of teachers

in Germany and Norway. Their difference from the international mean was significant but of low practical relevance. These groups of teachers also reached significantly lower performance levels than Swiss and Thai teachers. If we take into account the United Nations Human Development Index to indicate the social, economic and educational developmental state of a country, the high performance of teachers from Russia and Thailand was striking.

Regarding MPCK, the achievement of future primary teachers from the US was roughly on the same level as the achievement of teachers in Norway, which was significantly above the international mean (see also Table 5.5). In this case, the difference from the international mean was of practical relevance. Teachers from Singapore and Chinese Taipei outperformed the US teachers. Whereas Singapore was behind Chinese Taipei in the case of MCK, these countries were on the same level in the case of MPCK. Regarding MPCK, Norway and the US were only half of a standard deviation behind the two East Asian countries, whereas this difference reached one standard deviation regarding MCK.

Table 5.5. **Means and standard errors (S.E.) of future primary teachers' MCK and MPCK**

Mathematics Content Knowledge		Mathematics Pedagogical Content Knowledge	
Country	Mean (S.E.)	Country	Mean (S.E.)
Chinese Taipei	623 (4.2)	Singapore	593 (3.4)
Singapore	590 (3.1)	Chinese Taipei	592 (2.3)
Switzerland*	543 (1.9)	Norway[1 n]	545 (2.4)
Russia	535 (9.9)	US*** [1 2]	544 (2.5)
Thailand	528 (2.3)	Switzerland*	537 (1.6)
Norway[1 n]	519 (2.6)	Russia	512 (8.1)
US*** [1 2]	518 (4.1)	Thailand	506 (2.3)
Germany	510 (2.7)	Malaysia	503 (3.1)
International	**500 (1.2)**	Germany	502 (4.0)
Poland** [1]	490 (2.2)	**International**	**500 (1.3)**
Malaysia	488 (1.8)	Spain	492 (2.2)
Spain	481 (2.6)	Poland** [1]	478 (1.8)
Botswana	441 (5.9)	Philippines	457 (9.7)
Philippines	440 (7.7)	Botswana	448 (8.8)
Chile[1]	413 (2.1)	Chile[1]	425 (3.7)
Georgia	345 (3.9)	Georgia	345 (4.9)

* Colleges of Education in German-speaking regions
** Institutions with concurrent programmes
*** Public Universities
n Results for Norway are reported by combining the two data sets available to approximate a country mean.
1. Combined Participation Rate < 75%
2. High proportion of missing values

Source: Blömeke, S. et al., (2012), "Family background, entry selectivity and opportunities to learn: What matters in primary teacher education? An international comparison of fifteen countries", *Teaching and Teacher Education*, Vol. 28, pp. 44-55.

Senk et al. (2012) pointed out large structural variations across countries in how teachers were trained to teach mathematics. The authors grouped teacher education programmes therefore into four groups. Primary teachers trained as mathematics specialists tended to have higher MCK and MPCK than those trained as generalists. However, within each group of teacher education programmes, differences of about one to two standard deviations in MCK and MPCK occurred between the highest and the lowest achieving countries. The authors inferred from these results that the relative performance within countries might vary greatly, especially if more than one teacher education programme exists.

When it comes to future lower-secondary teachers, those from Chinese Taipei achieved the best MCK results at the end of their training (see Table 5.6). The difference from the international mean (of 500 test points) was very large – more than 1.5 standard deviations. The results of German lower-secondary mathematics teachers were notably above the international mean. They were, however, still a long way behind those of future teachers in Chinese Taipei. German teachers also performed more poorly than teachers from Poland, Russia, Singapore and Switzerland. Taking again into account the Human Development Index, the performance of lower-secondary mathematics teachers from Poland and Russia was remarkable. The results of future teachers from the United States were around the international mean.

With regard to MPCK, future lower-secondary teachers from the US again only performed around the international mean (see also Table 5.6). In contrast, the German teachers' results were well above the international mean. Even though Chinese Taipei was still a long way ahead, the gap between Germany and Russia was smaller than in MCK and the difference between Germany, Singapore and Switzerland was not significant. These results reveal how important it is to distinguish between MCK and MPCK when looking at teacher knowledge. Whereas Malaysian teachers scored only slightly below the international mean in MCK, they had lower scores when it came to MPCK.

Table 5.6. **MCK and MPCK of future lower-secondary teachers**

Country	MCK Mean (SE)	Country	MPCK Mean (SE)
Chinese Taipei	667 (3.9)	Chinese Taipei	649 (5.2)
Russia	594 (12.8)	Russia	566 (10.1)
Singapore	570 (2.8)	Singapore	553 (4.7)
Poland** 1	540 (3.1)	Switzerland*	549 (5.9)
Switzerland*	531 (3.7)	Germany	540 (5.1)
Germany	519 (3.6)	Poland** 1	524 (4.2)
US*** 1 3	505 (9.7)	US*** 1 3	502 (8.7)
International	**500 (1.5)**	**International**	**500 (1.6)**
Malaysia	493 (2.4)	Thailand	476 (2.5)
Thailand	479 (1.6)	Oman	474 (3.8)
Oman	472 (2.4)	Malaysia	472 (3.3)
Norway2 n	444 (2.3)	Norway2 n	463 (3.4)
Philippines	442 (4.6)	Philippines	450 (4.7)
Botswana	441 (5.3)	Georgia1	443 (9.6)
Georgia1	424 (8.9)	Botswana	425 (8.2)
Chile1	354 (2.5)	Chile1	394 (3.8)

* German-speaking regions
** Institutions with concurrent programmes
*** Public universities
n Results for Norway are reported by combining the data sets available to approximate a country mean.
1. Combined Participation Rate < 75%
2. Combined Participation Rate < 60%
3. High proportion of missing values

Source: Blömeke, S. et al., (eds.) (2014), *International Perspectives on Teacher Knowledge, Beliefs and Opportunities to Learn*, Dordrecht, Springer.

Overall, it is surprising that the ranking of countries in TEDS-M was very similar to the ranking of countries in the Trends in International Mathematics and Science Study (TIMSS) (Mullis et al., 2008), which allows the preliminary tentative conclusion that a cyclic relationship may exist – with the option to improve student achievement by increasing mathematics teachers' professional knowledge.

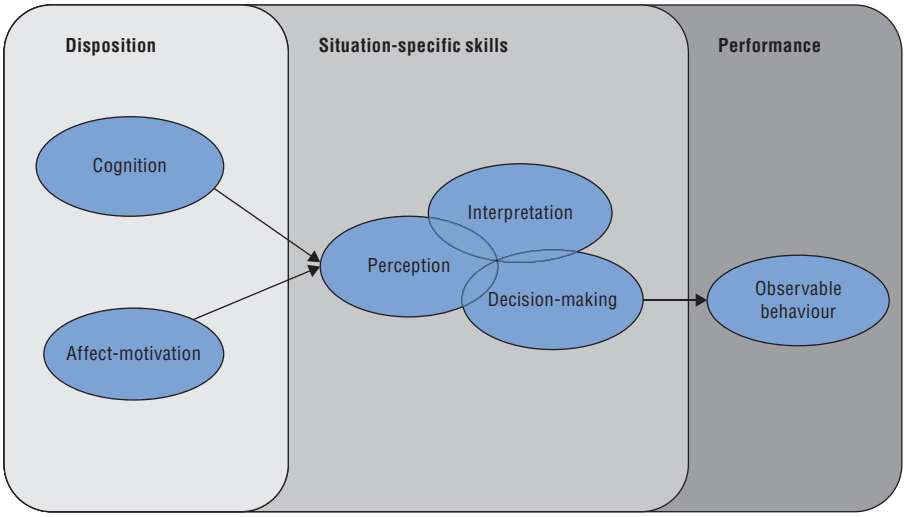
In addition to these country-level analyses, there is again much to be learnt by distinguishing between different types of teacher education programmes. This approach

must, however, be used with caution. The samples, which are already relatively small in the case of teachers compared to large-scale assessments of student achievement, are even smaller when teacher education programme types are examined. The estimates are thus less precise. With this caution in mind, however, we may hypothesise that, based on the TEDS-M data, teachers in concurrent programmes do just as well as teachers in consecutive programmes. Another hypothesis refers to the relevance of opportunities to learn mathematics, not only for achievement in MCK but also in MPCK. German lower-secondary teachers who were educated to teach on the upper-secondary level in addition to the lower-secondary level and thus had extensive education in mathematics, showed very strong MPCK, for example. Their MPCK was, on average, the same as that of Russian teachers and significantly higher than that of teachers from Singapore. German mathematics teachers who were qualified to teach on the lower-secondary level only did less well.

Processes mediating the transformation of teacher knowledge into classroom performance

A highly reliable assessment of important teacher characteristics has been accomplished through the studies described above. The analytical approach of TEDS-M allows precise diagnostics of strengths and weaknesses in teacher knowledge. Thus, the GPK, MPCK and MCK tests provide a feasible option of knowledge assessment. However, we have to point out that a research gap exists with respect to the transformation of these cognitive resources into classroom performance. Thus, an assessment of situation-specific teacher skills and a measure of instructional quality are necessary if one wants to link teacher knowledge to student achievement.

Figure 5.6. **Modelling competence as a continuum**

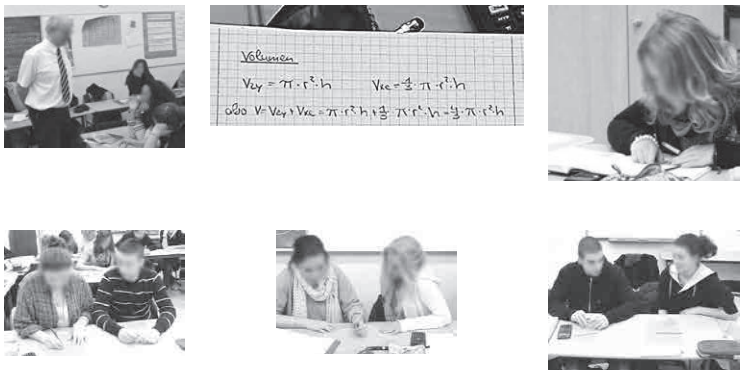


Source: Blömeke, Gustafsson and Shavelson (2015), "Beyond dichotomies: Competence viewed as a continuum", *Zeitschrift für Psychologie*, Vol. 223, pp. 3–13.

A theoretical framework on the transformation of cognitive resources into classroom performance was provided by Blömeke, Gustafsson and Shavelson (2015). It is displayed in Figure 5.6. Including a measure of situation-specific skills increases the validity of teacher knowledge assessments with respect to classroom performance. Classroom observations could be one such measure, but it is a very costly one. In addition, it could be unreliable given the unstandardised nature of classroom performance. Standardised video-based assessments

provide an alternative approach which can serve as a proxy. A tool specifically developed to address the mediating skills pointed out by Blömeke, Gustafsson and Shavelson (2015) was developed in the context of a German follow-up study to TEDS-M called TEDS-FU (Blömeke et al., 2014; König et al., 2014). It assesses generic and domain-specific perception, interpretation, and decision-making skills of mathematics primary and lower-secondary teachers. Different job requirements are presented via video-vignettes, for example, diagnosing student achievement, explaining mathematics to students, classroom management or dealing with heterogeneity. The clips are designed around critical incidents (see Figure 5.7).

Figure 5.7. **Example screenshots of one video-vignette (student pictures blurred to protect privacy)**



Expertise research provided the theoretical framework for the development of this video-based assessment. Eighteen open-response items and 16 or 22 rating scales respectively were developed to assess primary or lower-secondary teachers' skills related to classroom management and content-specific instruction. However, it is a challenge to improve the validity of knowledge assessments by using video-cued testing (Kane, 1992) because new sampling problems arise. The classroom situations selected have to be representative with respect to their frequency and centrality for teaching and learning. Furthermore, new evaluation problems arise because it is less straightforward in complex classroom situations to decide about correct–incorrect or effective–not effective teaching approaches than in distinct MC/CR items. Finally, new generalisability problems arise across the situations presented and towards the real world given the low number and variability of critical incidents that can be presented. Still, it is a worthwhile enterprise to improve the validity of competence assessments with respect to instructional quality.

Improving the validity of competence assessments with respect to student achievement is the next step. As pointed out, student achievement is domain-specific, and thus the value of an assessment that includes GPK only and neglects content and pedagogical content knowledge of teachers is limited. However, instrument development is particularly challenging in the case of MPCK. Depaepe, Verschaffel and Kelchtermans (2013) identified commonalities and differences in frameworks, study designs and instruments in a review of 60 publications about MPCK assessments. They identified as one commonality of several studies that MPCK is regarded as a bridge between CK and GPK and that it is a specific knowledge type of teachers. Döhrmann, Kaiser and Blömeke (2014) identified differences in the definition of MPCK between European (and partly Asian) countries and English-speaking countries though. This difference is also stressed by Hsieh, Lin and Wang (2014). The TEDS-M

tests assess a common core of MCK and MPCK in a set of 16 counties and have shown that MCK and MPCK can be reliably and validly assessed across the different countries.

Conclusions

Teacher competence has to be modelled in a multidimensional way including different cognitive and affective-motivational facets to provide a valid picture that can be linked to instructional quality and student achievement. Also, the transformation of knowledge into performance has to be addressed by modelling teacher competence as a continuum that includes situational perception, interpretation and decision-making skills as mediating processes. Frameworks of how to think about this complexity are available from prior research.

The assessment of crucial cognitive resources of teachers – general pedagogical knowledge, pedagogical content knowledge and content knowledge – can also build on prior research. Reliable and valid paper-and-pencil tests are available from TEDS-M. This study has already revealed important country differences in outcomes of teacher education which should be of strong concern for policy makers in those countries lagging behind. Building on existing comparative studies and instruments provides, as an additional benefit, the chance to connect new results to these existing ones. Similarly, although not discussed in much detail in this paper, a survey of affective-motivational characteristics can build on existing experience.

The assessment of situation-specific skills is a bigger challenge. Direct observation of behaviour through trained raters is one option, but it is costly. Video-based assessments provide a standardised alternative. Prior research is available that suggests how to proceed. However, whether such approaches work across different cultures is an open question which would need a lot of research on measurement invariance. If researchers succeed in developing such an assessment, a huge research gap could be closed with respect to the relationship among teacher knowledge, classroom performance and student achievement. We would finally have evidence about where reforms are necessary and how it is possible to improve the latter.

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Chapter 6

Connecting generic pedagogical knowledge with practice

by
Kathleen Stürmer
Technische Universität München;
and
Tina Seidel
TUM School of Education, Marsstraße

In this chapter, we introduce the concept of professional vision to assess aspects of pre-service teachers' knowledge referring to the contextualised and situated nature of real-world demands of the teaching profession. We use the concept to describe how pre-service teachers draw on their pedagogical, declarative-conceptual knowledge about effective teaching and learning to notice and interpret relevant features of classroom situations. In this chapter, we describe in a first section how the structure of pre-service teachers' professional vision is modelled. Based on the theoretical assumed structure, we outline in section two how pre-service teachers' professional vision is assessed by a standardised, formative approach. Finally, in section three we summarise findings with regard to the question how pre-service teachers change their professional vision within university-based teacher education.

Introduction

Teachers' knowledge as an aspect of their professional competencies is seen as essential for teaching quality in classrooms, and thus, for student achievement (Darling-Hammond and Bransford, 2005; Seidel and Shavelson, 2007). In this regard, defining and measuring professional knowledge acquisition from the beginning of a professionalisation process and therefore already within initial teacher education is of particular importance. In the last decade, research made significant progress in the standardised assessment of teachers' knowledge along the dimensions of content, pedagogical content and generic pedagogical knowledge. In using paper-pencil tests as an efficient and reliable way of formative assessment, evidence could be provided for the impact of professional preparation programmes on the acquisition of declarative-conceptual knowledge[1] (i.e. Baumert et al., 2010). However, initial teacher education faces the challenge to overcome the gap between theoretical and practical learning and thus, to support the transformation of cognitive resources into teaching practice. The ability to apply professional knowledge about effective teaching to components of complex classroom practice goes beyond what traditional knowledge tests are able to capture. Therefore, context-dependent approaches and measures are required (Blömeke, Gustafson and Shavelson, 2015; Shavelson, 2012) that focus on the assessment of integrated, flexible knowledge connected to multiple contexts of practice (Seidel, Blomberg and Renkl, 2013).

In this chapter, we introduce the concept of professional vision to assess aspects of prospective teachers' knowledge referring to the contextualised and situated nature of real-world job demands of the teaching profession. We use the concept to describe how prospective teachers draw on their generic pedagogical knowledge about effective teaching and learning to notice and interpret relevant features of classroom situations. In expertise research the ability to make sense of an observed situation in classroom is seen as indicator for the quality of knowledge representations. High abilities indicate differentiated and integrated knowledge with flexible applications to various teaching situations. Low abilities, in contrast, indicate fragmented and rather sparse knowledge structures without the ability to use this knowledge flexibly. In the last few years, the concept of professional vision has become an increasingly important element in describing the incipient processes of integrated knowledge acquisition within initial teacher education. We describe in a first section how the structure of prospective teachers' professional vision is modeled. Based on the theoretical assumed structure, we outline in section two how to assess professional vision by a standardised, formative assessment approach as an example. In section three, we summarise findings with regard to the question of how prospective teachers change their professional vision within professional preparation programmes. Finally, we discuss in section four the strength in identifying professional vision in order to support future teachers theory-practice integrated learning within initial teacher education.

Model of teachers' professional vision

Research in teacher education is still quite a young field (Grossman and McDonald, 2008). So far, only limited empirical research exists regarding the structure and development of teachers' competencies over time as a necessary prerequisite to model professional learning processes in a superior way. Until now, teachers' professional vision has been mainly studied by using qualitative approaches (Santagata and Angelici, 2010; van Es and Sherin, 2002). These findings have provided a valid basis for describing the quality of teacher knowledge and learning. In order to investigate learning processes within initial teacher education and to provide standardized instruments for formative assessment purposes, we model the structure of professional vision based on the findings of the previous qualitative research. This research highlights the key relevance of knowledge-based perceptual processes for teachers' professional competencies. This concept points out the social organised way of seeing and understanding environmental events by describing how persons observe and interpret situations specific to their profession (Goodwin, 1994). Sherin and van Es translated the concept into the context of teaching practice and define teachers' professional vision as the ability to notice and interpret relevant features of classroom events for student learning (Sherin, 2007; van Es and Sherin, 2002). The ability is informed by knowledge of what constitutes effective teaching and learning and requires integrated, flexible knowledge connected to the contexts of the observed situation (Seidel and Stürmer, 2014). Teachers' professional vision entails two interconnected subcomponents, which we will introduce in the following part: the selective attention to classroom events (noticing), and the interpretation of classroom events (reasoning).

Noticing: Selective attention to important classroom events

Noticing involves identifying classroom situations that, from a professional perspective, are decisive in effective instructional practice (Seidel and Stürmer, 2014). Teachers need to develop the ability to recognize the components of effective classroom teaching that support students' learning processes. In classroom teaching, numerous teaching and learning acts occur. Some are particularly important for student learning, others are not. In this vein, the situations to which teachers direct their attention while observing a classroom action serve as the first indicator of underlying knowledge (Sherin, Jacobs and Randolph, 2011). When it comes to defining situations that are relevant for teaching and learning, different knowledge foci that provide a frame for capturing knowledge application can be used. In our research we focus on the knowledge of the principles of teaching and learning as an aspect of generic pedagogical knowledge (Shulman, 1987), which represents a basic component of initial teacher education (Hammerness, Darling-Hammond and Shulman, 2002). Research on teaching effectiveness is based on knowledge about teaching and learning as an element of generic pedagogical knowledge. In the last decade, a substantial number of empirical studies have investigated the effects of teaching on student learning.

In understanding teaching as a process of creating and fostering learning environments in which students are supported in activities that have a good chance of improving learning, in their meta-analysis Seidel and Shavelson (2007) make the common results of those studies explicit by integrating the variety of effective teaching variables into the five teaching and learning (TL) components of a cognitive process-oriented teaching and learning model (Bolhuis, 2003). These TL components are: goal setting, orientation, execution of learning activities, evaluation of learning processes and teacher guidance and support (regulation). All TL components could be regarded as principles of teaching that show positive and differential effects on the cognitive and motivational-affective aspects of students' learning (Fraser et al. 1987; Hattie, 2009; Seidel and Shavelson, 2007).

Goal setting–referring to teacher's clarification of short- and long-term goals of the lesson–for example, has been shown to be an important condition for students' experience of their competence, autonomy and social relatedness (i.e. Kunter, Baumert and Köller, 2007). The component *orientation* focuses on the transition from goals to the execution of learning activities. This includes transparency as to how the goals will be achieved (e.g. mentioning the learning activities that will take place) and how the lesson will be structured. *Execution of learning activities* includes the social, cognitive, and motivational stimulation of the learners. It is characterised by teachers' support of social interactions between learners and teachers' provision of opportunities for processing information. *Regulation* refers to the monitoring of students' learning processes. It includes teachers' feedback on learning outcomes, and their support in choosing the appropriate learning strategies and prompting self-regulated learning situations. Finally, *evaluation* includes a retrospective look at students' progress towards the learning goals, as well as the learning processes that took place within the lesson.

Reasoning: Interpretation of important classroom events

The second subcomponent of professional vision describes teachers' reasoning about classroom events. This subcomponent captures the ability to process and interpret the situations noticed, based on knowledge of principles of teaching and learning (Borko, 2004; van Es and Sherin, 2002). The ability to take a reasoned approach to noticed situations in the classroom provides insights into the quality of the teachers' mental representations of generic pedagogical knowledge (Borko et al. 2008). In conceptualising teachers' reasoning, researchers distinguish among qualitatively different aspects (i.e. Berliner, 2001), which we have termed as follows: (a) description; (b) explanation; and (c) prediction (Seidel and Stürmer, 2014). *Description* reflects the ability to differentiate the relevant aspects of a noticed teaching and learning component (i.e. goal setting: the teacher refers to what the students should learn) without making additional judgments. *Explanation* refers to the ability to use conceptual knowledge about effective teaching to reason about a situation. This means classifying and accounting the situations according to the terms and concepts of the TL component involved. *Prediction* refers to the ability to predict the consequences of observed events in terms of student learning. It draws on broad knowledge about teaching and student learning as well as its application to classroom practice.

Because knowledge-based reasoning is an indicator of the quality of the knowledge representation, in initial teacher education the investigation of the reasoning ability regarding noticed TL components is seen as indicator for the incipient acquisition of theory-practice integrated knowledge (Seidel and Stürmer, 2014; Stürmer and Seidel, 2015). Previous research has shown that novice teachers are capable of describing classroom situations. In contrast, their ability to explain and predict the consequences and outcomes of those situations lags behind that of experienced in-service teachers (Seidel and Prenzel, 2007). However, little empirical research has systematically explored the interrelation of the three aspects of reasoning. For example, the ability might be regarded as one-dimensional so that the three aspects cannot clearly be separated; it might also be that the three aspects have to be seen as distinctive but highly interrelated. Taking into account the higher-order knowledge application processes involved and the results of previous studies, it also seems possible that explaining and predicting are so closely related that they can be treated as one aspect (i.e. as integration). Knowledge about the structure, however, serves to advance the field, especially when it comes to designing learning environments in initial teacher education. If the three aspects of reasoning are highly interrelated and represent distinctive dimensions of increasing difficulty, teacher educators could draw on this knowledge in order to structure and sequence programmes and courses on teaching and learning.

Assessment of professional vision within initial teacher education

Taking into account the contextual nature of professional vision, measurements capturing the initial acquisition of integrated knowledge have to be devised that go beyond traditional knowledge tests. In this respect, the use of video has been shown to be a suitable methodological approach to describing and investigating the phenomenon of professional vision. The use of video has been applied to groups of teachers with diverse kinds of expertise, ranging from pre-service teachers in initial university-based teacher education to experienced in-service teachers. Video is typically used to prompt the application of professional knowledge. Noticing and reasoning abilities are then assessed by open questions that are analysed qualitatively. Those approaches are prominent in professional vision research. They have helped identify sub-processes and dimensions of professional vision. However, they are limited with regard to investigating larger samples. To test the structure of professional vision and to evaluate developments of prospective teachers over time, standardised measures that are suitable for formative assessment in the long term are helpful. They provide a valid and reliable indicator of the major achievement of objectives in initial teacher education programs (e.g. applicable and integrated knowledge about teaching and learning). In this section, we introduce the *Observer research tool* (Seidel, Blomberg and Stürmer, 2010a) as the first video-based tool that assesses prospective teachers' professional vision in a standardised yet contextualised way. We show how we combined video clips recorded from real classroom situations with standardised ratings to assess prospective teachers description, explanation, and prediction abilities with regard to effective TL components.

The Observer Research Tool

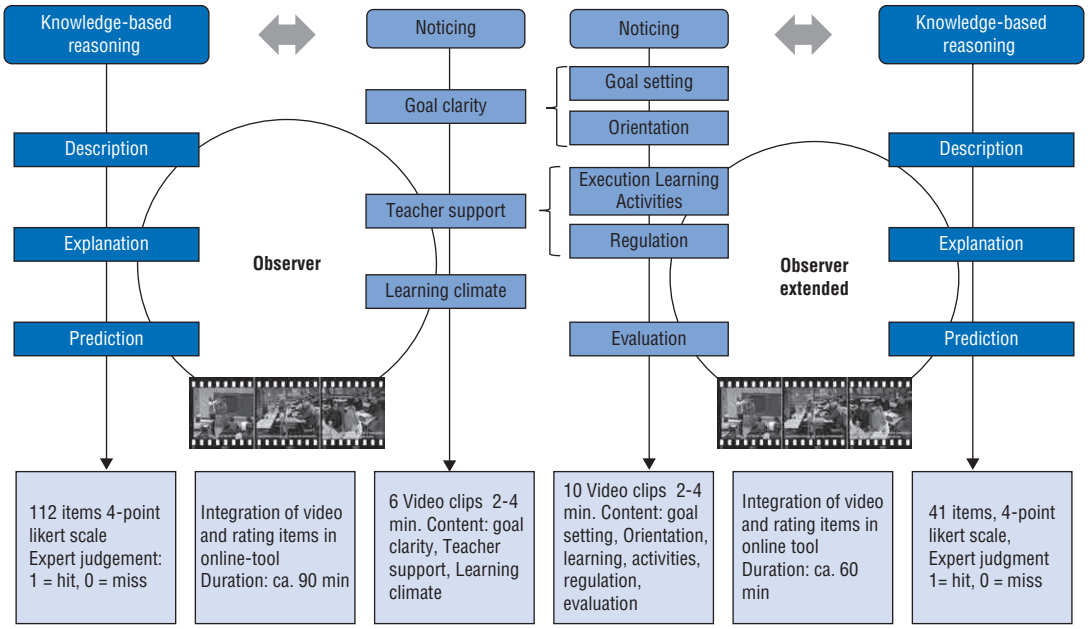
In the six-year project *Observe* (Seidel et al. forthcoming), a version of the *Observer Research Tool* was developed, which focuses on knowledge application regarding three TL components: goal clarity, teacher support, and learning climate. Since it was a first attempt of the project to create a standardised yet contextualised measure in order to investigate learning processes targeting initial integrated knowledge acquisition within university-based teacher education, the three components were selected because they represented a balanced knowledge base, integrating the TL components of the cognitive process-oriented teaching and learning model described in section one. Goal clarity served as an indicator of the successful preparation for learning, which includes the aspects of goal setting and orientation. Teacher support served as a guiding process involved in the execution and regulation of learning activities, and learning climate served as an indicator of the motivational-affective classroom context.

In the research tool, videotaped real classroom situations were combined with rating items (see Figure 6.1). Each video represents two TL components (e.g. teacher support and learning climate). The videos were selected based on the following criteria: authenticity of the selected classroom situations, activation of participants' knowledge, and particular relevance for student learning. Based on the application of these criteria, twelve videos were selected. A pilot study with N = 40 pre-service teachers showed that all twelve videos were perceived as authentic and cognitively activating (Seidel, Blomberg and Stürmer, 2010b). We also investigated the extent to which the twelve selected videos represent the three focused TL components (i.e. goal clarity, teacher support, and learning climate) and serve as "prompts" to elicit participants' knowledge. In a study with N = 119 pre-service teachers, two test versions were implemented in which videos were systematically rotated and varied with respect to the subject shown and the teaching and learning components represented

(Seidel and Stürmer, 2014). The mean agreements between participants and the judgment of the research team were 66.9 % for goal clarity, 80.4 % for teacher support, and 75.8 % for learning climate.

Consequently, the twelve videos can be regarded as valid examples of the three TL components. The videos were embedded in rating items with a four-point Likert-scale ranging from "1" (disagree) to "4" (agree). Rating items were developed to target the three reasoning aspects equally: describe (e.g. the teacher clarifies what the students are supposed to learn); explain (e.g. the students have the opportunity to activate their prior knowledge of the topic); and predict (e.g. the students will be able to align their learning process to the learning objective). Because the research on teaching effectiveness does not provide right or wrong answers regarding the quality of videos, we used an expert norm as a reference. To establish this norm, three expert researchers—each with 100 to 400 hours of experience in observing classroom situations—independently rated all developed rating items in connection with the selected videos (Seidel, Blomberg and Stürmer 2010b). The data were recoded according to the agreement with the expert rating: "1" (hit expert rating) and "0" (miss expert rating). This strict recoding proved to be superior to a less strict version that took tendency into account (Seidel and Stürmer, 2014).

Figure 6.1. **Assessment of professional vision in the Observer and the Observer Extended Research Tool**



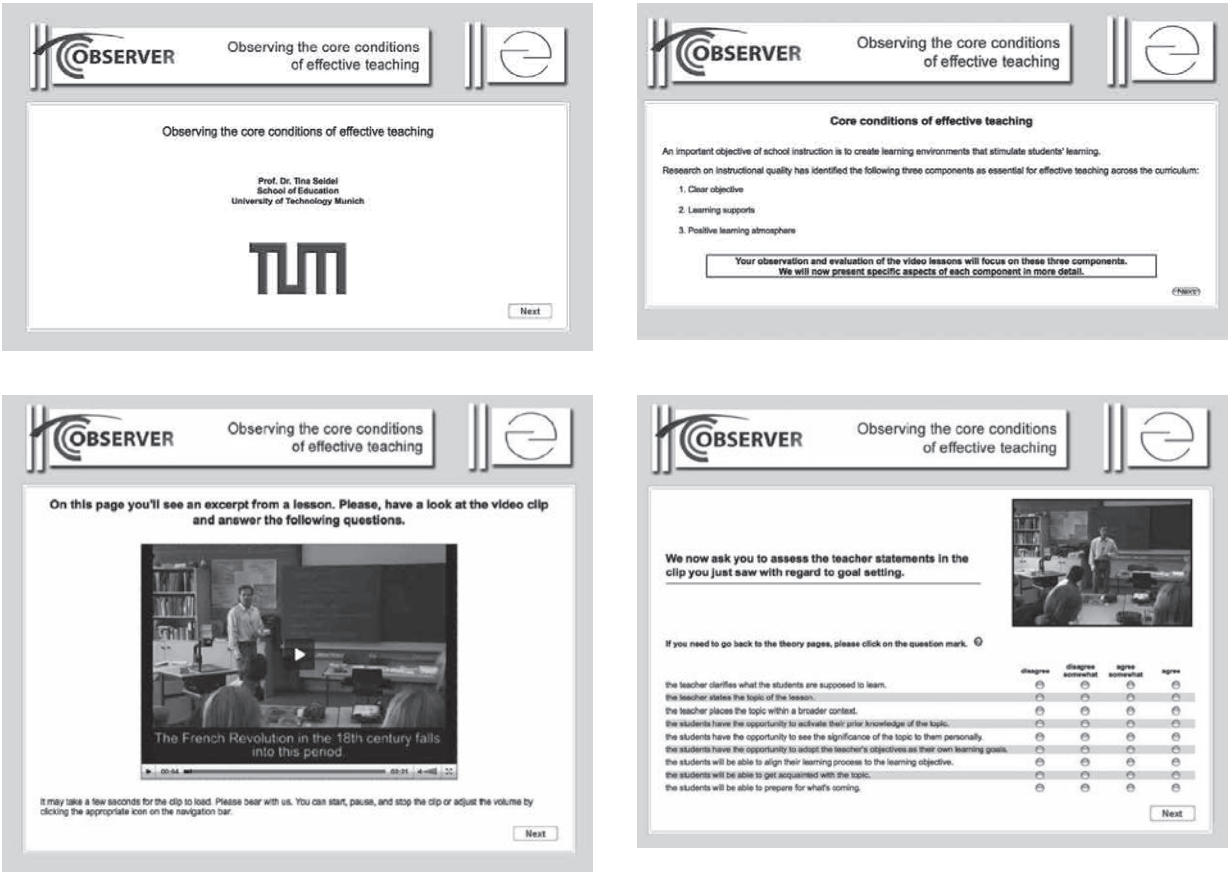
Seidel, T. and K. Stürmer (2014), "Modelling and measuring the structure of professional vision in pre-service teachers, *American Educational Research Journal*, Vol. 51/4, http://dx.doi.org/10.3102/0002831214531321, p. 56.

The *Observer Research Tool* is presented as a series of HTML pages. It starts with general instructions and short introductions of the three TL components: goal clarity, teacher support and learning climate. Brief contextual information about the class is provided before each video is presented. Participants have the opportunity to watch the videos a second time before responding to the rating items (see Figure 6.2). In order to limit the completion time of the tool and to reach a balanced ratio between the represented subjects and the teaching and learning components, participants are presented six of the twelve videos showing

secondary classroom instruction in physics, maths, French and history. In this form, the completion time of the instrument is about 90 minutes.

In the context of university-based teacher education, we investigated whether the measurement was stable over time. Evidence for this re-test reliability could be provided (Seidel and Stürmer 2014). Furthermore, the *Observer Research Tool* was processed under different conditions ("online" versus "on-site" processing and "voluntary" versus "compulsory" participation). Thus, we ensured that assessment of pre-service teachers' professional vision was not affected by different assessment conditions (Jahn et al. 2011). Regarding the assessment of generic pedagogical knowledge application, a further study shows no dependencies between the subject background of pre-service teachers (i.e. maths) and the subject shown in the videos (Blomberg, Stürmer and Seidel, 2011).

Figure 6.2. **The Observer Research Tool**



Source: Seidel, T. and K. Stürmer (2014), "Modelling and measuring the structure of professional vision in pre-service teachers, *American Educational Research Journal*, Vol. 51/4, http://dx.doi.org/10.3102/0002831214531321, p. 15.

In the project BilWiss "Role of Broad Educational Knowledge and the Acquisition of Professional Competence of Teacher Candidates for Career Entry" (Stürmer and Seidel, 2015), we extended the *Observer Research Tool* by expanding the facets of knowledge that the measurement of professional vision is based on by drawing on all TL components of the process-oriented teaching and learning model. In order to track prospective teachers' learning trajectories in different consecutive phases of initial teacher education, we aimed with the extension to capture professional vision of different subpopulation (pre-service

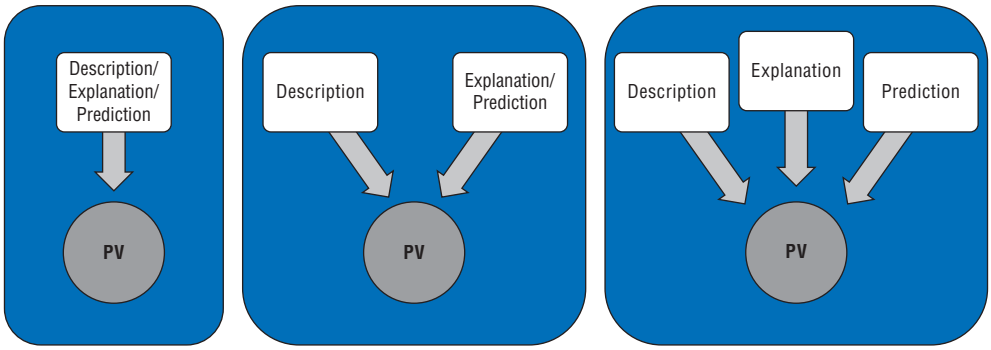
teachers who start initial teacher education with up to five years theory-based learning at universities followed by practice-based learning in a two year induction phase as teacher candidate).

Therefore, two video clips per TL component (in sum ten) were reassigned to goal setting, orientation, execution of learning activities, evaluation of learning processes, and teacher guidance and support (regulation). At the same time the item battery was shortened to reach an economical completion time of 60 minutes (see Figure 6.1). Similar to the procedure with the original *Observer Research Tool*, we investigated the extent to which the ten selected videos represent the five focused TL components. In a study with N = 317 pre-service teachers and teacher candidates the mean agreements between participants and the judgment of the research team were satisfying (67.5 % for goal setting, 61.5 % for orientation, 71.0 % for execution of learning activities, 65.5 % for regulation, and 63.5 % for evaluation). Furthermore, we tested that the *Observer Extended Research Tool* provides a reliable measure of professional vision for different subpopulations in initial teacher education (Stürmer and Seidel, 2015).

Interrelation between the three reasoning dimensions

In scrutinising the assumptions of different models regarding the structure of professional vision, we conducted scaling studies with the two versions of the *Observer Research Tool*. Analyses of the psychometric properties of the instrument based on item response theory have confirmed that the *Observer* tool provides a valid and reliable assessment of professional vision (Jahn et al. 2014; Seidel and Stürmer, 2014; Stürmer and Seidel, 2015). In these studies of more than 1,000 pre-service teachers and teacher candidates, different measures and models that describe the structure of professional vision were applied, and fit indices were compared. We tested a one-dimensional (reasoning as one overall ability) and a two-dimensional model (describe and integrate including explain and predict) against the theoretically postulated three-dimensional model (describe, explain and predict) (see Figure 6.3).

Figure 6.3. **Model comparison for identifying the structure of professional vision**



The results of the scaling studies show that all three models reliably assessed reasoning, but the three-dimensional model explained the most variance. Moreover, the three-dimensional model fit the data best. However, bivariate latent correlations of the person ability scores of pre-service teachers showed that the components describe, explain and predict were interrelated and highly correlated with the overall score of reasoning. Moreover, the structure of reasoning proved to be comparable to that of pre-service teachers in different teacher education tracks such

as primary, secondary and vocational education (Jahn et al., 2014) as well as between pre-service teachers and teacher candidates (Stürmer and Seidel, 2015). Thus, the Observer tool provided a reliable and valid measure of prospective teachers' professional vision and their sub-abilities of describing, explaining and predicting classroom situations in initial teacher education.

Changes in professional vision within initial teacher education

Based on the measurement approach outlined in section two, we present and discuss studies focusing on the role and design of formal and informal learning opportunities within initial teacher education as sources for knowledge acquisition. We summarise findings of studies using the *Observer Research Tool* as formative assessment tool. We show how the acquisition of declarative-conceptual knowledge, particularly in a situated contextualised way, support positive changes of professional vision and how changes are related to individual characteristics of prospective teachers.

The role of formal and informal opportunity-to-learn (OTL)

Regarding prospective teachers' formal learning, first findings indicated that teacher preparation programmes in general fostered a continuous and accumulative acquisition of declarative-conceptual professional knowledge (i.e. Kleickmann et al., 2013). In one study we investigated the relationship between important capacities students at university already gathered, such as interest in topics of teaching and learning, pre-experience in university courses on teaching and learning, as well as practical pre-experience and level of professional vision (Stürmer, Könings and Seidel, 2014). It was shown that the number of attended university courses on teaching and learning and the level of interest in this field are systematically related to higher levels of professional vision.

In particular, these two factors were positively associated with the subscales explanation and prediction, which indicated higher-order learning and knowledge integration. Furthermore, the factor of interest in topics of teaching and learning has been proven not only to be a strong predictor for theory-based learning at university, but also for the practice-based learning of teacher candidates in their induction phase (Stürmer, Seidel and Kunina-Habenicht, 2015). Regarding the question of what content of generic pedagogical knowledge supports positive changes in professional vision, in a further study, the *Observer Research Tool* was used as a pre- and post-test measure within three courses on the topic of teaching and learning principles at university (Stürmer, Könings and Seidel, 2013).

The three courses included: (a) a very specific video-based course directly targeting effective TL components; (b) a course focusing on important principles of learning and learner characteristics connected to principles of teaching and (c) a broad course on "hot topics in instruction", dealing partly with TL components but accompanied by other topics, such as relevance of homework or assessment. For all three courses, positive changes in three professional vision abilities were shown. Regarding the gains in description, explanation and predication, differential effects occurred. The two content-specific courses on TL components showed the highest increases in explaining and predicting and seem to support the integration of knowledge about TL components and student learning. The general course showed the highest increases in describing. These findings indicated that the *Observer Research Tool* is sensitive to specific learning effects that might occur because of different course objectives and learning goals in university courses.

In addition to formal OTL, informal learning, such as practical experiences in teaching, is seen as essential in acquiring integrated knowledge structures. It has been argued that well-defined and integrated knowledge can only be developed when it is applied to practice through contextualised generalisation over long periods of time (Darling-Hammond and Bransford, 2005). Consequently, different forms of internships and praxis elements have been implemented in initial, university-based, teacher education programmes. In this context, we examined the impact of practical experience (in the form of a praxis semester) accompanied by video-based courses at university on pre-service teachers' changes in professional vision (Stürmer, Seidel and Schäfer, 2013). The findings revealed overall positive changes, with a special benefit for students who started the semester with low abilities in professional vision. Because the students' practical experiences were guided by video-based courses at university, the study underlined the attempt to combine formal and informal OTL in order to foster the development of integrated knowledge in the domain of generic pedagogical knowledge.

The design of formal and informal OTL

To support prospective teachers in acquiring knowledge and applying it to real classroom situations, the constant monitoring of course instruction and activities is necessary for creating effective OTLs within initial teacher education preparation programmes (Hierbert et al. 2007). Research on the design of OTLs has outlined the advantage of videos as a learning tool that guides the acquisition, activation and application of teachers' knowledge in a meaningful way. However, videos must be implemented with clear objectives in mind. Because relatively little research has empirically investigated the effect of different video-based designs using different instructional strategies on prospective teachers' learning, Seidel et al. (2013) examined the impact of two instructional strategies embedded in video-based courses on pre-service teachers' learning at university.

Rule-example (firstly, theoretical knowledge about TL components is provided, followed by students analysis of video clips regarding TL components) vs. example-rule (firstly, students analyse video clips regarding effective teaching, followed by a theoretical summary provided by the lecture referring to TL components). The results revealed that pre-service teachers who were taught by the rule-example strategy scored higher on reproducing declarative knowledge about relevant TL components and on professional vision, whereas pre-service teachers in the example-rule group scored higher on lesson planning, particularly in identifying possible occurring challenges in a situated way.

Furthermore, distinct differences in the capacities of pre-service teachers to reflect about teaching were shown. The rule-example approach facilitated reasoning abilities in observing videotaped classroom situations, whereas the example-rule teaching approach fostered pre-service teachers' long-term reflection skills about own learning in a learning journal. These findings underlined the importance of choosing an appropriate instructional approach in the design of video-based formal OTLs, depending on specific learning goals (Blomberg et al. 2013). In addition, OTLs in teacher education should have clear learning goals, and they should take into account the heterogeneity of the target group (Stürmer et al. 2013).

Identifying professional vision within initial teacher education: Implications for practice

Initial teacher education faces the challenge to overcome the gap between theoretical-based and practical-based learning. In this respect, the investigation of students' professional vision could be regarded as a necessary link between the acquisition of declarative-conceptual

knowledge about effective teaching as well as the ability to apply this knowledge to components of real practice. In the current understanding of what constitute professional competencies, next to cognitive and motivational factors, situation specific skills such as the interpretation of the event in which the protagonist is required to act, determines successful job performance (Blömeke, Gustafson and Shavelson, 2015). Thus, the ability to notice and interpret relevant features of classroom events for student learning is seen as an important prerequisite for effective teaching practice. First studies show that the ability to make sense of an observed situation, which is relevant for student learning, relates to teaching quality (i.e. Kersting et al. 2010). In this vein, regarding prospective teachers' learning, the concept constitutes a promising approach for capturing knowledge acquisition that is relevant for future teaching practice.

In initiating competence development for successful job performance, initial teacher education is required to bring teaching practice into their preparation programmes and to provide opportunities to connect professional knowledge acquisition with the essential elements of the real-job demands. Because classroom teaching is a highly complex, dynamic process, the learning for effective teaching performance is determined by a myriad of factors that interrelates and build up on each other. The acquisition of professional practice is not characterised by simply increasing the quantity of classroom teaching. Rather, it is characterised by the context-based, reflective interplay of professional knowledge acquisition as well as the organisation and integration of this knowledge. Therefore, the pedagogy of practice within formal learning settings (Grossman et al., 2009) has to draw on authentic representations of practice, which illustrate relevant elements of the real job and enable students to link their knowledge to multiple contexts of practice. It has to decompose the complexity of teaching practice in crucial parts in order to help students in understanding what constitutes effective teaching practice. In this regard, professional educators can help students learn first to attend the essential elements of practice and then to enact them, for example, by a series of approximations to practice (i.e. role plays) that increase in complexity (Grossman, 2009).

By describing students' ability to apply their generic pedagogical knowledge about effective TL components while observing classroom situations, the approach of professional vision focuses on how prospective teachers build up an understanding of essential elements of the teaching profession. The use of authentic representations of practice in the *Observer Research Tool* allows an assessment of the quality of integrated knowledge proximal to real teaching practice. In a further step, teacher educators can draw on that initial knowledge acquisition in enabling students to enact in the TL components within authentic but, decomposed teaching events regarding their representation of practice (Seidel et al. 2015).

Notes

1. Declarative-conceptual knowledge describes theoretical, content-related knowledge representations referring to facts, principles, concepts and models as well as the deep understanding and connection among the representations.

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Chapter 7

Motivations for teaching and relationship to general pedagogical knowledge

by
Johannes König
University of Cologne, Germany

This chapter reports about research on the relationship between teaching motivations and the general pedagogical knowledge (GPK) of teachers. It focuses on two studies that have been carried out so far to specifically investigate pre-service teachers' GPK as an outcome of teaching motivations. The presentation will give input to discuss the following questions: What conceptual frameworks have been used to consider the relationship between motivations for teaching and GPK? What do the empirical findings show to explicate the relationship? What could be recommended for future research? The two studies focused on in this presentation have a longitudinal design investigating teaching motivations. To capture GPK, the paper-pencil test developed in the Teacher Education and Development Study in Mathematics (TEDS-M) is used. Teaching motivations are measured using the Factors Influencing Teaching as a Career Choice (FIT-Choice) scale inventory. Implications for future research are discussed.

Introduction

Results from the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) have challenged empirical educational research asking how the quality of both teachers and teacher education could be improved, due to the empirical evidence that teachers influence outcomes such as student achievement (Hattie, 2009). There is thus a growing body of research related to teacher competence. Following the concept of "competence" as, for instance, outlined by Weinert (2001) in general and specified for the teaching profession by Bromme (1992; 2001), focus is directed to the mastering of professional tasks and reaching important objectives of the teaching profession.

Models of professional competence of teachers postulate both cognitive and affective-motivational elements as relevant for successful mastery of professional tasks (Baumert and Kunter, 2006). Teacher knowledge is regarded as a multidimensional construct, consisting of content knowledge (CK), pedagogical content knowledge (PCK), and general pedagogical knowledge (GPK). Affective-motivational elements are considered to contain various constructs such as teaching motivation, beliefs or self-efficacy.

On a general level, hypotheses about interrelationships exist, for example in the field of motivational psychology, that highly intrinsically motivated people generally outperform less intrinsically motivated people, whereas extrinsic motivation is usually associated with poorer performance and educational outcomes (Baker, 2004). However, very few studies have specifically investigated the interrelationships between relevant cognitive and motivational elements of professional teacher competence (König and Rothland, 2012, 2013).

The aim of this chapter is to report about research on the relationship between motivations for teaching and general pedagogical knowledge (GPK) of teachers. It focuses on two studies that have been carried out so far to specifically investigate pre-service teachers' GPK as an outcome of teaching motivations (König and Rothland, 2012; König et al., 2013). This chapter will give input to discuss the following questions:

- Which conceptual frameworks have been used to consider the relationship between motivations for teaching and GPK (e.g. what hypotheses are used)?
- What do the empirical findings show to explicate the relationship (e.g. to what extent and how are motivation and knowledge connected)?
- What could be recommended for future research and what implications should be discussed?

The structure of this chapter is as follows: First, the test used in both studies to measure pre-service teachers' GPK will be outlined, and a summary of relevant empirical findings about that instrument will be given. Second, the framework developed by Watt and Richardson (2007) used in both studies to investigate teaching motivations will be presented. Third, the two studies on the relationship between motivations for teaching and GPK will be presented. While the first study is related to a pre-service teacher sample from one

university in Germany, the second study's data derives from a larger study that has been conducted in three German-speaking countries (Austria, Germany and Switzerland), thus allowing us to include an international-comparative perspective. In the final part, findings are summarised and implications for future research and educational policy are discussed.

General pedagogical knowledge (GPK)

In both studies, student teachers' general pedagogical knowledge is measured by a paper-and-pencil test instrument (König et al., 2011) that was developed in the "Teacher Education and Development Study – Learning to Teach Mathematics" (TEDS-M) (Tatto et al., 2008; see also Chapter 5 by Blömeke in this volume), therefore this measurement instrument is outlined first.

Conceptual framework - defining GPK

To account for a reliable and valid cognitive measure in the domain of general pedagogy, a paper-and-pencil test measuring general pedagogical knowledge (GPK) of teachers was developed in TEDS-M carried out under the supervision of the International Association for the Evaluation of Educational Achievement (IEA) in 2008. TEDS-M is a comparative study of teacher education and was the first international large-scale assessment of pre-service teachers that worked with representative samples. The TEDS-M target population was defined as mathematics teachers for elementary and middle schools in their final year of teacher education, and a central component of TEDS-M was to measure their professional knowledge (Tatto et al., 2012). Cognitive abilities were categorised into three facets: content knowledge (CK), pedagogical content knowledge (PCK), and general pedagogical knowledge (GPK; see, for details, König et al., 2011), which due to reasons of feasibility was examined in only three countries: Germany, Chinese Taipei, and the United States.

The theoretical framework of GPK developed in the context of TEDS-M is structured in a task-based way and related to generic dimensions of teaching quality. Four content-related dimensions of GPK are considered highly relevant allowing teachers to prepare, structure and evaluate lessons ("structure"), to motivate and support students as well as manage the classroom ("motivation/classroom management"), to deal with heterogeneous learning groups in the classroom ("adaptivity") and to assess students ("assessment"). Additionally, three dimensions of cognitive processes describing the cognitive demands on teachers when dealing with such generic classroom situations were defined based on Anderson and Krathwohl (2001): to retrieve information from long-term memory in order to describe the classroom situation; to understand or analyse a concept, a specific term or a phenomenon outlined; and to generate strategies for how they would solve the problem posed (for more details, see König et al., 2011). Generic dimensions of teaching quality and cognitive demands make up a 4 x 3 matrix which serves as a heuristic for the development of the GPK paper-and-pencil test items (see Figure 7.1).

Item examples

Two item examples (see Figures 7.2 and 7.3) illustrate the GPK test and the heuristic used to conceptualise GPK (see Figure 7.1). The first item measures knowledge about "motivating" students. Future teachers have to recall basic terminology of achievement motivation ("intrinsic motivation" and "extrinsic motivation") and they are asked to analyse five statements against the background of this distinction. Statement C represents an example of "intrinsic motivation" whereas A, B, D and E are examples of "extrinsic motivation".

Figure 7.1. **Test design matrix used to measure GPK in TEDS-M**

Three Cognitive Demands / *Four Content- related Dimensions of GPK*	**Recall/Retrieve** to retrieve information from long- term memory in order to describe the classroom situation	**Understand/Analyse** to understand or analyse a concept, a specific term or a phenomenon outlined	**Generate/Create** to generate strategies for how a teacher would solve the problem posed
Structure to prepare, structure and evaluate lessons			
Classroom Management and Motivation to motivate and support students as well as manage the classroom			
Adaptivity to deal with heterogeneous learning groups in the classroom			
Assessment to assess students			

Source: König et al. (2011) "General pedagogical knowledge of future middle school teachers. On the complex ecology of teacher education in the United States, Germany, and Taiwan", *Journal of Teacher Education*, Vol. 62, pp. 188–201.

Figure 7.2. **Item example for GPK about "motivation" and "analyse"**

Which of the following cases represents an example of intrinsic motivation, and which represents an example of extrinsic motivation?

Check one box in each row.

A student learns before a test in mathematics, because he/she…		**intrinsic motivation**	**extrinsic motivation**
A.	expects a reward for a good grade.	☐	☐
B.	wants to avoid the consequences of a bad grade.	☐	☐
C.	is interested in problems of mathematics.	☐	☐
D.	does not want to disappoint his/her parents.	☐	☐
E.	wants to maintain his/her relative rank in the class.	☐	☐

Source: König et al., (2011), "General pedagogical knowledge of future middle school teachers. On the complex ecology of teacher education in the United States, Germany, and Taiwan", *Journal of Teacher Education*, Vol. 62, pp. 188–201

The second item example (see Figure 7.3) is an open-response item. Here, future teachers are asked to support another future teacher and evaluate their lesson. This is a typical challenge during a peer-led teacher education practicum, but practicing teachers are also regularly required to analyse and reflect on their own as well as their colleagues' lessons. The item measures knowledge of "structuring" lessons. The predominant cognitive process is to "generate" fruitful questions.

Figure 7.3. **Item example for GPK about "structure" and "generate"**

Imagine you are helping a future teacher to evaluate their lesson because they have never done this before.
To help them adequately analyse their lesson, what question would you ask?
Formulate ten essential questions and write them down.

Source: König et al., (2011), "General pedagogical knowledge of future middle school teachers. On the complex ecology of teacher education in the United States, Germany, and Taiwan", *Journal of Teacher Education*, Vol. 62, pp. 188–201

For the open-response items, coding rubrics were used. The coding manual developed in TEDS-M is both theoretically and data-based. The codes are intended to be low-inferent, i.e. every response was coded with the least possible amount of inferences by the raters (see for details König et al., 2011). Besides reliable *coding* schemes, *scoring* strategies for complex open-response items such as the one shown in Figure 7.4 were used. Illustrating this with the test item shown in Figure 7.4, codes were scored as appropriate if they addressed four criteria: "context" of the lesson (e.g. prior knowledge of students), "input" (e.g. objectives of the lesson), "process" (e.g. teaching methods used), and "output" of the lesson (e.g. student achievement). The extract of an original answer given by a future teacher from the United States in the TEDS-M survey (see Figure 7.4) is a good example for these four criteria (for more details, see König, 2010; 2011).

Figure 7.4. **United States' future teacher's response to item example 2 in TEDS-M**

1) *Do your students have prior knowledge about the subject?*
2) *What are your objectives?*
3) *Are the students working individually or in groups?*
…
10) *Have your students gained the knowledge from the lesson?*

Source: König et al., (2011), "General pedagogical knowledge of future middle school teachers. On the complex ecology of teacher education in the United States, Germany, and Taiwan", *Journal of Teacher Education*, Vol. 62, pp. 188–201

Findings

In TEDS-M 2008, the GPK test was applied in three countries – Germany, Chinese Taipei and the United States. The measurement instrument was validated through expert reviews and confirmatory approaches based on large-scale data from these countries (see for details König et al., 2011; König and Blömeke, 2012).

Since TEDS-M, several follow-up studies have been carried out to apply the GPK paper-and-pencil test again using various samples of pre-service and in-service teachers in Germany, but also in other countries (such as Austria). These studies report good psychometric properties of the GPK test. In accordance with assumptions of the acquisition of teacher expertise, in-service teachers outperform pre-service teachers who are at the end of their initial teacher education (König et al., 2014), and in turn, pre-service teachers at the end of their initial teacher education outperform future teachers just entering initial teacher education (König, 2013).

Another study examined whether higher GPK test scores are associated with higher quality of instruction (König and Pflanzl, 2016). Findings clearly show there is a systematic relationship between teachers' GPK and aspects concerning the quality of their instruction. The higher a teacher scores in the GPK test, the better he or she is rated by his or her students regarding the instructional quality aspects of teaching methods/teacher clarity, effective classroom management and teacher-student relationships. Correlations are positive, statistically significant and of medium effect size.

To sum up, findings provided by TEDS-M and further studies show that GPK as measured by the TEDS-M test is a relevant construct both for teaching and teacher education. The

test provides a measure of knowledge that pre-service teachers acquire during initial teacher education (König, 2013). Also, further evidence shows that this knowledge is a significant factor for instructional quality. Teachers' GPK therefore can be considered both a dependent variable when the outcome of teacher education programmes is considered and an independent variable when variation in instructional quality is to be explained.

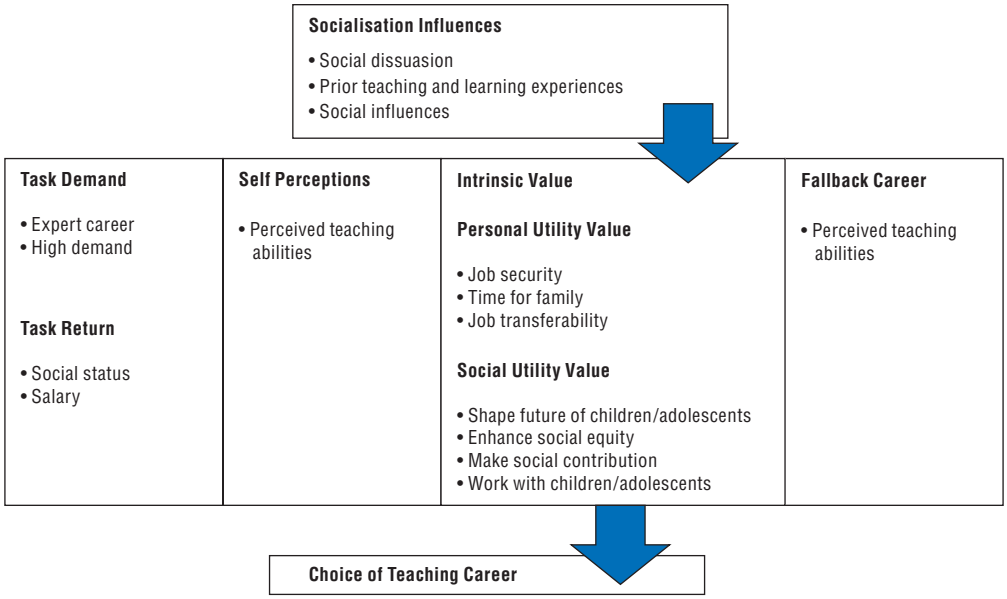
Teaching motivations

The career choice motivation of prospective teachers is considered a significant factor in the admission, progression, and graduation from a teacher education programme as well as an essential premise for motivation and enthusiasm in the teaching profession. Considering pre-service teachers' motivation is particularly relevant for at least two reasons. Firstly, teaching motivations are described as an important mandatory component of professional teachers. The modelling and empirical analysis of teacher competence therefore involves motivational components, including career choice motivation (cf. Kunter et al., 2008). Secondly, in recent years, worldwide teacher shortages have given rise to studies on motivation for choosing teaching as a career, which is particularly important when explaining why teacher education graduates do not enter the profession or drop out after a short period of time (cf., e.g. Thomson et al., 2012).

Fit-Choice: Factors influencing teaching as a career choice

Founded on expectancy-value theory and the international state of research on future teachers' motivations for choosing teaching as a career, Watt and Richardson (2007) developed and empirically examined a model with several factors that specifically influence future teachers' decisions to become a teacher (see Figure 7.5). The main components of the model are self-reports on individual ability related to teaching, individual values, professional beliefs, anticipated advantages, salary, external influences and prior experiences. This model of empirically tested factors provides the basis for its operationalisation into the Fit-Choice scale.

Figure 7.5. **Framework specified for choosing teaching as a career**



Source: Watt, H.M.G. and P.W. Richardson (2007), "Motivational factors influencing teaching as a career choice: Development and validation of the FIT-Choice scale", *Journal of Experimental Education*, Vol. 75, pp. 151.

The Fit-Choice scale supports research that aims to generate international findings concerning future teachers' motivations, using a valid and internationally validated instrument that can be linked and systematically contribute to the international discourse (see the APJTE's [Asia-Pacific Journal of Teacher Education] Special Issue in 2012, Vol. 40, No. 3).

Fit-Choice scale inventory

In the following studies, 52 items of the German translation of the FIT-Choice scale inventory documented by Watt et al. (2014) are applied in order to measure motivation for teaching, perceptions about teaching, and social dissuasion and satisfaction with choice (for a German translation see König and Rothland, 2012). Eleven motivational factors are measured by a total of 34 items that future teachers surveyed had to respond to after the introductory sentence, "I chose to become a teacher because…". Item response options ranged from 1 ("not at all important") to 7 ("extremely important"). Four factors of future teachers' - perceptions about teaching were measured by 13 items with response options from 1 ("not at all") to 7 ("extremely") after the introductory sentence, "Do you think …". The factor measuring social dissuasion was operationalised by three items, whereas the factor asking future teachers about their satisfaction with career choice was operationalised by two items with response option from 1 ("not at all") to 7 ("extremely") (for details see Richardson and Watt, 2006; Watt and Richardson, 2007; Watt and Richardson, 2012). Findings from confirmatory factor analysis and results on scale reliability provide evidence for the structure of the Fit-Choice scales (Watt et al., 2012; König and Rothland, 2012; König et al., 2013).

Figure 7.6. **Item examples of the FIT-Choice scale inventory**

FIT-Choice scale inventory	Item-Example
Motivations for teaching	
1. Perceived teaching abilities	I have the qualities of a good teacher.
2. Intrinsic value	I like teaching.
3. Fallback	I chose teaching as a last-resort career.
4. Job security	Teaching will be a secure job.
5. Time for family	Part-time teaching could allow more family time.
6. Shape future of children/adolescents	Teaching will allow me to shape child/adolescent values.
7. Enhance social equity	Teaching will allow me to benefit the socially disadvantaged.
8. Make social contribution	Teaching will allow me to provide a service to society.
9. Work with children/adolescents	I like working with children/adolescents.
10. Prior teaching and learning experiences	I have had inspirational teachers.
11. Social influences	My friends think I should become a teacher.
Perceptions about teaching	
1. Expert career	Do you think teaching requires high levels of expert knowledge?
2. High demand	Do you think teachers have a heavy workload?
3. Social status	Do you believe teachers are perceived as professionals?
4. Salary	Do you think teaching is well paid?
5. Social dissuasion	Were you encouraged to pursue careers other than teaching?
6. Satisfaction	How satisfied are you with your choice of becoming a teacher?

Source: König, J. and M. Rothland (2012), "Motivations for Choosing Teaching as a Career: Effects on General Pedagogical Knowledge during Initial Teacher Education", *Asia-Pacific Journal of Teacher Education*, Vol. 40/3, pp. 291–317.

Studies on motivations for teaching and relationship to general pedagogical knowledge

In the following, two studies will be presented that link the measurement of teachers' GPK via the TEDS-M assessment instrument with the FIT-Choice scale inventory. Whereas the first study by König and Rothland (2012) examines the possible effects that FIT-Choice motivational factors have on the acquisition of GPK of pre-service teachers during initial teacher education, the second study examines the way in which achievement motivation and goal orientations will mediate between motivations for choosing teaching as a career and GPK by König and Rothland (2013).

Study I: GPK as a motivational outcome

In the field of motivational psychology it is well known that highly intrinsically motivated students generally outperform less intrinsically motivated students, whereas extrinsic motivation is usually associated with poorer performance and educational outcomes (Baker, 2004).

Previous studies have contributed evidence that has strengthened this hypothesis (Brouwer and ten Brinke, 1995; Brühwiler, 2001; Mayr, 2009). For example, in a study conducted by Brouwer and ten Brinke (1995), intrinsically motivated pre-service teachers reported higher pedagogical competence than their less intrinsically motivated peers. This difference was even mirrored by teacher educators' ratings, who reported higher learning gains for intrinsically motivated future teachers than for predominantly extrinsically motivated future teachers.

However, to what extent future teachers' motivation for choosing teaching correlates with their pedagogical knowledge, and whether it has any influence on knowledge growth during pre-service teacher education, remains an unanswered research question. This is mainly due to research deficits regarding the standardised measurement of GPK (see for details König et al., 2011) as well as the measurement of motivations (Rothland, 2011).

While future teachers' teaching motivations are likely to be mainly related to the point of time when entering teacher education, it is highly important to examine the extent to which such motivations have an influence on central outcomes of teacher education. For example, future teachers with relatively strong intrinsic teaching motivations, such as being interested in working with children, might make use of teacher education opportunities to learn to a greater extent than their peers who are more motivated by extrinsic factors, such as teachers' salary. This might lead to differential learning developments of future teachers during initial teacher education, and result in differences in teacher education outcomes such as professional knowledge.

Thus the aim of this study was to investigate possible effects that FIT-Choice motivational factors would have on the acquisition of GPK of pre-service teachers during initial teacher education. The sample consists of student teachers from the University of Erfurt, Germany. Their GPK was measured on two occasions during the academic year 2009/2010 (with an interval of about nine months between t1 and t2). Achievement estimates at the first occasion of measurement were linearly transformed to a mean of 100 and a standard deviation of 20, and achievement estimates at the second occasion of measurement were transformed using the same formula, so that estimates could be directly compared. Looking at the descriptive statistics, a large learning gain could be observed. The first measurement (t1) recorded a mean value for future teachers to be 100.0 (SD = 20.0), while on the second occasion of measurement

(t2) the mean was nearly one standard deviation higher (*M* = 117.8, *SD* = 18.8) indicating a large learning gain within that academic year.

Table 7.1. **Bivariate Correlations between FIT-Choice Scales and GPK**

	n = 130		
	t1	t2	Difference (t2 – t1)
Motivations for teaching			
1. Perceived teaching abilities	.15	.17*	.02
2. Intrinsic value	.11	.19*	.07
3. Fallback	-.17*	-.12	.11
4. Job security	-.21*	-.04	.18*
5. Time for family	-.03	-.06	-.02
6. Shape future of children/adolescents	-.05	.08	.13
7. Enhance social equity	-.16	-.02	.14
8. Make social contribution	-.05	.11	.15
9. Work with children/adolescents	.28*	.23*	-.07
10. Prior teaching and learning experiences	-.16	-.09	.07
11. Social influences	-.11	.05	.15
Perceptions about teaching			
1. Expert career	-.03	.08	.11
2. High demand	-.06	.07	.13
3. Social status	-.05	.07	.12
4. Salary	-.20*	-.12	.08
5. Social dissuasion	-.02	.04	.05
6. Satisfaction	-.06	.03	.08

* $p < .05$

Source: König, J. and M. Rothland (2012), "Motivations for Choosing Teaching as a Career: Effects on General Pedagogical Knowledge during Initial Teacher Education", *Asia-Pacific Journal of Teacher Education*, Vol. 40/3, pp. 291–317.

Looking at the bivariate correlations between the FIT-Choice scale and GPK, we generally saw that motivations and knowledge were not very closely connected (see Table 7.1). The clearest correlations were between the highest motivation "work with children" and knowledge, on both occasions of measurement. Especially with *r* = .28 at t1, we considered it substantial. Interestingly, the subscales "perceived teaching ability" and "intrinsic value" seemed to be increasingly correlated with knowledge, since both were significantly correlated at t2 but not at t1. Moreover, the two extrinsic motivations "job security" and "salary", as well as the motivation of selecting a teaching career as "fallback", were negatively correlated with knowledge at t1: Future teachers who were extrinsically motivated and regarded teaching as a fallback career, were outperformed by their fellow future teachers who were less extrinsically motivated and agreed less with the fallback subscale. However, it was most interesting to observe that the job security motivation showed a significant effect on the learning gain between the two occasions of measurement, whereas the other scales did not.

Study II: a mediation model to describe GPK as a motivational outcome

To better understand the connection between knowledge and motivation, the effects of the FIT-Choice motivational factors on GPK were investigated in Study II using a *mediation model* in which achievement motivation and goal orientations mediate between motivations for choosing teaching as a career and GPK.

We started this study with the conception that the acquisition of professional knowledge in initial teacher education is influenced by numerous factors (Reynolds and Walberg, 1993) and that learning and achievement motivation are central factors that predict attainment

(Schiefele and Urhahne, 2000). When the relationship between motivation and knowledge was questioned, our rationale behind this was to distinguish between direct and indirect motivational effects. Direct effects are exemplified by learning behaviour such as time on task. Indirect effects are mediated by educational decisions such as selecting an educational programme or course (Schiefele, 2009). So motivations for choosing teaching as a career can be considered as having indirect motivational effects on attainment during initial teacher education. For example pre-service teachers acquire teacher professional knowledge during training because that knowledge acquisition is linked with immediate and long-term consequences. Not acquiring the knowledge that is required by a teacher education programme means a pre-service teacher will not pass their exam and thus will not become a teacher. But this leads us to question whether there are other motivational factors that have direct effects on teachers' professional knowledge.

Following classic achievement motivation theory, activity in achievement settings may be oriented towards the attainment of success or the avoidance of failure. The *hope for success* is related to a person's striving for successful performance through ambitious goals and the willingness to reach such goals through effort and persistence, whereas, by contrast, *fear of failure* is related to a person's feeling of shame towards his or her failure thus also leading to his or her avoidance of performance situations (Brunstein and Heckhausen, 2006). In Figure 7.7, item examples of the Achievement Motive Scale (AMS) are provided to illustrate aspects of the two motives. The AMS is an instrument measuring the hope for success and the fear of failure that is also used in our study and thus in the following analysis.

Figure 7.7. **Item examples of the Achievement Motive Scale (AMS) measuring the two motives "hope for success" and "fear of failure"**

Hope for success	Fear of failure
Situations that allow me to test my abilities appeal to me.	If I do not understand a problem immediately I start feeling anxious.
I like situations in which I can find out how capable I am.	Even if nobody is watching, I feel quite anxious in new situations.

In addition, researchers have identified goal orientations related to learning, effort, and improvement such as *learning goals* (Dweck and Legett, 1988; 256), describing the learner's goal "to increase (…)[his or her] competence" when doing an academic task. And they have identified goal orientations related to performance goals (Andermann et al., 2002). According to Elliot and Harackiewicz (1996), performance goals can be differentiated into *performance-approach goals* and *performance-avoidance goals*. "Approach-type performance goals involve the goal of demonstrating one's competence relative to others; individuals with these goals are interested in demonstrating their ability relative to others. In contrast, avoidance-type performance goals involve the goal of avoiding looking incompetent at a task" (Andermann et al., 2002: 200). Although there are more differentiations of terms used to describe goal orientations (see Andermann et al., 2002, for further details), learning goals, performance-approach goals, and performance-avoidance goals make up a trichotomous framework (Elliot and Church, 1997; Spinath, 2009). They are frequently used, and therefore applied in our study. Again, to illustrate aspects of the three goals, item examples are provided in Figure 7.8 of SELLMO-ST[1], a German measurement instrument we use in our study to analyse future teachers' goal orientations.

Figure 7.8. **Item examples of the SELLMO-ST measuring the three goal orientations**

Learning goals	Performance-approach goals	Performance-avoidance goals
When studying, I find it important…	*When studying, I find it important…*	*When studying, I find it important…*
to learn something interesting.	to get better grades than others.	that other students do not think I am dull.
to acquire a deep understanding for the content.	that others think I am smart.	no one realises if I do not understand something.

Elliot and colleagues have developed a framework that integrates classic achievement motivation with the goal orientation concept (Elliot, 1997; Elliot and Church, 1997). In their hierarchical motivation model, goal orientations are described as concrete representations of classic achievement motivation (Elliot and Church, 1997) and are regarded as cognitive manifestations of achievement motivation (cf. Robbins et al., 2004). Thus the motives "hope for success" and "fear of failure" represent higher order motivational constructs, whereas achievement goals represent midlevel motivational surrogates. One might assume that learning goal orientation should be predicted by the achievement "hope for success" motive and performance avoidances by the "fear of failure" motive (Spinath, 2009). Hope for success and fear of failure can be regarded as distal influential factors that generally influence relevant goals and, moreover, indirectly impact achievement-relevant outcomes (Brunstein and Heckhausen, 2010). However, it remains an open question how achievement motivation, goal orientation and academic attainment can be related to other motivational constructs such as teaching motivation.

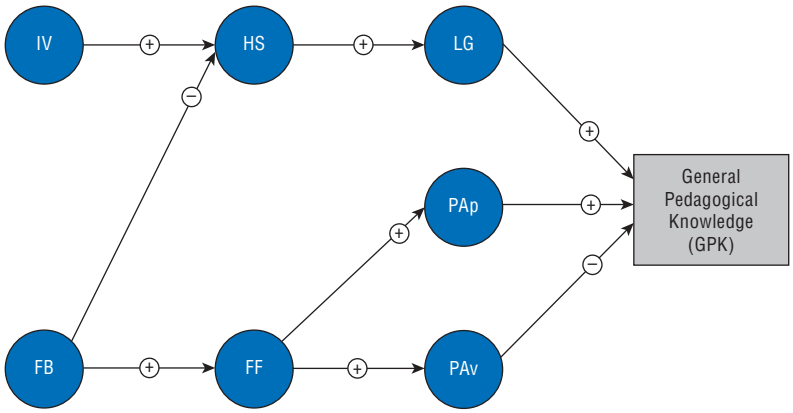
Following these concepts, we assumed in our research model that at least a selection of pre-service teachers' motivations for choosing teaching as a career have an influence on achievement motivation and goal orientation, which in turn predict professional knowledge and its acquisition during initial teacher education. As a selection, we chose two teaching motivation scales that seemed to be relevant: intrinsic value and choosing teaching as fallback career.

Figure 7.9 shows a corresponding research model, with which we hypothesised positive (+) and negative effects (–). We assumed that pre-service teachers who choose teaching mainly as a fallback career and report little intrinsic value will have lower GPK (Hypothesis 1), whereby we also assumed these teaching motivations would not have a direct effect on pre-service teachers' attainment. They are regarded as distal motivational factors that in turn influence motivational factors that are proximal to learning outcomes such as professional knowledge that is trained and acquired during teacher education.

Following the hierarchical model by Elliot and Church (1997), achievement motivation and goal orientations will mediate between motivations for choosing teaching as a career and GPK. We assume that the learning goal orientation has a particularly positive, direct effect on GPK (cf. Fasching et al., 2010), while it can be predicted directly by the hope for success motive, as well as indirectly by the intrinsic value teaching motivation (Hypothesis 2). Similarly, we assumed that choosing teaching as a fallback career would have a negative effect on a future teacher's motivation to succeed, therefore we marked this with a negative path related to the hope for success and a positive path related to the fear of failure achievement motivation. However, since there might also be future teachers

who, although having chosen teaching as a fallback career, may be motivated to succeed, we assume only slight negative effects on the achievement motivation of hope for success. Since research studies show learning goal orientation is not influenced by fear of failure and in turn performance avoidance is not influenced by hope for success (see Elliot and Church, 1997; Spinath et al. 2002), these correlations seemed obsolete to mark in the model.

Figure 7.9. **Hypothesised effects between teaching motivation, achievement motivation, goal orientation, and teacher knowledge**



Abbreviations:
teaching motivations: intrinsic value (IV), fallback (FB);
achievement motivation: hope for success (HS), fear of failure (FF);
goal orientation: learning goal (LG), performance approach (PAp), performance avoidance (PAv).

In this study we used a much larger sample of 6 601 pre-service teachers who started teacher education in winter term 2011, from 31 universities/teacher training colleges in the German-speaking countries (Austria, Germany, Switzerland). They represent a population of nearly 50,000 pre-service teachers at the beginning of their teacher education (see for details König et al., 2013).[2] As outlined before, in addition to the FIT-Choice scale (Watt and Richardson, 2007) and the TEDS-M GPK test, we measured general achievement motivation with the AMS (Gjesme and Nygard, 1970, see item examples in Figure 7.7) and goal orientation related to university studies by the SELLMO-ST (Spinath et al., 2002, see item examples in Figure 7.8). We expected similar findings for samples from the three German-speaking countries due to similar cultural and linguistic backgrounds.

As the findings from a correlational analysis with a good model fit (χ^2/df = 2.22, CFI = .923, RMSEA = .024, SRMR = .039) show, at the start of teacher education, motivations for choosing teaching as a career and GPK were only loosely inter-correlated (see Table 7.2). However, the directions of correlations were as expected by Hypothesis 1: Future teachers' motivation to choose teaching as a fallback career is negatively correlated, whereas intrinsic value and perceived teaching abilities is positively correlated with their GPK. This correlation pattern is clearly visible in the Austrian and the German sample, but comparatively vague in the Swiss sample. Moreover, in Austria and Germany, inter-correlations are statistically significant ($p < .05$), however they are relatively low ($\leq .15$).

Findings from path analysis show that assumptions outlined by Hypothesis 2 were generally supported. As can be seen in Figure 7.10, for the Austrian and the German sample, the learning goal orientation functions as a mediator between the achievement hope for success motive (which is predicted by intrinsic value teaching motivation) and pre-service

teachers' GPK. For the Swiss sample, performance-approach and performance-avoidance orientations function as a mediator between the achievement motive fear of failure (which is predicted by the motivation to choose teaching as a fallback). A possible explanation could be that in Switzerland, different cultural connotations are associated with the teaching profession with the consequence that those who decide to enter a teacher education program already have specific goal orientations that differ from those pre-service teachers have in Austria or Germany. To conclude, for each of the three countries, goal orientations have a mediating function. By contrast, path coefficients measuring direct effects of teaching motivation on GPK are not statistically significant (see additional dotted lines in Figure 7.11).

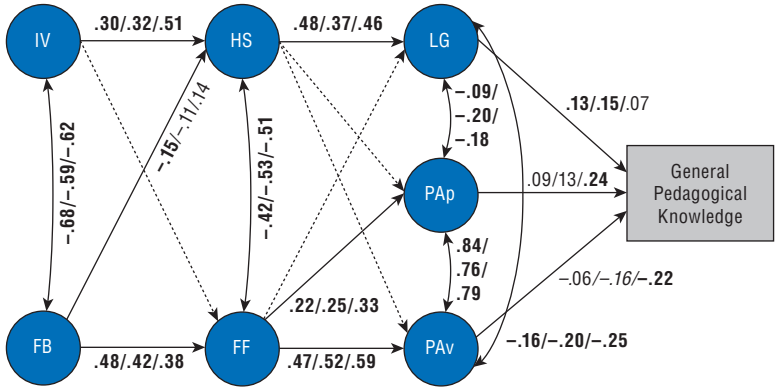
Table 7.2. Intercorrelations between motivational variables and general pedagogical knowledge

	General Pedagogical Knowledge (GPK)		
	Germany	Austria	Switzerland
Teaching motivations (FIT-Choice)			
1. Perceived teaching abilities	**.07****	**.14****	-.04
2. Intrinsic value	**.06***	**.15****	-.08
3. Fallback	**-.08***	**-.14***	.03
4. Job security	-.01	-.06	.04
5. Time for family	.00	-.03	.04
6. Shape future	.05#	-.01	.01
7. Enhance social equity	-.02	.02	-.06
8. Make social contribution	.03	.02	-.06
9. Work with children/adolescents	**.05***	.05	-.01
10. Prior teaching and learning experiences	.01	-.05	-.02
11. Social influences	.04	-.06	-.08
Achievement Motive Scale (AMS)			
13. Hope of success	.05	.12*	-.01
14. Fear of failure	-.01	-.10*	-.08
Goal Orientation (SELLMO-ST)			
15. Learning goals	**.13*****	**.15****	.10#
16. Performance-approach goals	.04	-.03	.05
17. Performance-avoidance goals	-.02	**-.10***	-.05

*** $p < .001$, ** $p < .01$, * $p < .05$, # $p < .1$.

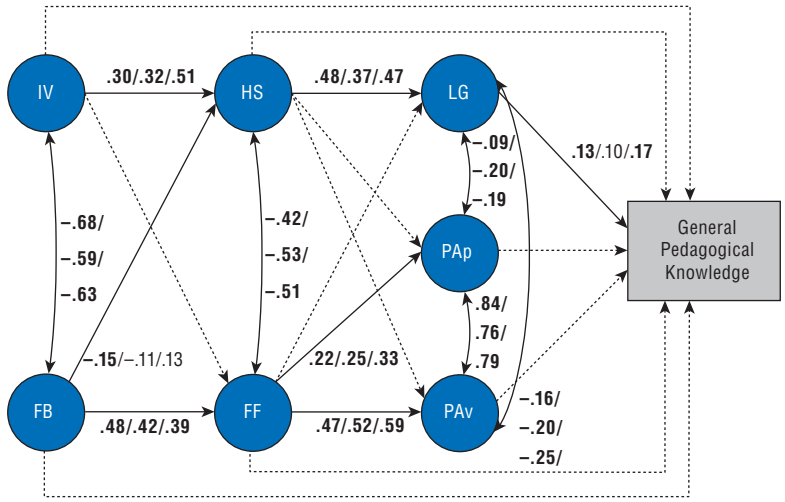
Figure 7.10. **Teaching motivation effects on GPK, mediated by achievement motivation and goal orientation**

without direct path coefficients



Note: Results from path analysis (χ^2/df = 2.53, CFI = .915, RMSEA = .026, SRMR = .046) for Austria/Germany/Switzerland; bold coefficients: * p ≤ .05; italic coefficients: p ≤ .10; dotted line: all coefficients are p > .10; Abbreviations: IV – Intrinsic Value, FB – Fallback; HS – hope of success; FF – fear of failure; LG – learning goals; PAp – performance-approach goals; PAv – performance-avoidance goals.

Figure 7.11. **Teaching motivation effects on GPK, mediated by achievement motivation and goal orientation (with direct path coefficients)**



Note: Results from path analysis (χ^2/df = 2.54, CFI = .915, RMSEA = .026, SRMR = .046) for Austria/Germany/Switzerland; bold coefficients: * p ≤ .05; italic coefficients: p ≤ .10; dotted line: all coefficients are p > .10; Abbreviations: IV – Intrinsic Value, FB – Fallback; HS – hope of success; FF – fear of failure; LG – learning goals; PAp – performance-approach goals; PAv – performance-avoidance goals.

Discussion

Findings on GPK as measured via the TEDS-M instrument contribute to the theoretical and empirical research base in the area of teacher knowledge. As a core variable of teaching and teacher education, findings show GPK is relevant for providing high quality opportunities to learn for students (König and Pflanzl, submitted).

Moreover, findings have policy implications for initial teacher education and professional development. As teaching motivations influence student teachers' knowledge acquisition during initial teacher education, obviously there are ways to address future teachers' development.

Findings from the study presented here contribute to the discourse insofar as in Germany (Rothland, 2011) and also internationally (Farkas, Johnson and Foleno, 2000; Wadsworth, 2001) the impression that only those who choose teaching as a career because of intrinsic or altruistic motivations may become a "good teacher", whereas pragmatic motivations are less appreciated. Compared with other professions where job security, a comfortable salary, or arranging time for family are ordinary needs that are widely accepted in society, future teachers' possible motivations are often evaluated differently. The findings from the first study presented here lead to the conclusion that future teachers in Germany also make use of these extrinsic motivations. Therefore, one may recommend that the current highly normative debate should be extended by pragmatic views on motivations that future teachers actually have.

With the comparative research of the second study, international research with the FIT-Choice scale was extended to the context of German-speaking countries. The study gives insight into the predictive validity of the FIT-Choice scale when related to other motivational constructs as well as GPK, and – for the first time – supports the hierarchical motivational model developed by Elliot (1997) among samples of future teachers. Especially with regards to study II, our continuing longitudinal work will enable examining *growth* in GPK as a motivational outcome, which should be more heavily influenced by motivation factors, than GPK at entry to teacher education.

Currently we have collected an additional set of data on a second occasion allowing us to continue our work. First findings show there is a large learning gain of future teachers' GPK in the course of their first two years of initial teacher education not only in Germany, but also in Austria (König and Klemenz, 2015). In addition to TEDS-M findings on GPK from an international-comparative perspective built on samples of pre-service teachers from Germany, Chinese Taipei, and the United States, and (König et al., 2011), findings from our longitudinal analyses allow important insights into the effectiveness of initial teacher education in Austria, Germany and Switzerland. How such knowledge growth depends on teaching motivations is still an issue to be examined. Empirical findings will be available in the near future (see König and Rothland, forthcoming).

Recommendations for future research

Teacher competence is a multidimensional construct. If teacher knowledge is examined, teaching motivations, but also other psychological constructs such as teacher beliefs (compare König, 2012) should be taken into account. Also, little is known about the actual effects of teaching motivations or the interplay of knowledge and motivation for providing high opportunities to learn to students and student achievement. Compared with the broad normative discourse about the "good" teacher, what a teacher should know, be able to do and be motivated for, it seems that future research should seriously account for an examination of the relationship between motivation and teaching.

Implication of policy

Motivations for teaching result in participation in a teacher education programme, therefore they can be regarded as a "first step in becoming a teacher" (Sinclair, 2008: 81), and they are most important at the start of teacher training. Teaching motivations are essential when looking at those who choose teaching as a career (Rothland, 2011). Career choice motivation of prospective teachers is supposed to be a significant factor not only in the admission to, but also in the progression through a teacher education programmes (König and Rothland, 2012). As future teachers proceed through these teacher education programme, their teaching motivations may change. While pursuing their career paths, future teachers may subsequently be distanced from some of their previous motivations (König et al., 2016) and possibly other motivations may come into the foreground.

The closer future teachers get to professional life, the more important ordinary working conditions such as salary, time for family and job security might be for them, especially as they age during their years spent in teacher education programmes, and thus start to incorporate other developmental tasks such as raising a family. Here it remains an open though very important research question as to whether extrinsic motivations might slightly replace previous intrinsic ones. As a consequence, currently it is very difficult to decide which teaching motivations or specific constellation of teaching motivations should be possessed by a beginning pre-service teacher. For example, research studies such as our study I, in which extrinsic motivations fostered GPK growth, do not come to the clear conclusion that intrinsic teaching motivations of beginning pre-service teachers are always better for their professional development than extrinsic motivations (see also Wilhelm, Dewhurst-Savellis and Parker, 2000). In the case of our study I, extrinsic motivation of having a secure job and therefore motivating people to become a teacher can be considered a superior goal of future teachers. Pursuing this goal during initial teacher education leads them to acquire professional knowledge.

Although initial teacher education perhaps mainly intends to foster academic achievement such as pedagogical knowledge (König, 2013), it also intends that those who have already decided to enter initial teacher education do not give up their motivation for the teaching profession. This is, at least, true when looking at teaching motivations that contribute to the general idea of a "good" teacher: Hardly anyone favors a teacher who is not very motivated to work with children or adolescents, who does not like teaching in general, or teaching his/her subjects. These intrinsic teaching motivations and altruistic or social motivations are believed to be important both to enter and graduate from initial teacher education (Brookhart and Freeman, 1992), and there is empirical evidence that they can be important for the professional development of teachers. But it is still an open question as to how to foster "good" teaching motivations during initial teacher education and how to keep teacher candidates who have the potential to become highly qualified teachers.

In Germany, there is evidence from student teacher surveys that student teachers often criticise initial teacher education for the missing link between theory and practice (Hascher, 2011). In TEDS-M, there was no country such as Germany in which future teachers reported extremely little coherence of their initial teacher education (Hsieh et al., 2011), and it is unclear whether these finding are associated with the right levers to increase the quality of initial teacher education in order to attract young people to the teaching profession. Again, future research should work on such issues. Our research on these questions (see König et al., 2016) shows that in-school opportunities to learn are an important element during initial teacher education that may lead to changes of teaching motivations.

Deciding what the teaching motivations of beginning future teachers should be is also difficult, since these motivations may only partly (or even not at all) influence academic achievement during initial teacher education, whereas other motivations such as achievement motives and goal orientations come to the forefront as findings from our study II show. Therefore, when discussing the vocation-related motivation of teachers, their achievement motivations related to academic expectations in teacher education should also be taken into account. This is especially important when the acquisition of teacher knowledge is focused on and related to specific motivations that lead to the successful acquisition of professional knowledge in the academic setting, such as in university or teacher training college. Findings from our study II have clearly shown that, as hypothesised, learning and achievement motivation are proximal measures for GPK, whereas teaching motivations are a more general construct to predict future teachers' GPK (see, for longitudinal analyses, also König and Rothland, forthcoming).

Regarding pedagogical knowledge as assessed in our studies, one may say that pre-service teachers might have attained GPK even before entering teacher education, for example, following Lortie's notion of the "apprenticeship of observation" (Lortie, 1975: 61) as a result of their socialisation as a student in school they attended for many years. As early as the beginning of initial teacher education in the German-speaking countries (Austria, Germany and Switzerland), we see substantial variation of pedagogical knowledge among those who have decided to become a teacher, which means that some of the beginning pre-service teachers perform well in the GPK test, whereas others do not.

From further analysis we know that such knowledge is associated with pedagogical experience gained before entering initial teacher education, e.g. by giving private lessons, working with children, or even working at school as a teaching assistant (König, Tachtsoglou and Seifert, 2012; König et al., 2013). Then, for example, it is interesting to see that there is a substantial group of beginning teachers who report (and think) they have good teaching abilities, but who have never worked with children (i.e. have never given a private lesson,

never babysat etc.). Again, it is difficult to judge which learning experiences beginning teachers should have when entering initial teacher education. However, such cognitive heterogeneity at the start of initial teacher education implies – similarly to the setting at schools – that initial teacher education and possibly professional development of teachers should account for the diversity pre-service and in-service teachers bring with them into the institutional setting of teacher training (König and Herzmann, 2011).

Finally, in a time of globalisation, when the discourse on teacher education and the definition of what pre-service teachers have to know and be able to do are no longer limited to institutional, regional or national boundaries (OECD, 2005, 2009; Schleicher, 2011; Townsend and Bates, 2007), it seems to be essential to clarify such problems from a comparative perspective. As with TEDS-M or the study II presented here, one can recognise the added value of such comparisons. Future research on teaching and teacher education should master such challenges in order to bring about new insights into the relationship between motivation and knowledge of teachers.

Notes

1. SELLMO-ST is an Abbreviation for „**S**kalen zur **E**rfassung der **L**ern- und **L**eistungs**MO**tivation“ which has been translated with „Learning and Achievement Motivation Scales”. The ST only stands for one type of scale. More precisely it indicates the time allocation for the test: ST = 8 minutes and 33 item numbers versus S = 8 minutes and 31 item numbers.
2. The data derives from the project “Development of Teaching Motivations and the Acquisition of Pedagogical Knowledge during Initial Teacher Education” (*Entwicklung von berufsspezifischer Motivation und pädagogischem Wissen in der Lehrerausbildung*, EMW), which is a longitudinal and comparative study in the German-speaking countries led by Prof. Dr. Johannes König (University of Cologne, Germany) and Prof. Dr. Martin Rothland (University Siegen, Germany) and funded by *Rhein-Energie* Foundation (W-13-2-003 and W-15-2-003).

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Chapter 8

Teacher motivation, responsibility, pedagogical knowledge and professionalism: a new era for research

by
Fani Lauermann
University of Bonn, Germany

The key objective of this chapter is to provide an overview of current research on teacher motivation and its relevance to the instructional process and to teachers' professional competence. The chapter begins with a brief review of different approaches to the conceptualisation of teachers' professional competence, with a special focus on high-leverage teaching practices and dimensions of teaching quality. Next, the chapter focuses on teacher motivation as an element of teachers' professional competence and describes different theory-driven conceptualisations of teacher motivation, including perspectives grounded in socio-cognitive theory, expectancy-value theory, self-determination theory, achievement goal theory and research on teacher responsibility. The chapter concludes with a discussion of open questions, methodological and theoretical challenges for teacher motivation research, as well as directions for future research.

Introduction

With the exception of research on teachers' perceived teaching ability and job satisfaction, systematic theory-driven research on teacher motivation represents a relatively new and, until recently, an "overlooked" phenomenon (Watt and Richardson, 2008a; Woolfolk Hoy, 2008). The landscape of educational research on this topic has changed dramatically over the past years, however, as researchers have adapted established theoretical frameworks of motivational processes for the teaching profession. Examples include systematic analyses of teachers' expectancies and values related to teaching (Abrami, Poulsen and Chambers, 2004; Reeve et al., 2014; Watt and Richardson, 2008a, 2008b), achievement goals (Butler, 2007, 2012), basic psychological needs and self-determination (Eyal and Roth, 2011; Roth et al. 2007), enthusiasm for teaching and for their subject area (Frenzel et al., 2009; Kunter et al., 2011, 2008), and teachers' sense of professional responsibility (Lauermann and Karabenick, 2011, 2013, 2014).

Accumulating evidence suggests that teachers' motivations have critical implications for the teaching profession, including those for teachers' professional commitment, psychological well-being and instructional practices (for a review, see Richardson, Karabenick and Watt, 2014). Furthermore, various operationalisations of teacher motivation have emerged as key elements of teachers' professional competence.

Accordingly, the purpose of this chapter is threefold. First, we focus on the concepts of pedagogical knowledge and professionalism, and provide a working definition to guide the analysis and discussion of available evidence on teacher knowledge and motivation. We will illustrate that pedagogical knowledge is necessarily multifaceted. Included is knowledge about educational processes, goals and evidence-based practices, and which instructional practices are adaptive or maladaptive with respect to students' learning, motivation and socio-emotional needs, but also motivational and self-regulatory characteristics of teachers (Blömeke and Delaney, 2012; Kunter et al., 2013).

Second, we review current work on teacher motivation, elaborate on evidence regarding how these conceptualisations of teacher motivation are related to different aspects of the instructional process, and discuss implications for teachers' pedagogical knowledge and professionalism. Specifically, we focus on major theoretical frameworks that have provided the foundation for recent research on teacher motivation: socio-cognitive theory, expectancy-value theory, self-determination theory and achievement goal theory.

Finally, drawing from multiple theoretical perspectives, we present current work on teachers' sense of professional responsibility (Lauermann, 2014a; Lauermann and Karabenick, 2011; 2013; 2014). Teacher responsibility has a dual status as both a motivational antecedent of teachers' behaviours (e.g. teachers engage in various behaviours out of a sense of responsibility) and a key element of teachers' knowledge about their professional roles (e.g. what responsibilities teachers believe are included in a particular instructional context). Convincing, although still scarce evidence indicates that teachers do differ in how they conceptualise their professional responsibilities, which has implications for their instructional practices and professional well-being.

The chapter concludes with a discussion of directions for future research, including (a) methodological challenges such as the use of observational data versus self-report measures and the use of multiple data sources such as linking student-teacher data over time and (b) theoretical challenges, including the limited applicability of available motivational theories to the teaching profession and the need for modifications.

The multifaceted nature of teachers' professional competence

What types of competencies do teachers need in order to produce desirable outcomes in the classroom? What qualifies as "sufficient" evidence that a teacher possesses such competencies? Which competencies are essential for what types of outcomes? These fundamental questions of teaching effectiveness have posed a challenge for educational researchers, even though a substantial knowledge base is available about more or less adaptive instructional practices and approaches to teaching, as well as about their consequences for teachers and students. In the following sections, we review examples of systematic lists of evidence-based instructional approaches and practices. Then, we turn to proposed types of knowledge about teaching and teaching competencies. Finally, we discuss the links between knowledge about the instructional process and affective-motivational competencies of teachers, and why both types of competencies are essential for teachers' professional success.

High-leverage teaching practices and dimensions of teaching quality

A substantial knowledge base about effective instructional practices and approaches to teaching has been developed over the past decades (e.g. Brophy, 1999; Hattie, 2009; Rosenshine, 2010; Seidel and Shavelson, 2007). As one example, Box 8.1 lists twelve principles of effective teaching identified by Brophy (1999). Such lists of research-based teaching principles and practices typically focus on *relational and motivational aspects* of the instructional process such as developing positive relationships with students, establishing a collaborative learning environment and a well-managed classroom, setting high expectations for students, fostering students' mastery orientation (emphasis on effort, personal improvement and task mastery), and students' sense of autonomy; as well as aspects of the *delivery of instruction and monitoring of learning outcomes* such as reviews of previous learning and continuous monitoring, and assessment of *all* students' learning and understanding (Boekaerts, 2002; Brophy, 1999; Brophy and Good, 1986; Rosenshine, 2010).

Current educational debates, however, are focusing not only on the question of "what works", but also on the question of "what works best" (Hattie, 2009; Seidel and Shavelson, 2007), and which practices form the core of the teaching profession by being generalisable across educational contexts and situations, but also specific enough to be named, identified, taught and assessed (Ball, 2012; Ball and Forzani, 2009). The process of identifying such core practices is often hampered by lack of precise shared technical language and by the contextual specificity of particular practices (Ball and Forzani, 2011). Nonetheless, a set of "high-leverage" practices have been proposed to guide teacher training efforts and to serve as common professional standards for the practice of teaching (see Box 8.2). Practices are considered to have high leverage when their skillful implementation maximises the effects of teaching on student learning. Whether, how and to what extent the decomposition of the teaching profession into a set of specific practices (as opposed to philosophies and general approaches to teaching) will lead to improved teacher training and professionalism remains an open question, although ongoing efforts to train and assess these core teaching practices are promising (e.g. TeachingWorks).

In addition to fine-grained analyses of educational practices, researchers have also proposed a set of overarching dimensions of teaching quality. Notably, three dimensions of teaching quality have emerged across a set of large scale national and international assessments: classroom organisation (e.g. structure, discipline, classroom management), supportive climate (e.g. social and learning support to students and positive classroom climate), and the provision of cognitively activating, thought-provoking instruction (Klieme, 2012; Vieluf et al., 2012). These dimensions of instructional quality, as well as aspects of these dimensions have been linked to desirable outcomes such as student achievement and motivation (Baumert et al., 2010; Fauth et al., 2014; Klusmann et al., 2008; Kunter and Baumert, 2006; Kunter et al., 2011, 2013), and teachers' self-reported practices. For instance, for teachers who participated in the Teaching and Learning International Survey (TALIS) conducted by the Organisation for Economic Development and Co-operation (OECD) (2014), a positive disciplinary climate in the classroom was related to the self-reported use of small group and project-oriented work, as well as to the use of technology for instructional purposes.

Box 8.1. **Principles of effective teaching**

1. **A supportive classroom climate:** Development of cohesive and caring learning communities, which includes supportive and caring teacher-student and student-student interactions.
2. **Opportunity to learn:** Allocation of most of the available instructional time to curriculum-related activities.
3. **Curricular alignment:** Alignment of curricular components, so that student learning is focused on interconnected ideas and instructional goals, rather than on disconnected content.
4. **Establishing learning orientations:** Provision of structure and clarification of intended outcomes of the learning process and of desired learning strategies.
5. **Coherent content:** Facilitation of meaningful learning through clear and coherent explanations of new content.
6. **Thoughtful discourse:** Stimulation of student discourse around powerful ideas.
7. **Practice and application activities:** Provision of opportunities for practice and application of new knowledge and skills, and provision of improvement-oriented feedback.
8. **Scaffolding students' task engagement:** Provision of assistance that supports students' cognitive, affective, and behavioural engagement in the learning process.
9. **Strategy teaching:** Modelling and instruction of learning and self-regulation strategies that enable students to monitor, regulate, and reflect upon their learning.
10. **Co-operative learning:** Provision of opportunities for students to work in pairs or small groups.
11. **Goal-oriented assessment:** Use of a variety of formal and informal assessment methods to monitor progress towards learning goals.
12. **Achievement expectations:** Establishment and communication of appropriate expectations for learning outcomes.

Source: Brophy, J. E. (1999), *Teaching*, International Academy of Education, Brussels, Belgium.

General dimensions of instructional quality have been assessed from the perspective of students (Klieme, 2012), but comparative analyses of students' and teachers' perspectives have also been conducted, with somewhat mixed results. One study, for instance, indicated that teachers' and students' perceptions of the occurrence of classroom management problems (problems with discipline and interruptions) are generally consistent with each other; teachers' and students' views of cognitively activating instruction and social support by the

teacher overlap, but are less consistent; and their perceptions of the instructional tempo – an aspect of teachers' provision of learning support – can be discordant (Kunter and Baumert, 2006). Bivariate correlational patterns revealed that classroom management rated from the perspective of students was related to student achievement in mathematics, whereas teachers' and students' perceptions of classroom management and cognitively stimulating instruction were related to students' satisfaction with their math teacher (Kunter and Baumert, 2006).

Box 8.2. **High-leverage practices of teaching, TeachingWorks, University of Michigan**

1. Making content explicit through explanation, modelling, representations and examples.
2. Leading a whole-class discussion.
3. Eliciting and interpreting individual students' thinking.
4. Establishing norms and routines for classroom discourse central to the subject-matter domain.
5. Recognising particular common patterns of student thinking in a subject-matter domain.
6. Identifying and implementing an instructional response to common patterns of student thinking.
7. Teaching a lesson or segment of instruction.
8. Implementing organisational routines, procedures and strategies to support a learning environment.
9. Setting up and managing small group work.
10. Engaging in strategic relationship-building conversations with students.
11. Setting long- and short-term learning goals for students referenced to external benchmarks.
12. Appraising, choosing and modifying tasks and texts for a specific learning goal.
13. Designing a sequence of lessons toward a specific learning goal.
14. Selecting and using particular methods to check understanding and monitor student learning.
15. Composing, selecting, interpreting and using information from methods of summative assessment.
16. Providing oral and written feedback to students on their work.
17. Communicating about a student with a parent or guardian.
18. Analysing instruction for the purpose of improving it.
19. Communicating with other professionals.

Source: TeachingWorks, University of Michigan, www.teachingworks.org/work-of-teaching/high-leverage-practices.

Subsequent longitudinal analyses of these data by Kunter and colleagues (2013) have identified the dimensions of classroom management (operationalised as a composite of teacher and student perceptions) and cognitive activation (operationalised as expert ratings of the cognitively activating features of quizzes and exams used by the teacher) as positive predictors of students' learning gains in mathematics between grades 9 and 10. Furthermore, Kunter and colleagues' (2013) research identified teacher- and student-reported classroom management and student-reported learning support as positive predictors of students' intrinsic interest in mathematics. This study is an example of the selective use of teachers' and students' ratings for analyses of different aspects of the instructional process.

This line of research is important for the present chapter for the following reasons. First, it implies that some teaching qualities may be more easily observable than others (e.g. classroom management problems versus learning support; Praetorius, Lenske and Helmke, 2012). Second, it suggests that teachers' and students' ratings complement each other rather than being redundant. Third, students' perceptions of their teacher's practices can be an indispensable source of information when attempting to link instructional quality to students' academic outcomes such as achievement.

Examples of core teaching practices and general dimensions of instructional quality reviewed thus far have a clear focus on students' academic, socio-emotional and developmental needs. However, factors that motivate teachers to engage in such practices and that enable them to successfully implement these practices in specific situations, also constitute key elements of teachers' professional competencies. Indeed, recent evidence suggests that motivational characteristics of teachers can have positive effects on student learning and motivation, beyond the effects of teachers' knowledge about effective instruction (Kunter et al., 2013). This topic is addressed in the following section, with special attention to the relevance of motivational factors for teachers' competence and professional success.

Types of professional competencies and the role of teacher motivation

The definition of professional competence guiding this discussion is competence in terms of "skills, knowledge, attitudes, and motivational variables that form the basis for mastery of specific situations" (Kunter et al., 2013: 807). Since the successful mastery of instructional situations requires not only knowledge about instructional practices and learning processes, but is also influenced by teachers' affective, motivational and self-regulatory characteristics, such characteristics constitute a core element of teachers' professional competence.

For instance, in a recent study of German math teachers whose classes had participated in the Programme for International Student Assessment (PISA) in 2003 (OECD, 2004), Kunter and colleagues (2013) demonstrated that motivational characteristics such as teachers' enthusiasm for teaching predicted not only student- and teacher-reported instructional quality (learning support and effective classroom management), but also students' achievement and interest in mathematics. Notably, enthusiasm for teaching was a positive predictor of student outcomes, even after controlling for the effects of other competencies such as teachers' pedagogical content knowledge (knowledge about the teaching and learning of mathematics), teachers' self-regulatory skills, and their beliefs about teaching (constructivist views). This is one of the few existing studies to assess the combined effects of knowledge-related, motivational and self-regulatory constructs on instructional quality and student outcomes, and provides convincing evidence in support of a multi-faceted conceptualisation of professional competence that includes motivational factors.

Although the evidence is still relatively scarce, educational researchers have presented strong arguments in support of this multifaceted conceptualisation. For instance, a review of teacher knowledge conceptualisations and assessments in the math domain by Blömeke and Delaney (2012) concluded that professional competence includes two main elements: professional knowledge and affective-motivational characteristics of teachers. Teachers' professional knowledge base includes content knowledge (knowledge of a content area such as mathematics), pedagogical content knowledge (knowledge about the teaching and learning of a content area) and general pedagogical knowledge (overarching principles of high quality teaching that are not content-specific) (Baumert et al., 2010; Blömeke and

Delaney, 2012; Shulman, 1986, 1987). Among these three types of knowledge, pedagogical content knowledge has emerged as the strongest predictor of student achievement (Baumert et al., 2010; Hill, Rowan and Ball, 2005).

Affective-motivational characteristics include teachers' beliefs about their content area, about teaching, and about student learning, as well as teachers' own motivation and self-regulation (Blömeke and Delaney, 2012). Blömeke and Delaney (2012) proposed that the affective-motivational characteristics of teachers have implications for teachers' decision making in particular situations (e.g. how and whether they use available knowledge), as well as for teachers' self-evaluations of their strengths and weaknesses, and corresponding engagement in professional development. Indeed, as discussed subsequently, types of teachers' motivations have been linked not only to desirable instructional practices in the classroom, but also to adaptive professional behaviours such as help-seeking in the face of professional challenges, and involvement in professional development (see review in Richardson et al., 2014). Furthermore, as Kunter et al. (2013) demonstrate, motivational characteristics such as teacher enthusiasm can predict instructional quality and student outcomes beyond the positive effects of teachers' pedagogical content knowledge.

Thus, motivational characteristics are relevant for teachers' professional competence, because such characteristics influence teachers' decision-making, professional learning, instructional practices and, indirectly, students' academic success. Theoretical frameworks of teacher motivation and associated implications for teachers and students are discussed in the following section.

Recent developments in teacher motivation research and its relevance for teachers' professional competence

The major theoretical frameworks that have informed systematic teacher motivation research are socio-cognitive theory, expectancy-value theory, self-determination theory and achievement goal theory. Even though there is abundance of empirical studies that directly or indirectly reference teachers' motivations, it has been only recently that theoretical frameworks of motivational processes have been systematically applied to the teaching profession. One of the pioneers of this field, Ruth Butler (2007), who has focused on teachers' relational and achievement goals in the context of teaching, noted for example:

> *Indeed, in the absence of coherent theoretical frameworks, it is not clear how initial goals can be expected to influence either teachers or their students. Conversely, many studies of practicing teachers have examined the role of individual differences in variables such as teachers' qualifications, personality, instructional values, and perceptions of students […], but few have focused on teacher motivation, and most of these have examined the strength, rather than the quality, of motivation. (p. 241)*

The reasons behind this lack of systematic research are likely grounded in the multiple roles implied by the teaching profession. Due to their role as employees, teachers have been included in research on work motivation. Yet, the objective of this line of research is not to study teaching, but rather to assess generalisable organisational processes across occupations that just happen to include teaching. Due to their role as learners, teachers have been included in research on motivation for learning in teacher education settings. However, this line of work has not focused on teachers in their capacity as educators, but rather as students. Finally, due to their role as facilitators of student learning and motivation, teachers have been included in research on instructional practices designed to influence student motivation, without an explicit focus on teachers' own motivations for teaching.

How this gap in the literature has been addressed over the past years is discussed in the following sections, with a focus on the following theoretical frameworks: socio-cognitive theory, expectancy-value theory, self-determination theory and achievement goal theory. In addition, drawing on multiple theoretical frameworks such as attribution theory, self-discrepancy theory and the job characteristics model, recent research on teacher responsibility and the motivational implications of personal responsibility are discussed.

Although each theoretical framework concentrates on different aspects of motivation, a general definition that is compatible with all approaches is motivation as "the process whereby goal-directed activity is instigated and sustained" (Schunk, Pintrich and Meece, 2008, p. 4). Because it is a process, motivation needs to be inferred from actions rather than products (e.g. choices, effort, persistence and verbal statements). In addition, the stipulation that motivational processes are goal-oriented implies awareness of something that individuals would like to attain or avoid. These characteristics of the motivational process are evident in the following conceptualisations of teacher motivation.

Socio-cognitive theory

Socio-cognitive theory, originally developed by Albert Bandura (1977), is one of the most frequently utilised frameworks in teacher motivation research (Klassen, Durksen and Tze, 2014; Tschannen-Moran and Woolfolk Hoy, 2001; Woolfolk Hoy, 2008). The key motivational construct in this framework is teachers' sense of self-efficacy, defined as a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran and Woolfolk Hoy, 2001: 83). Efficacy beliefs are essential for the motivational process, since individuals are unlikely to engage in behaviours and activities at which they do not expect to succeed. Sense of self-efficacy has been linked to the adoption of challenging goals, effort investment, persistence and resiliency in the face of difficulty (Bandura, 2000, 1997; Tschannen-Moran, Woolfolk Hoy and Hoy, 1998).

Efficacy judgments are influenced by mastery experiences, vicarious experiences of relevant role models, verbal persuasion by others, and physiological arousal such as experienced nervousness or anxiety in a given situation (Bandura, 1977, 1997). Analyses in the context of teaching corroborate the importance of mastery experiences and persuasion in the form of interpersonal support for teachers (Tschannen-Moran and Hoy, 2007; Tschannen-Moran and McMaster, 2009), although systematic analyses of the antecedents of teachers' self-efficacy are still rare (Klassen et al., 2014).

Critical implications of teachers' self-efficacy beliefs have been demonstrated for both teachers and students, but a recent review of the literature indicated that less than 3% of teacher efficacy research between 1998 and 2009 had focused on links to student outcomes (Klassen et al., 2011). Correlational research has established positive links between teachers' self-efficacy and their psychological well-being in terms of stress resiliency and lower likelihood of experiencing burnout (Klassen and Chiu, 2010; Skaalvik and Skaalvik, 2007), as well as with job satisfaction and commitment to the teaching profession (Caprara et al., 2003; Klassen and Chiu, 2011), desirable instructional practices (Ciani, Summers and Easter, 2008; Holzberger, Philipp and Kunter, 2013; Thoonen et al., 2011a), school-level student achievement (Caprara et al., 2006), and student-reported well-being in school (Thoonen et al., 2011b).

A meta-analysis of the links between teacher self-efficacy and teaching effectiveness by Klassen and Tze (2014) indicated that teachers' personality characteristics had a negligible effect on teaching effectiveness (operationalised in terms of student achievement and

observations of teaching performance), whereas teachers' self-efficacy had a moderate effect. Thus, available research, including meta-analytical evidence, supports the relevance of teachers' self-efficacy beliefs for the instructional process, and has outlined positive implications for both teachers and students.

Expectancy-value theory

The key assumption in expectancy-value frameworks is that individuals are motivated to pursue goals and to engage in activities that they view as both achievable and subjectively valuable (Eccles et al., 1983). If an activity is viewed as achievable (e.g. as a consequence of high self-efficacy) but not personally valuable, or valuable but not achievable, individuals would be unlikely to engage in that activity.

One of the most popular adaptations of this framework for the teaching profession, the "Factors Influencing Teaching Choice" (FIT-Choice) framework developed by Watt and Richardson (Watt and Richardson, 2007, 2008a, 2008b), has focused in particular on reasons for choosing teaching as a career. The expectancy component of this framework captures perceived teaching abilities and expected success in teaching, whereas the value component captures the perceived intrinsic value of the teaching profession (e.g. enjoyment and interest in teaching), personal utility value (e.g. job security and time for family) and social utility value (e.g. desire to help others, to work with children and adolescents, and to make a social contribution). Teaching as a fallback career and the influence of demands and formal returns associated with teaching (e.g. social status) are also considered in this model as factors that may shape the choice to pursue teaching. Proposed antecedents of aspiring teachers' expectancies and values include socialisation processes such as prior teaching and learning experiences, as well as persuasion by others (Richardson and Watt, 2014; Watt and Richardson, 2007).

Initial expectancies and values reported by aspiring teachers at the beginning of their teacher education programme have been associated with self-reported engagement in teaching (e.g. planned persistence) and professional development aspirations at the end of their programme (Watt and Richardson, 2007). Pre-service teachers' expected success, intrinsic values and social values have emerged as positive correlates of planned professional engagement (Watt and Richardson, 2007, 2008b). Furthermore, preliminary evidence reported by Richardson and Watt (2014) confirmed positive associations between pre-service teachers' motivations for teaching reported at degree entry and their self-reported instructional practices as novice teachers. Perceived teaching ability and social utility value at degree entry predicted a positive (self-reported) teaching style after the transition to in-service teaching (e.g. positive student-teacher relationships, clear expectations for students, emphasis on effort). Choosing teaching as a fallback career and social persuasion, on the other hand, were related to self-reported negativity towards students.

Overall, ability beliefs and social utility values for choosing teaching have emerged as most adaptive with regard to professional engagement and self-reported teaching styles. However, recent evidence from Germany suggests that some aspects of personal utility value – an extrinsic form of motivation – may also be associated with desirable outcomes (König and Rothland, 2012). Specifically, König and Rothland (2012) found that although intrinsic and social motivations were positively correlated with the general pedagogical knowledge of pre-service teachers, the desire for job security (an extrinsic factor) predicted an increase in general pedagogical knowledge between two measurement points within the same academic year, whereas intrinsic and social motivations did not. Thus, extrinsic forms of motivation are not necessarily maladaptive.[1]

Expectancy-value constructs have been utilised not only for analyses of choices to pursue teaching, but also with regard to the endorsement and use of particular instructional practices, as well as self-reported engagement in teaching among in-service teachers. Both components – expectancies and values – have emerged as complementary predictors of teacher-reported professional engagement such as involvement in extracurricular activities (Jesus and Lens, 2005) and affective commitment (Chatzistamatiou, Dermitzaki, and Bagiatis, 2014), self-reported implementation of desirable instructional strategies (Abrami et al., 2004; Leithwood and Jantzi, 2006; Reeve et al., 2014; Wozney, Venkatesh and Abrami, 2006), teachers' own self-regulatory strategies and encouragement of students' self-regulation (Chatzistamatiou et al., 2014).

In sum, expectancy-value research overlaps with teacher efficacy research in that both frameworks underscore the importance of teachers' confidence in their teaching abilities. However, expectancy-value theory suggests that teachers' subjective valuing of selected instructional practices or of the teaching profession as a whole can be equally important for their decision making and (self-reported) instructional behaviours. Thus, a consideration of both aspects is necessary for analyses of motivational processes.

Self-determination theory and intrinsic orientations

According to self-determination theory, human motivation stems from three basic psychological needs: competence, relatedness and autonomy (Ryan and Deci, 2000, 2002, 2006). *Competence* refers to the need to effectively interact with one's social environment and to produce desired outcomes. This implies that people are motivated to seek situations in which they can be successful and can maintain and develop their skills and potential. *Relatedness* reflects the need to establish positive relationships with others. Consequently, people are motivated to seek emotional attachment and a sense of belonging to a community. *Autonomy* reflects the need for self-determination of one's own behaviour. Accordingly, people are motivated to seek situations in which they experience a sense of personal freedom. When the social environment is designed to foster these three basic needs, the individual's performance, psychological well-being and intrinsic motivation (motivation that is independent of external incentives or threats) increase. Ample evidence suggests that a higher degree of self-determination leads to increased personal commitment, persistence, higher quality of engagement and positive self-perceptions (Burton et al., 2006; Ryan and Deci, 2000, 2002, 2006).

Although the preponderance of available evidence is based on research with students, teachers' basic needs, self-determination and resulting autonomous motivation, that is, motivation stemming from factors within the individual (e.g. genuine interest), have been examined as well. Analogous to the student literature, teachers' own autonomous motivation and sense of self-determination in their teaching have been linked to the degree to which their basic psychological needs for autonomy, relatedness and competence are satisfied in the workplace (Carson and Chase, 2009; Fernet et al., 2008; Taylor, Ntoumanis and Smith, 2009; Taylor, Ntoumanis and Standage, 2008).

Autonomous forms of teacher motivation have been associated with lower levels of burnout (Eyal and Roth, 2011; Soenens et al., 2012), with teachers' willingness to engage in professional development (Gorozidis and Papaioannou, 2014), with teacher- and student-reported autonomy-supportive instruction, as well as with students' self-reported autonomous motivation and self-determination (Roth et al., 2007; Soenens et al., 2012). Taylor and Ntoumanis (2007), however, found no association between teachers' and students'

reports of autonomous motivation in physical education, even though the teachers' autonomous motivation was positively related to their self-reported autonomy-supportive practices. Thus, evidence linking teachers' autonomous motivation to their own psychological well-being and perceived instructional approaches is more consistent than the evidence linking teachers' motivations with actual student outcomes. Nonetheless, there is convincing evidence that both students and teachers benefit from conditions that support their autonomous (rather than externally controlled) motivation.

Including the concept of autonomous motivation, Kunter and Holzberger (2014) reviewed the literature on intrinsic orientations towards teaching across theoretical frameworks such as self-determination theory and expectancy-value theory. The authors noted that multiple labels such as autonomous motivation, enjoyment, enthusiasm and interest in teaching seem to reflect an intrinsic orientation towards teaching that captures teachers' enjoyment, excitement about, and interest in, teaching tasks and activities. Consequences of teachers' intrinsic orientations examined in the literature include links with teachers' psychological well-being and job satisfaction (Kunter et al., 2011; Kunter et al., 2008), desirable teacher- and student-reported instructional practices (Kunter et al., 2013), and students' motivation and achievement (Frenzel et al., 2009; Kunter et al., 2013).

It is important to consider the specific tasks and outcomes towards which teachers may be intrinsically motivated. For instance, Kunter et al. (2008) found that teachers' enthusiasm for teaching predicted both teacher-reported and student-reported high quality instructional practices, whereas teachers' enthusiasm for their subject area predicted teacher-reported, but not student-reported instructional quality. Schiefele, Streblow and Retelsdorf (2013) distinguished between teachers' interest in their subject matter, interest in approaches to teaching (didactic interest) and interest in educational processes. The authors found that all three types of interest were positively related to teachers' self-efficacy, psychological wellbeing and self-reported instructional practices such as mastery orientation, but only their didactic interest and educational interest (and not subject interest) were positively related to their self-reported differentiation of instruction to fit individual student needs. Thus, intrinsic orientations towards teaching rather than a given subject area appear to be particularly adaptive for the instructional process.

Achievement goal theory and relational goal orientations

According to achievement goal theory, achievement situations elicit habitual tendencies to pursue particular goals such as the goal to learn, to outperform others, or to avoid being perceived as incompetent (Elliot, 2005). Which goal orientations are activated in a given situation have implications for the individual's learning, performance and intrinsic motivation towards achievement tasks (Dweck and Grant, 2008; Elliot, 2005; Elliot and McGregor, 2001; Elliot et al., 2005). The adaptation of achievement goal theory for the teaching profession rests on the assumption that "the school is an achievement arena not only for students but also for teachers who presumably strive to succeed at their job but who may differ in the ways they define success, in the goals they strive to attain, and, thus, in their personal achievement goal orientations for teaching" (Butler, 2007:242).

Analogous to the student literature, the following goal orientations have been distinguished in research with teachers (Butler, 2007; Nitsche et al. 2011; Papaioannou and Christodoulidis, 2007): Mastery or learning orientation reflects the goal to learn and develop teaching mastery and professional competence. Ability approach or performance approach orientation reflects

the goal to demonstrate superior teaching ability relative to other teachers. Ability avoidance or performance avoidance orientation reflects the goal to avoid the demonstration of inferior teaching ability relative to others. Work avoidance goal orientation reflects the goal to minimise effort investment in teaching. Finally, Butler (2012) modified her achievement goal framework for teaching to include a focus on teachers' social or relational goal orientations. Such goal orientations reflect the goal to establish positive relationships with students. Butler argued that social goals are inherent in the teacher's role and that therefore analyses of teachers' goal orientations cannot be limited only to their orientations towards professional learning and performance, but should also include a focus on their relationships with students (see also Klassen, Perry and Frenzel, 2012).

Evidence on teachers' achievement and relational goal orientations is generally consistent with a long tradition of research with students. For instance, teachers' mastery/learning goals have been related to teachers' psychological well-being, interest in teaching and job satisfaction (Papaioannou and Christodoulidis, 2007; Retelsdorf et al., 2010), engagement in professional development (Nitsche et al. 2013), adaptive help-seeking in the face of professional challenges (Butler, 2007; Nitsche et al., 2011), teacher-reported high quality instruction that emphasises a mastery orientation for students and cognitive stimulation (Butler, 2007; Retelsdorf et al., 2010), student-reported teacher support (Butler and Shibaz, 2008) and student interest (Butler and Shibaz, 2014).

The evidence on teachers' ability-approach goals is mixed. Such goals are positively related to perceived teaching ability (Nitsche et al., 2011), but also to occupational strain (Nitsche et al., 2013), and have not been systematically linked to either teachers' well-being, professional help-seeking or instructional approaches (Butler, 2007; Nitsche et al., 2011; Retelsdorf et al., 2010). Avoidance-oriented goals, on the other hand, have been associated with such maladaptive outcomes as burnout, dissatisfaction with one's job (Papaioannou and Christodoulidis, 2007; Retelsdorf et al., 2010), disengagement from professional development opportunities (Nitsche et al., 2013), lower interest in teaching (Retelsdorf et al., 2010), negative attitudes towards help-seeking (Butler, 2007), teacher-reported instructional practices that place emphasis on students' demonstration of ability rather than on learning, on surface-level learning strategies and low demands for students (Butler, 2012; Retelsdorf et al., 2010; Retelsdorf and Günther, 2011), and lower levels of student-reported teacher support and student-reported cheating (Butler and Shibaz, 2008). In sum, mastery/learning goals generally have desirable implications for the instructional process, ability-approach goals can have mixed effects, and avoidance-oriented goals are linked to undesirable outcomes.

The inclusion of relational goals in recent research on teachers' goal orientations has outlined another channel through which teacher motivation can impact the instructional process. Although both relational and mastery goals are correlated with mastery-oriented instructional practices – practices that emphasise student learning and personal improvement – relational goals have emerged as the stronger predictor of such practices (Butler, 2012). Analyses of links between teacher and student reports further revealed positive associations between teacher-reported relational goals and student-reported mastery-oriented instruction, social support by the teacher and student interest (Butler, 2012; Butler and Shibaz, 2014). Relative to relational goals, teachers' mastery goals have emerged as the stronger predictor of cognitively stimulating instruction, whereas relational goals are the stronger predictor of mastery-oriented instruction and social support by the teacher (Butler, 2012; Butler and Shibaz, 2014). Thus,

even though the mechanisms through which they affect teachers and students may differ, both types of goals – mastery-oriented and relational – have desirable consequences for the instructional process.

Teacher responsibility

Unlike the previous four frameworks, research on teacher responsibility is not yet based on a coherent theoretical approach, but rather draws on research from multiple theoretical perspectives (see review in Lauermann and Karabenick, 2014). Personal responsibility is defined as "a sense of internal obligation and commitment to produce or prevent designated outcomes or that these outcomes should have been produced or prevented" (Lauermann and Karabenick, 2011: 127). It is a motivational source since individuals may engage in various activities not because these activities are necessarily enjoyable, but because of an internal sense of obligation and a sense of duty to do so.

A critical distinction exists between formal responsibility (or accountability), which refers to one's awareness of others' expectations of another person's areas of responsibility, and personal responsibility, which refers to an internal sense of obligation, commitment and duty (Lauermann and Karabenick, 2011). This distinction is analogous to the differentiation between intrinsic (stemming from within) and extrinsic (stemming from external sources) forms of motivation in self-determination theory (Bacon, 1991; Deci and Flaste, 1995). Whereas formal accountability requires external monitoring and control, personal responsibility implies internal motivation and self-regulation.

Willingness to assume personal responsibility for a given outcome results from characteristics of the organisational environment, mainly the amount of job autonomy (independence and freedom in how people do their work), from situational characteristics such as social roles that apply in a given context, judgments of causal controllability over an outcome for which one might feel responsible, mitigating circumstances such as excuses or justifications that can limit one's perceived responsibility and from personal characteristics of the individual (see reviews in Lauermann and Karabenick, 2011, 2014).

Relevant personal characteristics include self-efficacy, proactive personality (habitual tendency to be proactive), work ethic and trust (defined as willingness to be vulnerable to others e.g. school administrators, parents and students) due to the belief in others' willingness and ability to contribute to student learning and academic success (Lauermann and Karabenick, 2011). Outcomes consistently associated with personal responsibility in organisational contexts, including evidence from a meta-analysis, are intrinsic work motivation, job satisfaction and job performance (Humphrey, Nahrgang and Morgeson, 2007).

Various operationalisations of responsibility have been applied to the teaching profession, linking teacher responsibility for student learning to fewer disciplinary problems (Rose and Medway, 1981a, 1981b), teachers' positive affect towards teaching, positive change in student learning (Guskey, 1984), willingness to implement new instructional approaches (Guskey, 1988), job satisfaction (van Dick et al., 2001; Winter, Brenner and Petrosko, 2006), an optimism about teaching effectiveness, a hopeful attitude towards personal goals and challenges, and positive emotions towards teaching (Eren, 2013). There is mixed evidence regarding possible links between teachers' self-judgments of responsibility and reported sympathy felt towards a failing student, as well as intentions to actually pass (vs. fail) the student, with some studies showing positive associations (Matteucci and Gosling, 2004, Study 1), but others no significant links (Matteucci, 2007; Matteucci and Gosling, 2004, Study 2).

It is important to note that there is substantial variation in how responsibility for teaching has been operationalised, making inferences about its influence on the instructional process difficult (Lauermann and Karabenick, 2013). Some researchers, for instance, have operationalised responsibility as internal locus of control in terms of teachers' beliefs that educational outcomes depend on their actions rather than on factors that are external to the teacher (Guskey, 1981, 1988), or have included items originally developed to assess self-efficacy to measure responsibility (Lee and Smith, 1996, 1997).

Accordingly, recent work on teacher responsibility has focused on three main issues. Firstly, research has focused on the distinction between teachers' personal sense of responsibility and teacher self-efficacy. Evidence with pre-service teachers suggests that even though beliefs about responsibility and beliefs about ability and control are correlated, they constitute distinct constructs (Lauermann and Karabenick, 2013; Silverman, 2008). Secondly, a multi-dimensional assessment of responsibility has been proposed that distinguishes between responsibility for such outcomes as student motivation, student achievement, relationships with students, and for the quality of teaching (Lauermann and Karabenick, 2013). Multi-dimensional assessments provide the foundation for outcome-specific analyses of responsibility in the context of teaching that go beyond a simple distinction between more or less responsible teachers. Finally, in a sample of Israeli teachers and their students, preliminary evidence has provided support for the importance of teacher responsibility in shaping teachers' instructional behaviours, as well as for the usefulness of an outcome-specific assessment (Lauermann, 2014b; Lauermann, Karabenick and Butler, forthcoming). Controlling for teachers' self-efficacy, responsibility for having positive relationships with students was positively related to student reports of their teacher's enthusiasm for teaching and mastery-oriented instruction. In addition, responsibility for student achievement, for relationships, and for teaching quality was positively related to student reports of more equitable instruction that considers the needs of students with different ability levels.

In sum, even though personal responsibility constitutes a well-established construct in psychological and organisational research, with implications for motivational and performance outcomes of the individual, research on teachers' sense of professional responsibility is still in its infancy. Scarce yet promising evidence indicates that teachers do differ in how they conceptualise their professional responsibilities, which has implications for their professional well-being and instructional practices.

The importance of teacher motivation, open questions and directions for future research

The review of available evidence on teacher motivation in the previous sections reveals a promising and burgeoning field of research that has implications for how educational researchers, policy makers and educators conceptualise the roles, responsibilities and professional competencies of teachers. Knowledge of and ability to implement particular instructional practices that help students learn and actively engage in the instructional process are necessary ingredients of teacher professionalism, but so are teachers' motivational characteristics, including their beliefs about their teaching abilities, their expectancies and values, their goals, their intrinsic orientations towards teaching, as well as their perceived responsibilities.

Motivational characteristics matter for teachers' professional success in the following ways:

- Teachers' motivational characteristics have been consistently associated with their *psychological well-being* in terms of experienced levels of stress, burnout and job satisfaction.
- Teachers' motivational characteristics have been associated with their *involvement in professional development*.
- Teachers' motivational characteristics have been linked to teachers' *professional decision-making* in terms of willingness to implement new instructional practices that they have learned in the context of professional development.
- Teachers' motivational characteristics have been associated with their self-reported as well as student-reported *use of high-quality instructional practices*.
- Teachers' motivational characteristics have been associated with their *students' motivation and performance*.

Despite such promising evidence, research on teacher motivation is still underdeveloped and thus many open questions remain to be addressed in future work, both methodological and theoretical. Methodological challenges include several issues. Firstly, the vast majority of available evidence is correlational and cross-sectional, so that the ability to make causal inferences is limited. Secondly, because student outcomes are an important, albeit indirect, indicator of professional competence, analyses of the impact of teachers' professional competence on the instructional process and on students necessitate linking teacher and student data. Currently, researchers are often limited by relatively small samples or by their focus solely on teachers because such study designs and analyses are challenging and costly. Thirdly, different aspects of teachers' professional competence can be highly interrelated, so that disentangling their effects can be difficult, especially in the absence of sufficiently large samples and longitudinal data. Fourthly, social and psychological phenomena and outcomes are typically interrelated, so that "predictors" and "outcomes" often influence each other over time, further obfuscating the distinction between cause and effect.

Theoretical challenges exist as well. Much of the literature on teacher motivation has been inspired by research with students, under the assumption that motivational factors that influence students' performance on academic tasks likely also apply to the performance of teaching tasks. Thousands of articles have documented that student motivation matters both for student performance on achievement tasks, and also for students' decisions on their educational and occupational pathways. Yet, there are obvious differences between achievement on academic tasks and teaching tasks, most notably the fact that teachers are not only responsible for their own actions and decisions, but also for their students.

This has led to modifications of existing theories (e.g. achievement goal theory) to include a focus on relational aspects of teaching, and to differentiations of specific aspects of the teaching task towards which teachers might have varying motivations (e.g. fostering student engagement and achievement, developing positive relationships with students, classroom management, using particular instructional practices, and interest in and knowledge of their subject area). Taking achievement goal theory as an example, the focus on teachers' relational goals has been a necessary and valuable adaptation of this framework. However, such goals are not traditionally part of the achievement goal framework, so that theory-based inferences about their effects are not as straightforward as the predictions about achievement goals. Accordingly, such goals are the focus of ongoing research and theory development.

Even though this is still an emerging field, researchers have begun to address these concerns. For instance, in addition to confirming the applicability of theory-based predictions about the effects of teachers' motivations, theoretical frameworks have been adapted to focus on specific features and tasks of the teaching profession. Furthermore, researchers are increasingly utilising longitudinal data to examine the implications of teachers' motivations for the instructional process, including analyses of implications for teachers and students. This ongoing research has helped to move the field forwards and researchers are no longer asking "Does teacher motivation matter for the instructional process?". It does. It matters for teachers' psychological well-being, for their professional engagement, for their decision-making, for their instructional practices and for their students.

Notes

1. Further research is warranted to clarify this finding. The desire for job security had a significant negative association with general pedagogical knowledge at the first time point, and was not significantly related to knowledge at the second time point. Thus, the observed positive association between pre-service teachers' desire for job security and their increase in general pedagogical knowledge does not imply a concurrent positive association between extrinsic motivation and knowledge. Furthermore, the correlational nature of the data precludes causal inferences.

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PART III

21st Century demands on teacher knowledge

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Chapter 9

Developmental cognitive neuroscience: Implications for teachers' pedagogical knowledge*

by
Daniel Ansari, *University of Western Ontario in London, Ontario;*
Johannes König, *University of Cologne, Germany;*
Marilyn Leask, *De Montfort University, UK;*
and
Tracey Tokuhama-Espinosa,
Latin American Faculty for Social Science in Quito, Ecuador

This chapter critically considers the role that insights from research in Developmental Cognitive Neuroscience (the study of the neural underpinnings of developmental changes in psychological functioning) might play in teachers' pedagogical knowledge. The chapter reviews key findings in neuroscience with implications for learning, such as functional and structural brain development and brain plasticity. We discuss concepts such as transfer of learning from one domain to another as well as the role that neuroscience can play in the prediction of educational outcomes. In addition, we consider how such evidence might be integrated into pre-service teacher education as well as ongoing in-service teacher professional development. Finally, the chapter discusses the importance of considering Developmental Cognitive Neuroscience as an important contribution towards more evidence-based education and highlights that such information must be integrated with evidence from psychology, cognitive science and other research enterprises related to learning and education.

* The four authors were invited by the Organisation for Economic Co-operation and Development (OECD) to attend an Expert Group meeting held in Paris in June 2013 to discuss how research in the neurosciences can be used to inform pedagogy. The chapter was authored by Daniel Ansari. The textboxes were authored by Francesca Gottschalk.

Why should neuroscience inform teachers' pedagogical knowledge?

Neuroscience is a rapidly growing field of inquiry. Tens of thousands of individuals attend the annual meeting of the Society for Neuroscience,[1] and new breakthrough studies are published almost every week, increasing our understanding of how the brain works (Carlson, 2013; Kandel et al., 2013). Newspapers are filled with reports about the latest neuroscientific research and how this might impact the reader's life. As a consequence, there is growing public interest in findings from neuroscience, especially as it relates to behaviour, including learning.

Neuroscience is becoming a hub science for addressing key questions concerning humanity, such as how we develop, how we learn complex cultural skills such as reading, what drives our behaviours, how we make decisions and how our emotions influence our decisions. Neuroscience covers investigations at multiple levels of analysis, ranging from the study of how genes influence the functioning of single nerve cells through to the study of large-scale systems and networks in the brain and how these generate human behaviour. Not only do neuroscientists work at multiple levels of analysis, but their work also intersects with many other disciplines, such as philosophy, psychology, anthropology, economics, as well as education.

In education, there have been growing calls to use evidence from the study of the human brain to influence what goes on in the classroom. It has been argued that the study of how the brain develops and acquires new information has the potential to transform education (Sigman et al., 2014). As such, teacher training might benefit from integrating evidence from neuroscience. In this chapter, we highlight how evidence from neuroscience might influence how teachers conceptualise and think about learners in their classrooms, with a critical discussion of what neuroscience can and cannot do for education. In doing so, we will argue that neuroscience *is one of many pieces of evidence* that can lead to more "evidence-based" practice in education and can help empower educators to become more informed practitioners. It is critical to emphasise that neuroscience should not be considered the most valuable source of evidence to influence how teachers think about students in their classrooms, but that together with evidence from other levels of analysis (such as cognitive science, psychology and educational research) it has the potential to further enrich teachers pedagogical knowledge.

One way of bringing research from neuroscience to bear on education is to make it a fundamental part of teachers' pedagogical knowledge both through pre-service teacher education, as well as through on-going professional development. In order to present how this might be achieved and what kind of knowledge from within neuroscience would become part of teachers' pedagogical knowledge, this report consists of a non-exhaustive review of some overarching neuroscience concepts that are essential for a basic understanding of the research. Throughout, we include examples of research from within neuroscience that illustrate the implications for teaching and learning. Critically, the description of these illustrations will provide a justification for why the research should be a part of teachers'

pedagogical knowledge. The aim is not to propose a framework of teachers' pedagogical knowledge that will overturn or replace existing ones, but rather to add to what are already considered as essential components of teachers' knowledge. Again, neuroscientific evidence should not be considered as being superior to other forms of evidence about learning and development, but rather as complementary to them. Indeed, often neuroscientific evidence can simply serve to confirm what we already know from evidence coming from cognitive science and psychology.

It is clear that teachers are actively seeking to learn more about the latest research and how it might impact their practice. For example, the "Learning and the Brain" conference series is attended by thousands of teachers from around the world. Similarly, the Mind Brain and Education Society (IMBES) as well as the European Association for Research on Learning and Instruction's Special Interest Group on "Neuroscience and Education" are organising conferences that aim to bring together educators and cognitive neuroscientists to discuss evidence and forge new collaborations. There are many new resources such as online courses and books (e.g. Tokuhama-Espinosa, 2011, 2014; Blakemore and Frith, 2005; Della Sala and Anderson, 2012; Howard-Jones, 2009) that are available to teachers.[2,3] This provides an important basis for the potential success of educating educators about neuroscience in an effort to inform their practice. In fact, evidence suggests that teachers believe that knowledge about brain function will aid their pedagogy by helping them to understand the mechanisms underlying their students' learning (Dubinsky, 2010; Pickering and Howard-Jones, 2007).There is already some evidence to suggest that when teachers learn about neuroscience it positively impacts their practice (Dommett et al., 2011).

While the field of neuroscience is growing rapidly, the ways in which research within this field are translated into education are not formalised. A systematic integration of neuroscience evidence into the knowledge that teachers are expected to have to optimally carry out their profession is currently lacking. Anecdotal reports suggest that evidence about how children's brains develop and learn, is not a focus of current pedagogical knowledge frameworks (Ansari, 2005; Wilson and Conyers, 2013). If teacher education programmes do include empirical research on how children learn and develop, the knowledge transmitted is based on comparatively old theoretical models (e.g. Jean Piaget, Lev Vygotsky) (Tokuhama-Espinosa, 2014). The present report argues to integrate the latest neuroscience evidence into a formalised framework of teachers' pedagogical knowledge rather than just presented ad-hoc or dependent upon the initiative of educators.

It is important to acknowledge that the notion that neuroscience can play a role in education has been heavily criticised. For example, in a recent paper (Bowers, 2016) contends that neuroscience has no role to play in education and that only evidence from psychological experiments that examine behaviour is relevant to education. We argue that such a perspective is unnecessarily narrow and that educators can benefit from multiple levels of analysis (brain, behaviour, social environment, etc.). There is no need to pit neuroscience and psychology against one another and to be forced to choose which level of explanation is superior to the other in terms of informing education (Howard-Jones et al., 2016). In Developmental Cognitive Neuroscience, evidence from neuroscience and behaviour meet on a level playing field and mutually constrain one another. Indeed, that is why we emphasise that it is Developmental *Cognitive* Neuroscience that has potential to be meaningful to teachers' knowledge and thereby fully acknowledge the important and critical role played

by behavioural and cognitive evidence. Therefore, both levels of explanation (in addition to others) can inform teacher's thinking and practice in meaningful ways.

It is important to emphasise at the outset that the aim is not to integrate knowledge that is prescriptive in terms of teaching practice. The proposal being put forth here is that information about how learner's brains learn, develop and change as a function of experience will help educators to become more informed practitioners and to see the children in their classrooms in the light of evidence about child development and learning. It is the integration of this knowledge with their experience that will influence teachers' practice. The analogy with medical education can be useful here (Thomas, 2012). All doctors in training take courses on molecular and cellular biology and it is accepted without question that an understanding of cell biology most likely improves a doctor's probability of correct diagnosis. Yet it is also clear that this knowledge is not going to lead to clear prescriptions in medical practice, but rather form an important aspect of multiple knowledge sources that inform the practice and decision-making of doctors. The present report argues that the research from within neuroscience can serve a similar, important function in informing educational professionals by serving as part of the broader knowledge that educators bring to the task of teaching. Furthermore, by instilling a culture of evidence-based practice, educators will be better equipped to critically evaluate programmes and seek out evidence-based approaches.

Moreover, by making this kind of knowledge part of teachers' overall professional knowledge, it is hoped that bidirectional relationships between educators and developmental cognitive neuroscientists will be established. Interdisciplinary approaches to problems, including how to teach better, may yield more comprehensive and efficient solutions. There is currently a divide between neuroscientists working on problems related to children's learning and skill acquisition and teachers or education professionals working with children having to learn these new skills and concepts. Bidirectional relationships between researchers and educators will improve the integrated knowledge base and lead to research questions that are educationally relevant and results that are increasingly more informative for educators.

Finally, we argue that educating teachers about neuroscience can help to prevent the damaging influence of so-called "neuromyths" – apparent facts about the functioning of the brain and its role in learning for which there is, in fact, poor quality, little or no evidence (Ansari, De Smedt and Grabner, 2012; Dekker et al., 2012; Pasquinelli, 2012). Having an understanding of neuroscience would enable educators to evaluate misconceptions about the brain and avoid accepting information or commercial products that are not evidence-based (Dekker et al., 2012; Goswami, 2006).

At the same time, the increasing public interest in neuroscientific findings raises the importance of neuroscientists becoming involved with efforts to diffuse accurate knowledge into the public consciousness and bringing about ethical challenges of the implications that can and are being derived from neuroscience research on the human condition (Illes et al., 2010; Morein-Zamir and Sahakian, 2010). For example, new insights into how measures of brain activation predict educational outcomes need to be carefully reported to avoid that misconceptions arise (e.g. the mistaken notion that because measures of brain structure and function predict educational outcomes, there is nothing that educators can change). In other words, scientists need to provide balanced accounts that take into account the scientific literacy of the audience and guard against misconceptions and potential misapplications of the evidence. As is evident, neuroscience is a highly complex science and handling the implications of neuroscience for individuals and society at large is a complex and multi-level endeavour.

Defining neuroscience and its sub-disciplines

In the domain of human neuroscience, fuelled by the advent of non-invasive neuroimaging methods, such as functional Magnetic Resonance Imaging (fMRI) and many other methods, it has become possible to look at how the brain functions and to study the neural correlates of complex human behaviours, such as problem solving and the processing of emotions (Immordino-Yang, 2011). Consequently, a new, interdisciplinary field of inquiry has flourished over the past quarter of a century: cognitive neuroscience. Cognitive neuroscience represents the integration of cognitive psychology and neuroscience. Put simply, the aim of cognitive neuroscience is to study how the brain enables the mind (Gazzaniga, Ivry and Mangun, 2008). In other words, cognitive neuroscience provides biological constraints on our understanding of human psychology. This field of interdisciplinary inquiry is rapidly growing and is beginning to investigate questions relevant to virtually all aspects of human behaviour. Today, departments of psychology at universities throughout the world are becoming increasingly populated with researchers who integrate neuroscientific methods and approaches into their study of psychological processes. Indeed, many departments of psychology have renamed themselves to acknowledge the growing role that neuroscience plays in psychological research and are now called 'Department of Psychological and Brain Sciences' or 'Department of Behavioural and Brain Sciences' and even 'Educational Neuroscience'.

As part of this field, researchers have gained unprecedented insights into human brain development through neuroimaging studies with children. Such studies have looked at age-related changes in both the structure and functions of the brain (Casey, Giedd and Thomas, 2000). The term brain "structure" refers to variables such as the volume of certain brain areas and other measures that quantify neurophysiology in the absence of its relationship to psychological processes (e.g. attention, emotion). Brain "function", on the other hand, is used to refer to variables that are correlated with psychological processes, such as the signals derived from functional Magnetic Resonance Imaging (fMRI) where the brain's response during psychological processing is investigated. Of course, structure and function are intimately linked with one another, so the terms "structure" and "function" refer to the level at which the brain is being measured. By studying both brain function and structure, it has become possible to investigate how the brain changes over developmental time and how experiences influence brain structure and function, often referred to as studies in developmental cognitive neuroscience (Johnson, 2001; Munakata, Casey and Diamond, 2004). Developmental cognitive neuroscientists study how the brain changes as a function of experience and how this varies over the course of learning and development. By doing so, developmental cognitive neuroscientists study how children learn complex skills such as reading (Dehaene, 2009; Schlagger and McCandliss, 2007) and arithmetic (Ansari, 2008; Ashkenazi et al., 2013) and how the acquisition of these skills is influenced by other cognitive functions such as working memory (Diamond, 2013), attention (Posner and Rothbart, 2007) and exercise (Hillman, Erickson and Kramer, 2008), to mention just a few.

Researchers in developmental cognitive neuroscience also address questions such as adolescent risk-taking (Blakemore and Robbins, 2012; Steinberg, 2008) and how arts education affects cognitive functions (Winner, Goldstein and Vincent-Lancrin, 2013), which are just a few of the topics that are investigated by researchers in this quickly growing field. In this context, it is also important to note that developmental cognitive neuroscience is not simply concerned with topics typically associated with the study of cognition, such as reasoning, problem-solving and thinking, but also encompasses the study of social behaviours and the

influence of emotional factors, such as motivation and reward processing (Blakemore, 2008, 2010; Somerville and Casey, 2010), in an effort to better understand the interface between emotion and cognition and their interactive neural substrates.

Notwithstanding strong critics (e.g. Bruner, 1997), over the past 15 years or so, the enthusiasm for a new "science of learning" that combines insights from cognitive science, neuroscience and psychology to inform education has grown exponentially (Carew and Magsamen, 2010; Goswami, 2004; Sigman et al., 2014; Varma, McCandliss and Schwartz, 2008), thanks in great part to advances in imaging technology and co-operative efforts by neuroscientists with educators and psychologists. Terms such as "neuroeducation", "educational neuroscience", and "mind, brain and education" have been used to describe these efforts. In the present report, we use the term "developmental cognitive neuroscience" in reference to this field of research.

Neuroscientific findings with implications for learning

In this section, we provide an overview of the overarching concepts that, according to the argument put forward in this chapter, should become part of teachers' knowledge base. An understanding of these concepts will turn teachers into more informed practitioners and decision-makers in an age where evidence from developmental cognitive neuroscience is, for better or worse, increasingly being drawn upon to help inform many problems that humanity faces, including how best to educate our learners. A clear understanding of key concepts and their limitations will, in combination with their everyday classroom experiences, help teachers optimise their practice.

One key neurobiological process that will be discussed below is that of brain plasticity. Early neurophysiological studies revealed that sensory deprivation or enrichment (i.e. adding toys and/or other animals to a cage of an animal that was previously isolated) changes the brains of animals, revealing that experience shapes the brain (Buonomano and Merzenich, 1998). Plasticity refers to how the brain responds to experience and changes its structure as a consequence of alterations in the environment. In other words, experiences embed themselves into the way in which the brain functions. This occurs at the level of connections between neurons. Plasticity changes in the brain occur when new connections are formed, existing connections are eliminated or existing connections are strengthened. Today, we can study the effects of complex environmental and experiential differences, such as cross-cultural and socio-economic variability, on brain structure and function (Ansari, 2012; Hackman, Farah and Meaney, 2010; Noble et al., 2006). Meaning, while research with other species has been important in providing fundamental insights into neuronal plasticity and its mechanisms, the availability of non-invasive neuroimaging methods has enabled researchers to study plasticity in the human brain. Mounting research suggests that the brain is more plastic than we originally thought (though, importantly, within constraints) and that our brains continue to be capable of functional and structural changes into adulthood. This is the second key neurobiological process, and it has potential implications for life-long learning, a topic of much interest in many ageing Western societies (for a recent review see May, 2011).

Plasticity is key to education: Without the ability of the brain to change in response to experience, education would not be possible. If our brains were static organs or had very limited ability to change in response to information, then our ability to learn would be severely compromised. The brain allows humans to be educated and, at the same time, puts constraints on the effects of education. For learning to occur, the brain needs to be

able to encode, retrieve and process information and this requires physical changes within brain circuitry. This type of change in the brain architecture in response to experience is often referred to as "experience-dependent brain plasticity". Experience-dependent plasticity represents the key mechanism by which individuals learn to adapt to their unique socio-cultural niches and function successfully within them (Greenough, Black and Wallace, 1987). Thus, in order for children to learn, experience-dependent plasticity needs to occur.

Even though most may not be aware of it, teachers are tasked with finding the best way to induce experience-dependent brain plasticity in order for students to encode knowledge, make connections between different pieces of information and acquire essential skills, such as reading, writing and mathematics. It follows from this that teachers are the orchestrators of their students' neuronal plasticity during classroom time. Hence, if teachers possessed a greater understanding of neuroscience, their practice would be significantly enriched. More specifically, accurate information translation from neuroscience to teacher education will, in deep interaction with their experience, affect and inform teachers' pedagogical decision-making.

Higher-level brain functions continue to develop into adulthood

The basic building blocks of the human brain

The mature human brain contains over 80 billion neurons. *Neurons* are the nerve cells that are thought to underlie brain functions. The basic units of a neuron are its cell body (containing the nucleus), an *axon* (an extension through which the neuron sends electrical signals away from the cell body) and *dendrites* (extensions away from the cell body through which the neuron receives information from other neurons). Neurons connect with one another. The points at which neurons connect are called *synapses*. The most common type of synapse in the brain is the so-called "chemical" synapse. In this type of synapse there is no actual direct physical contact between one neuron and another, but the synapse represents a junction between two neurons into which chemicals (known as *neurotransmitters*) are released from one neuron (referred to as the presynaptic neuron) and taken up by another neuron (referred to as the postsynaptic neuron). Neurotransmitters can inhibit or increase (*potentiate*) activity. The brain is a highly interconnected network of neurons. The cell bodies of the neurons make up what is commonly referred to as the *grey matter*. *White matter*, on the other hand, consists of axons that extend from the cell bodies and enable both short and long-range connectivity between neurons (via synapses). The brain also contains other cell types, such as *glial cells*. These cells are involved in supporting neuronal function through, for example, being involved in the insulation of neurons (*myelination*) to allow for more efficient neuronal communication.

Pre- and postnatal brain development

The human brain undergoes tremendous changes over the course of both pre- and postnatal development. During prenatal (before the child is born) development neurons are "born" (*neurogenesis*) and migrate from the innermost parts of the brain to form the different parts of the brain. Furthermore, during prenatal development the two hemispheres of the brain are formed. The hallmark of postnatal brain development (occurring after the child is born), in contrast, is not so much the birth of new neurons (though this also occurs; there is currently much effort being made to better understand the mechanisms that guide postnatal neurogenesis), but instead a burst in the connections (*synapses*) that neurons make followed by a period of the elimination (or *pruning*) of some of these synapses.

Put differently, postnatal brain development is primarily about connections between cells and the fine-tuning of connections both within and between local neuronal circuits.

There are, to date, no methods available to non-invasively measure developmental changes in brain structure at the level of the synapse and therefore such research needs to be carried out with animals or on the basis of the analysis of postmortem brains. However, while it is not possible to directly measure developmental changes in the number of synapses in humans, structural neuroimaging methods, such as MRI, have been used to quantify changes in brain volumes (where the unit of measurement includes tens of thousands of synapses) and these studies have provided convergent evidence (for a review, see Giedd and Rapoport, 2010).

The process of synaptogenesis is then followed by a developmental time period in which synapses are eliminated. In other words, following an overgeneration of synapses, the total number of synapses in the brain is reduced. However, it is important to note that synaptogenesis and pruning overlap during development and throughout the lifespan. In other words, while synaptogenesis occurs first, pruning does not replace synaptogenesis in a categorical way. Interestingly, both synaptogenesis and pruning differ substantially across brain regions. Specifically, brain regions associated with basic sensory motor processing, such as basic visual, auditory and motor cortex functioning, undergo these processes relatively earlier than brain regions associated with higher-level cognitive and emotional functions, such as the prefrontal and parietal cortices. Thus, in brain development there is not one, but multiple time-scales that differ between regions.

There are several important takeaways from the developmental changes described above. The first one is that postnatal development involves the initial overgeneration of synapses and their elimination. Secondly, these two processes (synaptogenesis and synaptic pruning) are not uniform across the brain but they differ by regions. More specifically, it appears that regions associated with basic sensory functions undergo these developmental processes earlier than regions involved in higher-level functioning *and therefore regions whose functions will be affected by learning and education*. Thirdly, it is evident that human brain development is protracted. *The brain is not fully developed by the time children reach 'culturally' defined adulthood*. The evidence pointing to brain development well into the early adulthood years has had a profound influence on the way in which we now think about adolescence. In particular, studies using structural measures of the brain, such as MRI, are revealing that the brain continues to change in structure during adolescence and into emerging adulthood (Gogtay et al., 2004; Houston, Herting and Sowell, 2013). Fourthly, in addition to synaptogenesis and synaptic pruning, there is another process referred to as *myelination*. Myelination is characterised by the "insolation" of axons that connect neurons to one another. This is achieved by *glial cells* (specifically oligodendrocytes), which wrap an insulating tissue (myelin) around these axons, allowing for faster transmission of neuronal signals between brain regions and also between the brain and the peripheral nervous system.

It is important to note what can and cannot be inferred from these findings. First of all, these changes are changes in the *structure* of the brain over the course of development (i.e. the amount of physical connections between neurons). Therefore, they cannot directly inform us about developmental changes in brain *function* (i.e. the degree to which such changes in the structure of the brain relate to changes in children's learning). Physical changes in the brain structure do not necessarily reflect functional changes, as in behaviour. This is an important distinction. Too often have these findings been interpreted

to tell us about when environmental inputs should be made (e.g. when the brain should be stimulated) and educational products proclaiming to be based on neuroscience often make a leap from such data to the timing of educational inputs. For example, it has been speculated in the popular press that children are "sponges" and "can learn anything" in the early years because they have more brain cells, which quickly deteriorate (are pruned away), justifying early stimulation products and a "critical period" for learning. Neuroscientists know that we cannot derive such implications from these findings, and it is critical that educators are aware of these explanatory limitations (for more discussion of this issues, see the section on sensitive and critical periods below). These findings are all about structural changes and reveal only that the structure of the brain continues to change over the course of postnatal development and that these changes differ in timing across brain regions and over the lifespan. In other words, in order to link changes in the structure of the brain to the emergence of new behaviours, the correlation between structure and behavioural/psychological variables needs to be demonstrated rather than inferred through evidence revealing structural changes alone.

Learning changes the brain

Brain plasticity

Connections in the brain (synapses) are not static once formed but rather they change as a function of synaptic activity. This notion that the connections in the brain change is referred to as "synaptic plasticity". When two neurons connect via the synapse, this leads to physical changes in the neurons and influences the subsequent activity at the synapse (*long-term potentiation* and *long-term depression*). Synaptic plasticity is thought to be one of the primary mechanisms by which the brain changes as a function of experience and results in learning.

Beyond the level of the synapse, there is also evidence showing that the organisations of large-scale neuronal networks are capable of change. Work with animals has shown that manipulating the experience of the animal affects the organisation of their brain. For example, it has been revealed that depriving animals of visual input changes the organisation of their visual system (for a review see Buonomano and Merzenich, 1998). One of the key principles of neuronal organisation in the sensory cortices (visual, auditory, somatosensory) is that these brain regions have a topographic representation of the sensory information. For example, the motor cortex is organised in such a way that different parts of this brain region represent the hand compared to, for example, the feet. Moreover within the region of the motor cortex that represents the hand there are different parts that represent each finger.

When one of the fingers is stimulated more than the others, it will be overrepresented relative to the other fingers (meaning that more neurons in the motor cortex will respond to the stimulated finger compared to the non-stimulated ones). Results similar to those from animals have been obtained from string instrument players in whom the cortical representation of the fingering hand is larger than that of their other hand or the hands of non-playing individuals (Pantev et al., 2003). Findings such as these demonstrate that the organisation of the brain is changed by experience, and this is what is meant by neuronal plasticity. Furthermore, evidence such as this demonstrates that the pioneering work on brain plasticity in animals is convergent with data from humans (using modern, non-invasive brain-imaging methods).

Another seminal finding showing experience-dependent plasticity in the human brain is the finding that second language learning affects the structural neuroanatomy of the left parietal cortex (Mechelli et al., 2004). Specifically, it was found that bilinguals have greater grey matter volume in the left inferior cortex, a region associated with verbal fluency. Moreover, the researchers found that the volume of this brain region was related to the age at which the second language had been learnt in such a way that relatively early bilinguals had greater amounts of grey matter in this region than comparatively late bilinguals. In addition to these findings, the authors also reported that the amount of proficiency in the second language correlated with the amount of grey matter. More specifically, bilinguals who had the greatest proficiency in their second language were also those who had the largest amount of grey matter in the left inferior parietal cortex. These data therefore show that age of acquisition and individual differences in proficiency affect brain structure.

One of the most striking examples of how educational experiences drive experience-dependent neuronal plasticity is the acquisition of reading skills. It has been shown that learning to read involves changes in the neural correlates of auditory, visual and language processing (Dehaene, 2009). For example, it has recently been shown that regions in the higher-level visual cortex of the brain that are specialised for processing print in adults (for a review see McCandliss, Cohen and Dehaene, 2003) become sensitised to print as soon as children learn the associations between letters and speech sounds, thereby providing strong evidence that learning a critical skill for reading leads to change in the way in which the brain responds to input (Brem et al., 2010).

Modern neuroimaging methods, such as structural and functional neuroimaging, have allowed cognitive neuroscientists to investigate neuronal plasticity in humans. There are now countless studies that show that experiences modulate the structure and function of the brain. Furthermore, it has been shown that brain plasticity can even be found in the adult brain (for a review see May, 2011). There are numerous examples showing that training (such as working memory training, learning how to juggle, learning how to navigate complex spatial environments and even video-game playing) can lead to changes in both the grey and white matter of the brain and changes in the amount of activation within brain regions. What these data are revealing is that different experiences lead to changes in different regions and to varying extents. That is, plasticity is not a uniform process, but specific experiences change the structure and function of particular neuronal circuits. Furthermore, while there are data to demonstrate plasticity in the adult brain, the evidence does point to a gradual age-related decline in neuronal plasticity (Thomas and Knowland, 2009). In other words, the potential for neuronal plasticity is greater early in development and declines gradually over the lifespan, though learning can and does occur into old age.

The notion that the potential for brain plasticity decreases with age has led to the suggestion that there are *critical periods* for the development of particular abilities or brain circuits and the concept of "critical periods" is often discussed in education. A critical period is a window of development within which experience must occur, and if it does not, a functional deficit occurs. It should be noted that while there is some evidence for windows of opportunities for the optimal organisation of certain brain circuits (such as speaking one's first language), most neuroscientists now prefer the use of *sensitive periods,* because the evidence suggests that the windows during which plasticity can occur are not as rigid as suggested by term "critical period" (Thomas and Johnson, 2008). Furthermore, it needs to be noted that most of what is known about such windows of opportunity comes from research on the effects of experience on the neuronal organisation of the sensory modalities (e.g.

vision). Much less is known about the time windows of optimal plasticity of brain circuits that underlie higher-level brain functions such as problem-solving or literacy, for example, and many agree that there are no critical periods for an academic subject (Thomas and Johnson, 2008; Tokuhama-Espinosa, 2011). In other words, there is no clear evidence on any precise developmental time points at which plasticity for higher-level functioning is enhanced. Taken together, while there is much evidence on sensitive periods for basic sensory functions, such as vision and audition, almost nothing is currently known about the best timing for experiences that go on to shape higher-level functions. This means that while curriculum structures may appear logical in sequence, it is not yet known whether or not the age of introduction is optimal given developing neurocognitive structures.

In this context, a distinction between two types of plasticity is useful. Specifically, Greenough and colleagues argued that plasticity should be divided into: *experience-expected* and *experience-dependent* plasticity (Greenough, Black and Wallace, 1987). This distinction has been very influential on subsequent research and has been widely cited. Experience-expectant brain plasticity refers to changes in the organisation of the brain that are ubiquitous to individuals within a species, such as light and sound. These kinds of experiences are likely to be had by members of a species within certain windows of development. In contrast, experience-dependent brain plasticity occurs in response to experiences that vary between members of a species, such as the language that is being spoken within the environment of the individual or the skills they acquire in their classrooms, such as learning how to read, do math, or appreciate the history of their country. Put differently, experience-dependent plasticity allows individuals to adapt to their unique environments.

Experience-dependent plasticity represents the study of how the environment impacts the biological organisation of the brain. Recent work suggests that complex variations in the environment (and therefore the individual's experience) affect brain structure and function. For example, it has been documented across several studies that individual differences in children's socio-economic status (SES) and the environment in which a child grows affect the brain circuits underlying functions such as those underlying literacy (Hackman, Farah and Meaney, 2010; Noble et al., 2006). These findings show that the environment in which children grow up affects their brain development. Another example of how environments impact the organisation of the human brain comes from research showing that the brains of individuals growing up in urban environments show a different response profile to stress than do the brains of individuals growing up in rural environments (Lederbogen et al., 2011).

Data such as these show that the particular socio-cultural niche in which learners find themselves affects the way in which their brains function. Variables, such as education and culture, are influencing the study of brain plasticity. In other words, cognitive neuroscience now finds itself in a position to move beyond the study of how sensori-motor experiences change the brain to gaining a better understanding of how socio-cultural environments shape the brain.

When discussing neuronal plasticity, it is important to note that plasticity does vary between individuals. In other words, experience will not have the same effects on the brain circuits of all individuals. Genetic variability between individuals interacts with experience to shape neuronal plasticity. An example of this interaction between experience-dependent plasticity and genetically constrained *variability* was provided through a neuroscience study by Golestani and colleagues (Golestani, Price and Scott, 2011). These authors studied expert phoneticians (individuals who transcribe speech as part of their professional lives). These individuals clearly receive many hours of training in transcription, raising not only

the question of whether their brains change as a function of this intense training, but also whether certain individuals show brain circuitry that makes them different from those who do not go on to become phoneticians and might therefore predispose them to engage in such activities.

What the authors found was that, consistent with the notion of experience-dependent plasticity, a region in the left hemisphere was positively correlated with the years that individuals had spent transcribing speech. However, in addition to this region, they found that the expert phoneticians differed from non-experts in the morphology (structure) of their auditory cortex and that this structural difference did not correlate with years of experience. In view of these data, the authors concluded that certain brain structures might vary between individuals for genetic reasons and thus predispose these individuals to engage in certain activities. These predispositions then interact with other brain circuits that exhibit experience-dependent brain plasticity, revealing the interactive role of genes and experience in shaping individual development and preferences.

Similarly, it is now well-understood that experience alters both biological and genetic mechanisms (for a review see Zhang and Meaney, 2010). This notion is well-described by the concept of *biological embedding* (for a review, see Hertzman, 2012), which postulates that the environment influences biology (such as mechanisms of gene expression) and that such processes are further modulated by individual differences (whereby the degree of biological embedding varies across individuals). Put differently, *neuronal plasticity is the result of a complex interplay between experience, biology and individual differences*. This is an important point for educators to be aware of because it shows that the knowledge and behaviour of students in their classrooms is not the result of one variable alone, but a complex interaction of experiential and biological factors. This can help to explain why certain teaching interventions resonate with some students and not with others.

Examples of cognitive neuroscience with relevance to education

In the above we reviewed some of the key concepts and terms in neuroscience that should, according to the proposal of the present chapter, become part of teachers' professional knowledge. Furthermore, we considered some recent innovative approaches to put this into practice, which show promising results of teaching teachers about neuroscience, but require further implementation and evaluation. In what follows, we now consider some insight from cognitive neuroscience that can be applied across domains of learning and therefore have relevance for education and could also be integrated into teacher training. This is not meant to be an exhaustive review of all the cognitive neuroscience research that is of relevance to educators, but covers a few topics and subjects of study that could impact the way that teachers think about learners in their classroom and the way in which they evaluate evidence and evidence-based products with which they may be presented.

Executive functions

In addition to studying how the brain represents specialised cognitive functions such as reading, language and mathematics, cognitive neuroscientists study brain systems that function across domains in order to enable learning. These systems represent the "gatekeepers" of learning since they determine how information is processed, encoded and retrieved. Cognitive neuroscientists have postulated many different systems that constrain how information is learnt. Terms such as *working memory* (the ability to hold information

in a temporary storage while operating upon it), *attention* (the ability to direct focus to a particular stimulus while ignoring or inhibiting other types of information) and *inhibitory control* (the ability to inhibit responses and select among different stimuli that are presented) are frequently used to refer to neurocognitive systems that constrain our ability to focus on information, mentally manipulate that information, select some information while inhibiting others and to encode information into long-term memory.

The aim of this chapter is not to discuss the subtle nuances of theories regarding the different constructs (although this should be part of any pre-service or on-going professional development programme), but rather to highlight the importance for educators to be aware of the existence of these general constraints on learning that may help them to better understand learners in their classroom, their behaviours and individual differences therein.

To describe these general constraints on learning, we adopt a recent classification put forward by Diamond (2013). Specifically, Diamond contends that the most superordinate category of neurocognitive systems that help us to control our thinking, learning and behaviour can be referred to as *executive functions* (henceforth EFs). Executive functions such as working memory influence what can be held in memory while students solve problems. Consider for example a student solving a complex multi-digit multiplication problem. To execute the processes necessary to resolve the problem, the student needs to hold information in mind temporarily, such as intermediate solutions, while at the same time engaging on the online process of calculation. The ability to hold information in memory temporarily and to operate on that information (e.g. problem-solving) is sub-served by working memory. While solving the problem the student might be distracted by other stimuli and would therefore need to exert inhibitory control to be able to inhibit other information that is being presented but is irrelevant to the task of solving the multiplication problem. This example illustrates that many components of executive functions are drawn upon during everyday tasks and therefore also during classroom activities. A consideration of EFs by educators can help them understand why some students might struggle in certain classroom activities. It may not be because they have an inability to grasp a particular subject or concept, but rather because they struggle to exert the necessary EFs to be able to engage with the material, hold in in mind, operate upon it, and select the relevant information, while at the same time inhibiting information that will not inform their understanding, but rather interfere with it.

It has long been known that individual differences in EFs are related to educational outcomes such as literacy ability (e.g. Blair and Razza, 2007) and maths achievement (for a recent review, see Cragg and Gilmore, 2014). The relationship between EFs and important educational outcomes shows that these neurocognitive functions are related to learning and skill acquisition.

EFs serve as an umbrella term for a broad set of neurocognitive functions. It is therefore not surprising that there is no single brain region that subserves EFs. In general, tasks that tap into executive functioning are subserved by a network of brain regions encompassing not only the frontal and parietal areas of the brain but also subcortical regions of the brain, showing that a large network is engaged during executive function execution. From a developmental perspective, it is important to recognise that the neural networks underlying EFs change over the course of an individual's development with networks undergoing age-related increases in activation (for a review see Morton, 2010). Furthermore, it has

been shown that the neural networks underlying EFs are changeable. Results of studies that have trained EFs, such as working memory, have shown that such training results in changes in the structure and function of the brain. Such findings imply that EFs are changeable and plastic rather than static.

Box 9.1. **Attention systems**

Just as there are multiple neural pathways associated with memory systems in the brain, so there are multiple circuits and pathways associated with attention (Petersen and Posner, 2012; Posner, 2012a; Posner, 2012b). Just as memory systems are vital for learning, so are attention systems; without memory or attention, there can be no learning. Posner and colleagues have identified at least three distinct neural pathways for attention that contribute to efficient learning (Posner & Rothbart, 2013). The altering and orienting system calls attention to stimuli; the sustaining system permits a learner to stay focused; and the executive functions permit the learner to choose the right things to pay attention to in any given moment. In order for efficient school learning to take place, all three systems must be working properly (Sarver et al., 2012). For effective teaching, teachers must be aware of how to get a students' attention (alerting system) and how to keep them on task (sustaining system) and how to help them develop criteria about what is of most importance (executive functions system).

Learning problems can be based in memory deficiencies, attention deficiencies, a combination of both, or neither. A high percentage of learning problems, however, are associated with problems of attention or attention and memory (see Lufi, 2013; Sarver et al., 2012 for examples). Some studies suggest that cognitive difficulties can arise due to chemical imbalances, which may be affected by diet or living conditions for example, which can affect attention systems as well as potential to learn (see Bhang et al., 2013 for an example). One pertinent example of chemical imbalances affecting attention and learning capacity is attention deficit hyperactivity disorder (ADHD). Individuals who present with ADHD tend to have a lower threshold for stimuli, suggesting their alerting systems are on high, and show low abilities for sustained attention through difficulties maintaining focus on specific tasks. The catecholamine hypothesis of ADHD suggests a dysregulation of two chemicals in the brain, norepinephrine and dopamine, which results in a diminished ability of the prefrontal cortex to fine-tune attentional processes, such as the directing or maintaining of attention on current activities (Curatolo et al., 2010). Issues such as chemical imbalance can be remedied through pharmacological intervention, for example in the case of ADHD through dextroamphetamine or methylphenidate, which are two of the more commonly used stimulants used to manage symptoms (Mash and Wolfe, 2012), or through lifestyle interventions such as increasing rates of aerobic exercise, which has been implicated in increases in attention-mediating neurotransmitters in the prefrontal cortex (Wigal et al., 2012). Proper diagnosis of the roots of learning problems is key to remediation, and teachers can play a key role in identifying issues or difficulties associated with attention.

Transfer of function across neurocognitive domains

In view of the finding that EFs are plastic, there has recently been a lot of interest in the possibility that such training can lead to improvements not only in EFs but can also improve functioning in neurocognitive domains that require EFs. More specifically, it has been argued that domain-general functions such as EFs can be trained through computerised games and that the effects of such training will result in participants becoming better at that

task/game or tasks/games that are closely related to it. For example, engaging in working memory training makes individuals better at the task/game that they are being trained and on games that also train working memory or measures of working memory. Far transfer, on the other hand, refers to effects of training that extend beyond those that are directly being trained. For example, given that solving complex mathematical problems involves EFs, it might be hypothesised that training them results in improvements in mathematical problem solving. If training EFs lead to changes in mathematical problem solving, then this would be a demonstration that the training of EF leads to transfer to domains that were not directly trained but are related to EF. While there have been some reports of far transfer, such as an effect of working memory training on (fluid) intelligence (e.g. Jaeggi et al., 2008), such findings have not been replicated in other studies (e.g. Harrison et al., 2013). Indeed, there are now several large-scale studies that provide no evidence for far transfer of so-called "brain-training games" that purport to train functions such as working memory and attention. What these studies consistently report is that such training improves performance on very similar tasks/games that simply use different materials but that they do not lead to changes in performance on tasks that tap into related but different processes (e.g. Owen et al., 2010; Shipstead, Redick and Engle, 2012; Egeland, Aarlien and Saunes, 2013; Dunning, Holmes and Gathercole, 2013).

There is similar, conflicting data on the effects of music training on non-musical abilities. While some studies have shown that music training leads to positive changes in IQ (Moreno et al., 2011; Schellenberg, 2004), others do not show evidence for such far transfer (Mehr et al., 2013).

The notion of training domain-general neurocognitive functions (such as EFs) is a relatively new concept. Thus far, the evidence is clearly conflicting, and there is not a lot of support for the notion that training on EF tasks leads to improvement in non-trained neurocognitive functions (e.g. that working memory training improves reading abilities). Yet, the possibility of such transfer effects should not be excluded *a priori*, since their absence may reflect a need to improve the training programmes to yield far-transfer effects or to look at a broader set of potential targets for far-transfer effects. As it stands, no firm conclusions about the effects of so-called "brain-training" can be made. There certainly is no quick fix, no magical "brain training" package, even though some companies would make you believe so in their advertisements. It is important that educators are aware of what the data currently says and to understand the distinction between near- and far-transfer. This will allow them to ask questions about training programmes or new educational tools that might be suggested to them and thereby become more informed and critical users. Being able to engage in such critical reflection will eventually benefit the learning of students in their classrooms.

Finally, it is important to note that the data on "brain training" show that just because one variable correlates with educational outcomes, such as EFs, that does not necessarily mean that training EFs will improve educational outcomes. In other words, demonstrating a relationship between a given neurocognitive function and learning in educational settings does not necessarily imply that training the function will lead to improvements in learning.

Box 9.2. **Memory systems**

Memory systems (short, working, long-term, among others) are vital for learning. Without memory, there is no learning (Baddeley, 2013). Memories are created when information passes through short and working memory into long-term storage, and recall is accessed to link old to new (Alberini, 2011). The ability to rapidly recuperate information stored in the brain is based on both how easy it is to find due to accessible placement, as well as how quickly it can be recalled (Baddeley, 2013). The location of storage is primarily based on mode of learning, how easily linked prior information is to new information due to past association, and the development of networks that chain different types of learning into whole circuits (Winocur, Moscovitch and Bontempi, 2010). The speed of recall is based on how well the information has been rehearsed; the more rehearsal, the quicker the recall (Ericsson, Krampe and Tesch-Römer, 1993).

To strengthen memory systems, significant learning experiences and practice are necessary. In schools, the use of classroom tests can enhance memory systems. But memory systems can also be enhanced through mechanisms of "self-testing", such as when students practice while studying (Roediger and Butler, 2011; Roediger and Karpicke, 2006). Holding frequent tests in the classroom setting, for example, encourages students to maintain a study regime throughout the duration of the course, rather than promoting small periods of concentrated study, which is more likely to occur when a teacher sets only a few tests per semester. Some research has also indicated that rates of retention could be higher with more frequent testing than if the student spent the equivalent amount of time purely engaging in studying. While testing may produce some negative effects, such as recall interference or the negative suggestion effect (i.e. when a teacher sets a multiple choice or true/false test, there are options that are correct and incorrect, subsequently students may endorse the incorrect answer on the first test and continue to do so on future evaluations), testing seems to generally be a robust mechanism for enhancing learning and memory (Roediger and Karpicke, 2006).

Neurocognitive predictors of educational outcomes

One area in which data from cognitive neuroscience is having a growing influence on education is the area of predicting academic outcomes from brain imaging data. For instance, there are several studies using event related potentials (ERPs) to record the brain responses of neonates and infants which have revealed that the infant's brain responses to sounds predict individual differences in reading years later (Guttorm et al., 2001; Guttorm et al., 2010; Molfese, 2000; Pihko et al., 1999). In other words, these data show that brain signature in infancy recorded during speech processing predict reading scores later in life, thereby potentially giving parents and teachers an early indication that a child may need special attention to learn how to read fluently. Such data show that the pre-reading brain of infants who will go onto experience difficulties in reading respond differently to those who will develop normal literacy skills and thereby draw attention to the early building blocks of reading, resulting in many potential implications for early diagnosis and remediation. In this context, it should also be noted that these kinds of data are difficult to obtain with any other measure traditionally used in behavioural research with young infants and children and that there are few studies currently available, thereby demonstrating the potential added value of using neuroimaging methods.

In studies with older children using both structural and functional neuroimaging, researchers have been able to demonstrate that structural variables, such as brain volume and white matter integrity, as well as functional measures of brain activation during reading-related tasks (e.g. rhyming), predict significant variability in children's reading scores. It could be said that this is not a surprising finding and that it is far more cost-effective to use traditional behavioural measures as predictor variables. However, Hoeft and colleagues demonstrated that the combined used of behavioural and neuroimaging measures as predictors of reading (specifically, decoding skills) explains significantly more variance than either measure used in isolation (Hoeft et al., 2007). Thus, neuroimaging and behavioural measures each explain unique variance, which leads to overall better prediction of reading outcomes. In other words, the combination of neuroimaging and behavioural data predicts success and failure in a better way than either measure alone.

In a more recent study, Hoeft et al. asked whether neuroimaging data could predict who will go onto show gains in reading performance over time. Both behavioural and neuroimaging data were acquired from children with and without developmental dyslexia. The same children were tested again 2.5 years later. Behavioural data suggested that while some children with developmental dyslexia exhibited significant gains in reading abilities, another group of children demonstrated no change on behavioural tests of reading competencies. By using the behavioural and neuroimaging data acquired at the outset of the study to predict who ended up showing reading gains compared to children who did not, the authors were able to show that structural and functional neuroimaging measures were able to predict which children end up exhibiting gains in their reading abilities.

In striking contrast, none of the behavioural variables were able to predict which children exhibited gains (Hoeft et al., 2011). These data point to the possibility of undertaking "neuroprognosis" and also demonstrate that, in some cases, neuroimaging measures (both structural and functional) may be a more sensitive way in which to predict later outcomes (given that the behavioural data did not exhibit such predictive power). It should be noted that in this context the data does not imply that the children who did not benefit from the particular intervention could not, in principle, benefit from another intervention. Instead, the data show that these children did not respond to the intervention used. Put differently, this kind of evidence cannot be used to classify children into those for whom education does or does not work. However, they can be used to predict who will gain most from a particular intervention. Therefore, it is possible that, in future, such analysis could be used to determine which kind of intervention is optimal for which child (i.e. individualised education).

In addition to providing evidence to suggest that neuroimaging measures can be used to predict change in educationally-relevant outcomes (e.g. gains in reading ability), Hoeft et al. found that individual differences in the structure and function of the right inferior frontal cortex were particularly predictive of such gains. This represents an intriguing finding because reading is typically associated with a predominantly left-lateralised network of brain activity and structure (Dehaene, 2009). However, there have been other studies suggesting that the right hemisphere plays an important role in response to intervention and may represent compensatory neural mechanisms (Temple et al., 2003). Thus, individuals who are better able to use these right-lateralised compensatory mechanisms may show greater gains in reading ability.

This finding provides a significant constraint on our understanding of the mechanisms that drive individual differences in improvements in reading abilities. It is not as though we necessarily see the normalisation of disrupted brain circuits, but instead it appears that the recruitment of regions not typically associated with reading is what is associated with the recovery of impaired reading skills. This is not only important from the point of view of understanding the mechanisms underlying the recovery of reading abilities, but it may also help to constrain how reading interventions are designed. In other words, future efforts may be directed at better understanding what mechanisms drive the recruitment of such compensatory neural processes and how these might be optimally harnessed. In this way, neuroimaging provides a novel constraint on recovery of cognitive function by revealing the mechanisms that can guide future intervention programmes.

The data reviewed above suggest that neuroimaging can play a role in predicting individual differences in educational achievements and can help to better understand who will benefit from intervention. Furthermore, neuroimaging methods acquired early in development can predict future outcomes. While these data are certainly exciting, their application in mainstream education seems hard to imagine at least at this point in time. There will likely never be MRI scanners in schools to help understand individual differences in response to educational interventions or for the use of predicting who might be at risk of academic failure (leading to a host of neuroethical questions as well, which go beyond the scope of this chapter). However, one might imagine that cheaper measures such as electroencephalogram (EEG) could be used in certain circumstances to help increase the precision of prediction in the future. After all, in the year 2001, when the first sequence of the human genome was published, nobody would have imagined that today it is possible to sequence a human genome in less than a day at a cost that is rapidly falling. Thus, while such neuroimaging methods to predict and track educational outcomes are currently not ready for mainstream use, it is possible that technological advances may make these useable in the future. In view of this, teachers should become aware of these future possibilities.

Furthermore, the kinds of brain networks that are revealed to predict individual differences in performance and change in performance over time inform our understanding of the neurocognitive mechanisms that are associated with improvement. By doing so, these findings will inform the design of training and intervention programmes. For example, the finding that responses to math tutoring are predicted by the volume of the hippocampus and its functional connectivity with the prefrontal cortex might indicate that individual differences in the general circuits underlying memory and learning rather than regions specifically associated with arithmetic processing are related to improvements in mathematics.

Box 9.3. **Emotion regulation and education**

There is much evidence for the interdependence between learning and emotion. Over 2000 years ago, Plato stated that learning inherently has an emotional base (Hinton, Miyamoto and Della-Chiesa, 2008), and in more recent literature the science has been focusing on the prevalence and development of social-emotional skills and competences in students. There are a number of competing schools of thought regarding the definition of emotions, although one commonly touted biological definition suggests emotions to be a system of response through which experience is appraised and actions are prepared based on a set of circumstances, and experience and meaning are infused (Cole, Martin and Dennis, 2004). Emotions are comprised of many dimensions, such as cognitive, experiential, behavioural and physiological (Gross, 1999).

Box 9.3. **Emotion regulation and education** *(continued)*

In the human brain, there are a number of neural networks associated with learning, one of which is the affective network, which tends to be involved in the more emotionally-based aspects of learning such as stress, motivation and interest (Hinton et al., 2008). This brain network encompasses regions such as the limbic system, which is considered to be the "seat of emotion" and consists of structures such as the hippocampus and amygdala (MacLean, 1949), which relay information to various cortical regions of the brain (LeDoux, 2000). This allows for a bidirectional flow of emotional information and cognitive processing, which allows the higher cognitive centres to be involved in the shaping and regulation of emotion, as well as the ways in which emotion can influence both cognition and behaviour. Emotion regulation is a highly adaptive skill that allows humans to reappraise various events through interpreting them in manners that change emotional responses to them (Gross and Thomson, 2007; Giuliani and Gross, 2009). Self-regulation of emotions encompasses a wide range of processes through which an individual can influence the emotions they have, how they experience and express the emotions, and when they have them using techniques such as reappraisal, rationalisation and suppression (Gross, 1999; Hariri et al., 2000).

According to an OECD report published in 2007, the ability to regulate one's emotions can be predictive of academic outcomes. This is consistent in much of the scientific literature, stating that self-regulatory skills and academic achievement are closely linked (e.g. Blair and Razza, 2007; Duncan et al., 2007; Payton et al., 2008). Emotion regulation has been shown to be positively correlated with teacher-reported academic success, productivity in the classroom environment, as well as scores in math and literacy (Graziano et al., 2007). One potential explanation for this finding could be that learning new information results in an arousal of emotions in children, which could range, for example, from anxiety to frustration. A student who is unable to cope with these emotions may become agitated or frustrated when trying to do an assignment, resulting in inaccurate completion (Graziano et al., 2007). Those students who are more apt at self-regulating their emotions also tend to show higher levels of resilience, fewer behavioural problems, and are more likely to have stronger social networks, including more positive relationships with teachers (OECD, 2007; Graziano et al., 2007). Student-teacher relationships are related to academic success, with more positive relationships indicating a higher likelihood for higher achievement potentially due to providing more motivation for children to succeed and please their teachers (Pianta and Stuhlman, 2004; Urdan and Maehr, 1995).

Children who are able to recognise and label their emotions also seem to have higher academic performance and are better socially adjusted, with similar findings reported for preschool-aged children (Izard, 1971; Walden and Field, 1990). Emotion knowledge skills may be exhibited more in children who are older and do not come from socially disadvantaged backgrounds, as well as those who are superior in self-regulation (Denham et al., 2012). Emotion knowledge as well as the ability to self-regulate seem to be important precursors to fostering academic achievement, social capital and a pro-social classroom. As these are skills and traits that can be developed, there is room for the introduction of social-emotional learning programmes in an educational context in order to enhance the capacity for self-regulation and emotion knowledge.

Does learning about brain development and plasticity improve teaching?

Educators play a critical role in driving experience-dependent changes in brain function. Put differently, because it is through education that individuals adapt to their environments and become members of their culture, education can be said to be a vehicle through which experience-dependent brain plasticity occurs. From this it might be hypothesised that if educators had a better understanding of brain plasticity and the role they play in this neurobiological process, changes in their teaching would occur.

Indeed, recent evidence in support of this notion comes from the work of Janet Dubinsky and her colleagues at the University of Minnesota. Since 2000, this team of neuroscientists, educators and educational psychologists have developed and run a professional development programme called "Brain U" for in-service teachers at primarily the middle school level of instruction. The philosophy behind the "Brain U" professional developmental programme is that teaching teachers about fundamental concepts in neuroscience, especially brain plasticity, will change their understanding of the processes of learning and therefore learners in their classroom. This in turn will make them better teachers. As Dubinsky et al. put it: "The goal of bringing the neuroscience of learning to in-service teachers provides a new perspective on instruction, one where teachers come to see themselves as designers of experiences that ultimately change students' brains" (Dubinsky, Roehrig and Varma, 2013, p. 318). In this way the philosophy of "Brain U" is very closely related that which forms the core of the present framework for integrating neuroscience into teacher education.

The content of "Brain U" is based on the Society for Neuroscience's core concepts.[4] These core concepts are taught using an inquiry-based approach that was developed in collaboration between the neuroscientists, educators and educational psychologists behind the "Brain U" programme. One key aspect of "Brain U" is that the focus is on learning the neuroscience concepts. The programme does not focus on discussions of the relevance of these concepts for education and pedagogy, nor is it deliberately focused on covering a discussion of whether or not neuroscience can inform education and at what level. Instead, key concepts about the brain and how the brain learns and changes through learning are acquired through inquiry-based pedagogical approaches such as experiments, group discussions and model building. In this way, the programme does not involve direct instruction of neuroscience concepts through lecture formats, but instead involves activities that enable in-service teachers to collaboratively construct their understanding of core concepts in neuroscience.

As one might expect, teachers who participated in this programme gained a better understanding of neuroscience. In other words, the investigators found a significant difference in their neuroscience knowledge when comparing it before and after their participation in "Brain U". This finding is promising because it shows that teachers' knowledge of neuroscience increases, which may also make them less susceptible to inaccurate statements about the brain or so-called "neuromyths" (Dekker et al., 2012).

While such data clearly show that the "Brain U" professional development programme was effective when it came to enhancing teachers' understanding of the brain, such findings do not speak to the central prediction behind "Brain U", which is that, as the authors clearly state: "The neurobiology of learning, and in particular the core concept of plasticity, have the potential to directly transform teacher preparation and professional development, and ultimately affect how students think about their own learning" (Dubinsky, Roehrig and Varma, 2013, p. 317). To address this prediction, Dubinsky and her colleagues asked independent observers to code for categories of quality of classroom instruction in both classrooms taught by teachers who had been students in "Brain U" as well as a comparison group of teachers who had not yet taken part in "Brain U" professional development. The results of these observational studies suggest that participation in "Brain U" had a positive effect on broad indicators of classroom instruction such as developing students' "deep knowledge", "making connections to the world" and developing "higher-order thinking skills". In other words, the observers coded the classrooms taught by teachers who had been students in "Brain U" as higher on these categories compared to classrooms taught by the control teachers (those who had not yet participated in "Brain U").

While these results are promising and appear to support the central motivation behind the professional development programme, it should be noted that there are several limitations that point towards the need for future development. One of the key limitations, which Dubinsky and her colleagues acknowledge themselves, is that "Brain U" involves both the teaching of neuroscience concepts as well as partaking in inquiry-based pedagogical approaches to do so. In other words, it is possible that teachers who participated in "Brain U" absorbed some of the pedagogical design principles behind this professional development programme and used these in their future instruction, quite independently from the neuroscience content. While this possibility cannot be fully excluded, it seems somewhat unlikely given that teachers repeatedly reported that understanding core concepts in neuroscience bolstered their teaching beliefs through showing them that teaching changes the brain and motivated them to teach their students more about neuroscience in order to enhance their motivation to learn (by showing students that if you learn your brain changes – learning does not simply involve using the brain, it entails continually changing the brain to deal with new content and information).

Another closely related limitation of "Brain U" is that it did not use an active control group. To further pinpoint the specific effects of "Brain U" or similar professional development programmes it will be necessary to have a control group of teachers who also underwent professional development during the summer months, but participated in professional development programmes that did not focus on neuroscience but used similar pedagogical principles (i.e. inquiry-based pedagogy). The comparison between the effects of "Brain U" and such a control condition is absolutely critical to enable a better understanding of whether neuroscience instruction specifically leads to the observed changes in classroom practice, independently of the pedagogical approach used to instruct it.

It should be noted that "Brain U" has thus far been used in professional development with teachers who were predominantly from middle-school classrooms. Therefore, there is a need to also use this or a similar programme with elementary school teachers. In addition, it should be explored, as stated previously in this chapter, whether making neuroscience part of pre-service training has the same effect. The disadvantage of professional development is that it may not be available to all teachers. If neuroscience were to be integrated into pre-service teacher training, it could reach a larger group of teachers and could influence their practice from the very beginning.

In this context it will also need to be carefully considered exactly how the information will be taught. In "Brain U" an inquiry-based approach is used. This is a laudable strategy, but one that does require relatively small classes of teachers. Such a way of instruction may not be feasible for pre-service training in neuroscience and other means of delivery, including multi-media approaches to the delivery of materials. Therefore, there is a need to develop additional frameworks for the integration of evidence from cognitive neuroscience into pre-service education and to test the efficacy of such approaches for improving teaching and teachers pedagogical knowledge.

Summary

The last two decades have seen a tremendous growth in our understanding of the functioning of the human brain and how the brain relates to the way we think, feel and learn. Moreover, by studying human brain function across the lifespan, researchers are improving our understanding of how changes in brain function underpin developmental changes in cognition and emotion. In view of this growth in our understanding, there have,

and continue to be, calls for this scientific knowledge to inform education. In the above, we consider how the study of how the brain relates to cognition and learning and how this relationship changes over development might impact educators. It is clear that new evidence from studies in developmental cognitive neuroscience does not generate findings for teachers that are prescriptive. It would be naïve to assume that it is possible to go straight from "brain scan to lesson plan". Knowledge transfer involves a complex, collaborative and iterative process between researchers and stakeholders. In this way, it is necessary to provide the infrastructure that will enable researchers working on enhancing our understanding of brain development to work collaboratively with educators and educational researchers.

We contend that an important part of creating a new, evidence-based, collaborative culture in education that is, among other scientific areas, grounded in what we learn from developmental cognitive neuroscience, is the systematic integration of such evidence into teacher training to impact their pedagogical knowledge. We contend that such knowledge can give teachers better grounding to the decisions that they make in their classroom and a fuller understanding of their students. Such findings need to be translated. In the above, we provide examples of the kind of research findings and empirically-supported theories that could be included into teacher training. Research from developmental cognitive neuroscience and allied disciplines can support teachers' professional judgment and help them rethink the way they practice (e.g. if they learn about neurocognitive functions, such as the effect of working memory on learning, they may change practice in their classrooms). But research can only be translated if teachers actually have an understanding of the evidence base that exists, what to trust and how to evaluate it. They must play a role in the translation, as many neuroscience researchers may have no experience of pedagogy.

This paper is not meant be prescriptive in that it tells teachers that this piece of science translates to that kind of practice. Rather it argues for the potential integration of basic principles of developmental cognitive neuroscience and development into teacher training in order to foster teachers' knowledge that, in combination with their professional judgement and skills, may support their teaching activities.

Notes

1. Society for Neuroscience (www.sfn.org).
2. The OECD is not endorsing any specific conferences or books in connection with this research.
3. www.learningandthebrain.com; www.learner.org/courses/neuroscience/about/about.html
4. www.brainfacts.org/about-neuroscience/core-concepts/.see

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Chapter 10

Teaching, learning and assessing 21st century skills

by
James W. Pellegrino
Learning Sciences Research Institute, University of Illinois, Chicago

This chapter draws upon the report Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century (Pellegrino and Hilton, 2012) to address questions about why the terms labelled "deeper learning" and "21st century skills" have achieved prominence in the thinking and actions of multiple stakeholder groups and what we know from research to help us think productively about their educational and social implications.
In particular, the chapter considers issues of construct definition and identifies three important domains of competence – cognitive, intrapersonal and interpersonal. It then considers research evidence related to these domains including their importance for success in education and work, their representation in disciplinary standards, and the design of instruction in areas such as reading, mathematics and science to promote their development. It concludes with implications for curriculum, instruction, assessment, teacher learning and professional development.

Introduction

Across the globe there is substantial common interest in changing the landscape of education by promoting ideas that have come to be labelled as "deeper learning" and "21st century skills." But what do these terms mean, why have they achieved such a degree of prominence in the thinking, writing, and actions of stakeholder groups ranging from parents, to professional educators, to educational foundations, to state departments of education and the federal government, and what do we know from research that can help us think productively about their educational and social implications? These were the questions posed by various stakeholder groups to a Committee established by the U.S. National Research Council (NRC) in 2010. The response was a report entitled *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century"* (Pellegrino and Hilton, 2012). This chapter draws upon that work as a way of introducing some of the key ideas underpinning the teaching, learning and assessment of 21st century skills, especially as they relate to teacher education and teacher professional development.

Key rhetoric

Many countries, including members of the Organisation for Economic Co-operation and Development (OECD), have long recognised that investments in public education can contribute to the common good (namely by enhancing national prosperity and supporting stable families, neighbourhoods and communities). Likewise, current economic, environmental and social challenges illustrate that education is even more critical today than it has been in the past. Today's children can only meet future challenges if they have opportunities to prepare for their future roles as citizens, employees, managers, parents, volunteers and entrepreneurs. This calls for methods of learning that support not only retention, but also the use and application of skills and knowledge—a process called "transfer" in cognitive psychology – and herein lies the challenge.

As the Programme for International Student Assessment (PISA) has demonstrated, teaching students to apply their knowledge is no easy feat. In the 2009 PISA reading and science tests – which measured students' ability to analyse, reason and communicate effectively while posing, interpreting and solving problems – the scores of 15-year-olds in the U.S. were merely average when compared to students from the other industrialised nations comprising the OECD. In mathematics, their scores were below the OECD average (OECD, 2010). Part of the reason for the weak performance of American students is uneven learning and achievement among different groups of students. Disparities in the relative educational achievement of children from high-income versus low-income families have grown enormously since the 1970s (Duncan and Murnane, 2011). In a related trend, the gap between average incomes of the wealthiest and poorest families has also grown.

Business leaders, educational organisations and researchers have begun to call for new education policies that target the development of broad, transferable skills and knowledge, often referred to as "21st century skills" (e.g. see Bellanca, 2014). For example, the US-based Partnership for 21st Century Skills[1] argues that student success in college and

careers requires four essential skills: critical thinking and problem solving, communication, collaboration, and creativity and innovation (Partnership for 21st Century Skills, 2010: 2). The 2012 NRC Report argued that the various sets of terms associated with the "21st century skills" label reflect important dimensions of human competence that have been valuable for many centuries, rather than skills that are suddenly new, unique and valuable today. The important difference across time may lie in society's desire for all students to attain levels of mastery—across multiple areas of skill and knowledge—that were previously unnecessary for individual success in education and the workplace. At the same time, the pervasive use of new digital technologies has increased the pace of communication and information exchange throughout society with the consequence that all individuals may need to be competent in processing multiple forms of information to accomplish tasks that may be distributed across contexts that include home, school, the workplace and social networks.

Although these skills have long been valuable, they are particularly salient today, and are increasingly becoming a priority for education officials. In the U.S., multiple states have joined the Partnership for 21st Century Skills, based on a commitment to fuse 21st century skills with academic content (Partnership for 21st Century Skills, 2011) in their standards, assessments, curriculum and teacher professional development. Some state and local high school reform efforts have begun to focus on a four-dimensional framework of college and career readiness that includes not only academic content but also cognitive strategies, academic behaviours and contextual skills and awareness (Conley, 2011). At the international level, the U.S. Secretary of Education participates on the executive board of the Assessment and Teaching of 21st Century Skills (ATC21S) project, along with the education ministers of five other nations and the vice presidents of Cisco, Intel and Microsoft. This project aims to expand the teaching and learning of 21st century skills globally, especially by improving assessment of these skills. In a separate effort, a large majority of 16 OECD nations surveyed in 2009 reported that they are incorporating 21st century skills in their education policies, for example, in regulations and guidelines (Aniandou and Claro, 2009). Thus, it is clear that multiple stakeholder groups have been energised and mobilised to consider the problem as well as potential solutions.

In the next two sections we consider what might be meant by "21st century skills" – including how to organise these in ways that can be productive for educational practice and research – as well as how we might conceptualise the construct of "deeper learning".

Three domains of competence

As a way to organise the various terms for "21st century skills" and provide a starting point for considering empirical evidence as to their meaning and value, the NRC Report (Pellegrino and Hilton, 2012) identified three broad domains of competence: cognitive, intrapersonal and interpersonal. The cognitive domain involves reasoning and memory; the intrapersonal domain involves executive functioning (metacognition) and emotion; and the interpersonal domain involves expressing ideas, and interpreting and responding to messages from others.

A content analysis was conducted, aligning several lists of 21st century skills proposed by various groups and individuals with the skills included in existing, research-based taxonomies of cognitive, intrapersonal and interpersonal skills and abilities. Through this process, various 21st century skills were assigned to clusters of competencies within each domain. Recognising areas of overlap between and among the skills and skill clusters, the

committee developed the following initial classification scheme (see Chapter 2 of Pellegrino and Hilton, 2012 for additional details of the elements within each cluster):

- The **Cognitive Domain** includes three clusters of competencies: cognitive processes and strategies; knowledge; and creativity. These clusters include skills such as critical thinking, reasoning and argumentation, and innovation.
- The **Intrapersonal Domain** includes three clusters of competencies: intellectual openness; work ethic and conscientiousness; and self-regulation. These clusters include skills such as flexibility, initiative, appreciation for diversity and metacognition.
- The **Interpersonal Domain** includes two clusters of competencies: teamwork and collaboration; and leadership. These clusters include skills such as co-operation and communication, conflict resolution and negotiation.

These three domains represent distinct facets of human thinking and build on previous efforts to identify and organise dimensions of human behaviour. For example, Bloom's (1956) taxonomy of learning objectives included three broad domains: cognitive, affective and psychomotor. Following Bloom, the cognitive domain is viewed as involving thinking and related abilities, such as reasoning, problem solving and memory. The intrapersonal domain, like Bloom's affective domain, involves emotions and feelings and includes self-regulation—the ability to manage one's emotions and set and achieve one's goals (Hoyle and Davisson, 2011). The interpersonal domain is not included in Bloom's taxonomy but rather is based partly on an NRC workshop that clustered various 21st century skills into the cognitive, intrapersonal and interpersonal domains (National Research Council, 2011a). In that workshop, Bedwell, Salas and Fiore (2011) proposed that interpersonal competencies are those used to express information to others and to interpret others' messages (both verbal and nonverbal) and respond appropriately.

Distinctions among the three domains are reflected in how they are delineated, studied and measured. In the cognitive domain, knowledge and skills are typically measured with tests of general cognitive ability (also referred to as *g* or IQ) or with more specific tests focusing on school subjects or work-related content. Research on interpersonal and intrapersonal competencies often uses measures of broad personality traits (discussed further below) or of child temperament (general behavioural tendencies, such as attention or shyness). Psychiatrists and clinical psychologists studying mental disorders use various measures to understand the negative dimensions of the interpersonal and intrapersonal domains (Almlund et al., 2011).

Although the three domains are differentiated for the purpose of understanding and organising 21st century skills, it is recognised that they are intertwined in human development and learning. Research on teaching and learning has begun to illuminate how interpersonal and intrapersonal skills support learning of academic content (e.g. National Research Council, 1999) and how to develop these valuable supporting skills (e.g. Yeager and Walton, 2011). For example, we now know that learning is enhanced by the intrapersonal skills used to reflect on one's learning and adjust learning strategies accordingly—a process called "metacognition" (Pellegrino, Chudowsky and Glaser, 2001; Hoyle and Davisson, 2011). At the same time, research has shown that development of cognitive skills, such as the ability to stop and think objectively about a disagreement with another person, can increase positive interpersonal skills and reduce anti-social behaviour (Durlak et al., 2011). The interpersonal skill of effective communication is supported by the cognitive skills used to process and

interpret complex verbal and nonverbal messages and formulate and express appropriate responses (Salas, Bedwell and Fiore, 2011).

In many respects, the foregoing use of "competencies" reflects terminology used by the OECD in its extensive project to identify key competencies required for life and work in the current era. According to the OECD (2005), a competency is:

> *"more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilising psychosocial resources (including skills and attitudes) in a particular context. For example, the ability to communicate effectively is a competency that may draw on an individual's knowledge of language, practical IT skills, and attitudes towards those with whom he or she is communicating" (OECD, 2005: 4).*

Although research on how these 21st century competencies are related to desired outcomes in education, work and other areas of life has been limited, there are some promising findings. Cognitive competencies, which have been the most extensively studied, show consistent, positive correlations of modest size with students' achieving higher levels of education, higher earnings and better health. Among intrapersonal competencies, conscientiousness, which includes such characteristics as being organised, responsible and hard-working, shows the strongest relationship with the same desirable outcomes. Conversely, antisocial behaviour, which reflects deficits in both intrapersonal skills (such as self-regulation) and interpersonal skills (such as communication) is related to poorer outcomes.

More research is needed to increase our understanding of relationships between particular 21st century competen-cies and desired adult outcomes—and especially to look at whether the competencies are causing the desired outcomes rather than simply correlated with them. This much is known, however: mastery of academic subject matter is not possible without deeper learning. The next section considers the process of deeper learning and how 21st century competencies develop.

In summary, while many lists of 21st century skills have been proposed, there is considerable overlap among them. Many of the constructs included in such lists trace back to the original SCANS report (Secretary's Commission on Achieving Necessary Skills, 1991), and some now appear in the O*NET Content database. Aligning the various competencies with extant, research-based personality and cognitive ability taxonomies illuminates the relationships between them and suggests a preliminary, new taxonomy of 21st century competencies. Much further research is needed to more clearly define the competencies at each level of the proposed taxonomy, to understand the extent to which various competencies and competency clusters may be malleable, to elucidate the relationships among the competencies and desired educational and workplace outcomes, and to identify the most effective ways to teach and learn these competencies.

Deeper learning and 21st century competencies

The broad call for "deeper learning" and "21st century skills" reflects a long-standing issue in education and training – the difficult task of equipping individuals with transferable knowledge and skills. Associated with this is the challenge of creating learning environments that support development of the cognitive, interpersonal and intrapersonal competencies that enable learners to transfer what they have learned to new situations and new problems. These competencies include both knowledge in a domain and the understanding of how, why and when to apply this knowledge to answer more complex questions and solve

problems.—integrated forms of knowledge that we refer to as "21st century competencies" and discuss further below.

If the goal of instruction is to prepare students to accomplish tasks or solve problems exactly like the ones addressed during instruction, then deeper learning is not needed. For example, if someone's job calls for adding lists of numbers accurately, that individual needs to learn to become proficient in using the addition procedure, but does not need deeper learning about the nature of number and number theory that will allow transfer to new situations that involve the application of mathematical principles. Today's technology has reduced demand for such routine skills (e.g. Autor, Levy and Murnane, 2003). Rather, for success in work and life in the 21st century, individuals must be able to adapt effectively to changing situations rather than rely solely on well-worn procedures. If the goal is to prepare students to be able to be successful in solving new problems and adapting to new situations, then deeper learning is called for. Calls for such "21st century skills" as innovation, creativity and creative problem-solving can thus also be seen as calls for deeper learning—helping students develop transferable knowledge that can be applied to solve new problems or respond effectively to new situations.

To clarify the meaning of "deeper learning" and illuminate its relationship to 21st century competencies, it is critical to consider two important strands of research and theory on the nature of human thinking and learning – the *cognitive* perspective and the *socio-cultural* perspective (also referred to as the *situated* perspective [Greeno, Pearson and Schoenfeld, 1996]).

The cognitive perspective focuses on types of knowledge and how they are structured in an individual's mind, including the processes that govern perception, learning, memory and human performance. Research from the cognitive perspective investigates the mechanisms of learning and the nature of the products – the types of knowledge and skill – that result from those mechanisms, as well as how that knowledge and skill is drawn upon to perform a range of simple to complex tasks. The goal is theory and models that apply to all individuals, accepting the fact that there will be variation across individuals in execution of the processes and in the resultant products.

The socio-cultural perspective emerged in response to the perception that research and theory within the cognitive perspective was too narrowly focused on individual thinking and learning. In the socio-cultural perspective, learning takes place as individuals participate in the practices of a community, using the tools, language and other cultural artefacts of the community. From this perspective, learning is "situated" within, and emerges from, the practices in different settings and communities. A community may be large or small and may be located inside or outside of a traditional school context. It might range, for example, from colleagues in a company's Information Technology department to a single elementary school classroom, or a global society of plant biologists.

Such research has important implications for how academic disciplines are taught in school. From the socio-cultural perspective, the disciplines are distinct communities that engage in shared practices of ongoing knowledge creation, understanding and revision. It is now widely recognised that science is both a body of established knowledge and a social process through which individual scientists and communities of scientists continually create, revise, and elaborate scientific theories and ideas (National Research Council, 2007, Polanyi, 1958). In one illustration of the social dimensions of science, Dunbar (2000) found that scientists' interactions with their peers, particularly how they responded to questions from other scientists, influenced their success in making discoveries.

The idea that each discipline is a community with its own culture, language, tools and modes of discourse, has influenced teaching and learning. For example, Moje (2008) has called for re-conceptualising high school literacy instruction to develop disciplinary literacy programmes, based on research into what it means to write and read in mathematics, history and science, and what constitutes knowledge in these subjects. Moje (2008) argues that students' understanding of how knowledge is produced in the subject areas is more important than the knowledge itself.

Socio-cultural perspectives are reflected in new disciplinary frameworks and standards for primary and secondary education. For example, the NRC Framework for primary and secondary Science Education (NRC, 2012) calls for integrated development of science practices, crosscutting concepts and core ideas. The Common Core State Standards in English language arts (Common Core State Standards Initiative, 2010a) reflect an integrated view of reading, writing, speaking/listening, and language and also respond to Moje's (2008) call for disciplinary literacy by providing separate English language arts standards for history and science. Based on the view of each discipline as a community engaged in ongoing discourse and knowledge creation, the science framework and the standards in mathematics and English language arts include expectations for learning of interpersonal and intrapersonal knowledge and skills along with cognitive knowledge and skills (see Section IV below for further discussion of these disciplinary learning issues).

The link between deeper learning and 21st century competencies lies in the classic concept of transfer—the ability to use prior learning to support new learning or problem solving in culturally relevant contexts. We define "deeper learning" not as a "product", but rather as the process through which transferable knowledge (i.e. 21st century competencies) develops. Through deeper learning, individuals not only develop expertise in a particular discipline, they also understand when, how and why to apply what they know. They recognise when new problems or situations are related to what they have previously learned, and they can apply their knowledge and skills to solve them.

The history of research on transfer suggests that there are limits to how far the knowledge and skills developed through deeper learning can transfer. Firstly, transfer is possible within a subject area or domain of knowledge when effective instructional methods are used. Secondly, research on expertise suggests that deeper learning involves the development of well-organised knowledge in a domain that can be readily retrieved to apply (transfer) to new problems in that domain. Thirdly, research suggests that deeper learning requires extensive practice, aided by explanatory feedback that helps learners correct errors and practice correct procedures, and that multimedia learning environments can provide such feedback. Fourthly, the work of psychologists allows us to distinguish between rote learning and meaningful learning (or deeper learning). Meaningful learning (develops deeper understanding of the structure of the problem and the solution method) leads to transfer, while rote learning does not (Mayer, 2010).

We can also distinguish between different types of tests and the learning they measure. Retention tests are designed to assess learners' memory for the presented material using recall tasks (e.g. "What is the definition of deeper learning?") or recognition tasks (e.g. "Which of the following is not part of the definition of deeper learning? A. learning that facilitates future learning, B. learning that facilitates future problem solving, C. learning that promotes transfer, D. learning that is fun."). While retention and recognition tests are often used in educational settings, experimental psychologists use transfer tests to assess learners'

ability to use what they learned in new situations to solve problems or to learn something new (e.g. "write a transfer test item to evaluate someone's knowledge of deeper learning").

Although using the senses to attend to relevant information may be all that is required for success on retention tasks, success on transfer tasks requires deeper processing that includes organising new information and integrating it with prior knowledge. Results from the two different types of assessments can be used to distinguish between three different types of learning outcomes—no learning, rote learning and meaningful learning (see Table 10.1; also Mayer, 2010). No learning is indicated by poor performance on retention and transfer tests. Rote learning is indicated by good retention performance and poor transfer performance. Meaningful learning (which also could be called deeper learning) is indicated by good retention performance and good transfer performance. Thus, the distinguishing feature of meaningful learning (or deeper learning) is the learner's ability to transfer what was learned to new situations.

Table 10.1. **Three types of learning outcomes**

Type of Outcome	Retention Performance	Transfer Performance
No learning	Poor	Poor
Rote learning	Good	Poor
Meaningful (deeper) learning	Good	Good

Source: Mayer, R.E. (2010), *Applying The Science Of Learning*, Pearson.

Mayer (2010) suggests that deeper learning involves developing an interconnected network of five types of knowledge:

- facts, which are statements about the characteristics or relationships of elements in the universe
- concepts, which are categories, schemas, models or principals
- procedures, or step-by-step processes
- strategies (general methods)
- beliefs about one's own learning.

Mentally organising knowledge helps an individual to quickly identify and retrieve the relevant knowledge when trying to solve a novel problem (i.e. when trying to transfer the knowledge). According to Mayer (2010), the way in which a learner organises these five types of knowledge influences whether the knowledge leads to deeper learning and transfer. For example, factual knowledge is more likely to transfer if it is integrated, rather than existing as isolated bits of information, and conceptual knowledge is more likely to transfer if it is mentally organised around schemas, models, or general principles. As the research on expertise and the power law of practice would indicate, procedures that have been practiced until they become automatic and embedded within long-term memory are more readily transferred to new problems than those that require much thought and effort. In addition, specific cognitive and metacognitive strategies, discussed later in this chapter, promote transfer. Finally, development of transferable 21st century skills is more likely if the learner has productive beliefs about his or her ability to learn and about the value of learning. Table 10.2 outlines the cognitive processing of the five types of integrated knowledge and dispositions that, working closely together, support deeper learning and transfer.

Table 10.2. **Transferable knowledge**

Type of Knowledge	Format or Cognitive Processing
Factual	Integrated, rather than separate facts
Conceptual	Schemas, models, principles
Procedures	Automated, rather than effortful
Strategies	Specific cognitive and metacognitive strategies
Beliefs	Productive beliefs about learning

Source: Adapted from Mayer, R.E. (2010), *Applying The Science Of Learning*, Pearson.

Deeper learning involves co-ordinating all five types of knowledge. The learner acquires an interconnected network of specific facts, automates procedures, refines schemas and mental models, and refines cognitive and metacognitive strategies, while at the same time developing productive beliefs about learning. Through this process the learner develops transferable knowledge, which encompasses not only the facts and procedures that support retention but also the concepts, strategies, and beliefs needed for success in transfer tasks. We view these concepts, thinking strategies, and beliefs as 21st century skills.

This proposed model of transferable knowledge reflects research on development of expertise, which has distinguished differences in the knowledge of experts and novices in various academic domains such as physics, as well as other domains of knowledge and skills such as chess and medicine (see Table 10.3). Novices tend to store facts as isolated units, whereas experts store them in an interconnected network. Novices tend to create categories based on surface features, whereas experts create categories based in structural features. Novices need to expend conscious effort in applying procedures, whereas experts have automated basic procedures, thereby freeing them of the need to expend conscious effort in applying them. Novices tend to use general problem-solving strategies such as means–ends analysis, which require a backwards strategy starting from the goal, whereas experts tend to use specific problem-solving strategies tailored to specific kinds of problems in a domain, which involves a forward strategy starting from what is given. Finally, novices may hold unproductive beliefs, such as the idea that their performance depends on ability, whereas experts may hold productive beliefs, such as the idea that if they try hard enough they can solve the problem. In short, analysis of learning outcomes in terms of five types of knowledge has proven helpful in addressing the question of what expert problem solvers know that novice problem solvers do not.

Table 10.3. **Expert–novice differences on five kinds of knowledge**

Knowledge	Novices	Experts
Facts	Fragmented	Integrated
Concepts	Surface	Structural
Procedures	Effortful	Automated
Strategies	General	Specific
Beliefs	Unproductive	Productive

Source: Adapted from Mayer, R.E. (2010), *Applying The Science Of Learning*, Pearson.

Findings from a vast array of research have important implications for how to organise teaching and learning to facilitate deeper learning and development of transferable 21st century competencies. As summarised in another NRC report, (Pellegrino et al., 2001), research conducted over the past century has:

> *…. clarified the principles for structuring learning so that people will be better able to use what they have learned in new settings. If knowledge is to be transferred successfully, practice and feedback need to take a certain form. Learners must develop an understanding of when (under what conditions) it is appropriate to apply what they have learned. Recognition plays an important role here. Indeed, one of the major differences between novices and experts is that experts can recognise novel situations as minor variants of situations to which they already know how to apply strong methods (p. 87).*

For example, we know that experts' ability to recognise familiar elements in novel problems allows them to apply (or transfer) their knowledge to solve such problems. The research has also clarified that transfer is also more likely to occur when the person understands the underlying principles of what was learned. The models children develop to represent a problem mentally, and the fluency with which they can move back and forth among representations, are other important dimensions of transfer that can be enhanced through instruction. The main challenge in designing instruction for transfer is to create learning experiences for learners that will prime appropriate cognitive processing during learning without overloading the learner's information-processing system.

The connection to disciplinary learning and standards

Deeper learning and the development of 21st century competencies do not happen separately from learning academic content. Rather, deeper learning enables students to thoroughly understand academic content and to recognise when, how and why to apply that content knowledge to solve new problems. Thus, it is important to consider the relationship between concepts of deeper learning and 21st century competencies and the disciplinary standards documents that have been introduced in recent years for English Language Arts[2], Mathematics and Science (CCSS, 2010a, b; Achieve, 2013). Given that these standards will likely shape curriculum and instruction in the United States for many years to come, the 2012 NRC Report considered how each of the different disciplinary standards documents aligns with concepts of deeper learning and 21st century competencies as described earlier. What follows is a glimpse of that alignment for the area of English language arts, mathematics and science learning.

Deeper learning in English language arts

Discussions of how to teach reading and writing in the United States are often contentious, as reflected in the military metaphors used to describe them, such as "the reading wars". These "wars" reflect the two ends of a wide spectrum of opinions about how to develop reading for understanding. One approach, which can be called the "simple view of reading", holds that reading comprehension is the product of listening comprehension and decoding. Its proponents argue that students in the early grades should learn all of the letters of the alphabet and their corresponding sounds to a high degree of accuracy, until they are automatic. Once the code is mastered, students will further their understanding of the written word through wide reading of literature, which allows them to gather new ideas about the world.

The opposite position, which might best be called the utilitarian view of reading and writing, instead starts with the ultimate goal of reading in order to motivate children to learn the basic elements of reading. Proponents argue that, beginning in kindergarten, educators should engage children in a quest to make sense of their world through deep engagement with the big ideas that have puzzled humankind for centuries. Then, as they seek new information to understand and shape their world, students will need to use and refine their reading and writing skills. Once students feel the need to learn to read, proponents say, it will be much easier to teach them the decoding and other basic skills they need to transform print into meaning.

Rather than solidly favouring either of these approaches, the research consistently supports a balanced position that includes both approaches. This balance strongly stresses the basic skills of phonemic awareness, alphabet knowledge and decoding for accurate word learning in the early stages of reading development, but places an equal emphasis on reading for meaning at all stages of learning to read. Although there is strong support for emphasising the basics in the all-important early stages of reading, this emphasis need not preclude monitoring one's reading and writing to see if it makes sense or transferring the reading competencies to disciplinary learning tasks. As students mature and the demands of school curriculum focus more on acquiring disciplinary knowledge, the emphasis on reading for meaning increases.

The Four Resources Model

The Four Resources Model, developed by Australian scholars Freebody and Luke in the 1990s, can be useful in understanding the meaning of deeper learning in the context of English language arts. The model is a set of four different stances that readers can take toward a text, each of which approaches reading differently. A reader can assume any one of these four stances in the quest to make meaning in response to a text.

1. The reader as **decoder** asks: What does the text say? In the process, the reader builds a coherent understanding of the text by testing each idea encountered for its coherence with all of the previous ideas in the text.
2. The reader as **meaning maker** asks: What does the text mean? In answering that question, the reader seeks to develop meaning based on a) the ideas in the text itself, and b) the reader's prior knowledge.
3. The reader as **text analyst** asks: What tools does the author use to achieve his or her goals and purposes? The text analyst considers how the author's choice of words, form, and structure shape our regard for different characters or our stance towards an issue, a person, or a group. The reader goes beyond the words and tries to evaluate the validity of the arguments, ideas, and images that the author presents.
4. The reader as **text critic** asks questions about intentions, subtexts, and political motives. The text critic assumes that no texts are ideologically neutral, asking such questions as: Whose interests are served or not served by this text? Who is privileged, marginalised or simply absent? What are the political, economic, epistemological or ethical goals of the author?

Reading and writing simultaneously consist of code breaking, meaning making, analysing and critiquing. The stance a reader takes can change from text to text, situation to situation, and even moment to moment when reading a text. Which stance dominates at a particular moment depends on many factors, including the reader's level of knowledge about and interest in the topic and the purpose of the particular reading task.

Drawing on the four resources model, deeper learning in English language arts can be defined from two perspectives: (1) as favouring activities that are successively higher on the list—those in which the reader acts as meaning maker, text analyst or text critic; or (2) as favouring the management of all four stances based on the reader's assessment of the difficulty of the text or task and the purpose of the task. In other words, deeper learning means that a student understands when and why it is appropriate to use each stance, as well as how to do so. These two approaches are not mutually exclusive. Deeper learning could involve selecting a stance that elicits the skills and processes that best fit the situation or problem that a reader faces at a given moment as well as suggest a preference for incorporating the higher levels – those of the text analyst and critic – whenever it is possible and appropriate to do so.

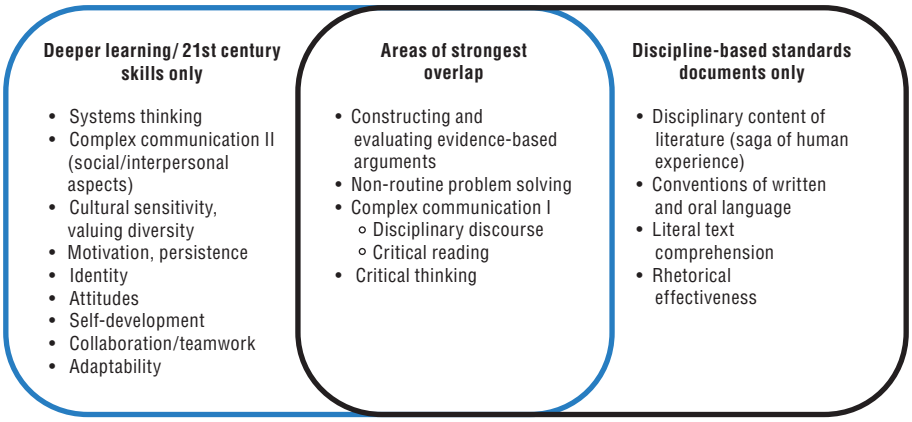
Deeper learning in the English language arts common core

The widely adopted Common Core State Standards in English language arts are highly supportive of deeper learning, as reflected in the four resources model. For example, the ten college and career readiness "anchor standards", which represent what high school graduates should know and be able to do, require students to be able to take all four stances toward a text: decoder, meaning maker, analyst and critic. The standards address the basics – including phonemic awareness, phonics and fluency – primarily in the foundational skills addendum to the standards for kindergarten through grade 5 (K-5). The standards also ask students to apply their developing reading skills to acquire disciplinary knowledge in literature, science, and history, especially in grades 6 through 12 – a significant shift away from treating reading as a separate subject.

The domain of cognitive competencies – including such skills as non-routine problem solving and critical thinking – is well represented in the standards, as the figure below shows. In contrast, serious consideration of the interpersonal and intrapersonal domains is missing. However, recent research in English language arts demonstrates the potential for developing competencies in these domains. Such work also illustrates the way in which the standards engage students in using reading, writing and language practice to acquire knowledge of the disciplines. These opportunities for additional practice of English language arts support deeper learning and transfer.

Figure 10.1. **English language arts**

Overlap between ELA Common Core State Standards and 21st Century Skills



Deeper learning in mathematics

Research studies provide a clear, consistent picture of typical school mathematics instruction in the United States. What we know is largely derived from two kinds of data and associated research analyses. One type of study that has been carried out over several decades has involved direct observation of classroom teaching (e.g. Hiebert et al., 2005; Stake and Easley, 1978; Stigler et al., 1999; Stodolsky, 1988), and another has used teacher self-reported data from surveys (e.g. Grouws, Smith and Sztajn, 2004; Weiss et al., 2001).

These studies present a remarkably consistent characterisation of mathematics teaching in upper elementary school and middle-grade classrooms in the United States: Students generally work alone and in silence, with little opportunity for discussion and collaboration and little to no access to suitable computational or visualisation tools. They focus on low-level tasks that require memorising and recalling facts and procedures rather than tasks requiring high-level cognitive processes, such as reasoning and connecting ideas or solving complex problems. The curriculum includes a narrow band of mathematics content (e.g. arithmetic in the elementary and middle grades) that is disconnected from real-world situations, and a primary goal for students is to produce answers quickly and efficiently without much attention to explanation, justification, or the development of meaning (e.g. Stigler and Hiebert, 1999; Stodolsky, 1988). Research evidence regarding how people learn best when the goal is developing understanding (National Research Council, 1999) strongly indicates that such pedagogy is at odds with goals aimed at deeper learning and transfer.

Although this pervasive approach to mathematics teaching has not been directly established as the cause of the generally low levels of student achievement, it is difficult to deny the plausibility of such a connection. In response, an array of reform initiatives has been aimed at changing what and how mathematics is taught and learned in American schools. While the reformers disagree over some issues, they share the goal of giving students more opportunities to learn what is called "mathematics with understanding". As summarised in Silver and Mesa, (2011: 69), teaching mathematics for understanding is sometimes referred to as:

> *…authentic instruction, ambitious instruction, higher order instruction, problem-solving instruction, and sense-making instruction (e.g. Brownell and Moser, 1949; Brownell and Sims, 1946; Carpenter, Fennema, and Franke, 1996; Carpenter et al., 1989; Cohen, 1990; Cohen, McLaughlin, and Talbert, 1993; Fuson and Briars, 1990; Hiebert and Wearne, 1993; Hiebert et al., 1996; Newmann and Associates, 1996). Although there are many unanswered questions about precisely how teaching practices are linked to students' learning with understanding (see Hiebert and Grouws, 2007), the mathematics education community has begun to emphasize teaching that aims for this goal.*

Studies over the past 60 years provide a solid body of evidence about the benefits of teaching mathematics in this way. Hallmarks of teaching mathematics for understanding include using:

1. **Cognitively demanding mathematical tasks drawn from a broad array of content areas**. Although research has shown that it is not easy for teachers to use cognitively demanding tasks well in classrooms, those tasks can lead to increased student understanding, the development of problem solving and reasoning, and greater overall student achievement.

2. **Teaching practices that support collaboration and mathematical discourse** among students and that engage them in mathematical reasoning and explanation, consideration of real-world applications, and use of technology or physical models.

The latest reform effort in the United States targeting mathematics for understanding has been the **Common Core State Standards for Mathematics**. If widely implemented, the new standards would enable a giant leap forward in the development of mathematics with understanding.

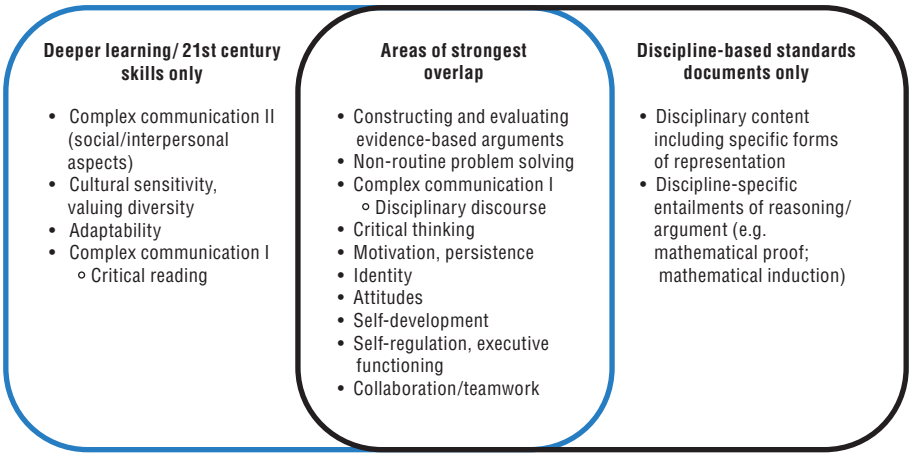
Deeper Learning in Common Core Mathematics Standards. The new Common Core standards emphasise deeper learning of mathematics, learning with understanding, and the development of usable, transferable mathematics competencies. By identifying several important learning goals – critical thinking, problem solving, constructing and evaluating evidence-based arguments, systems thinking and complex communication – these new standards emphasise the deeper learning of mathematics and the development of transferable numerical competencies.

As shown in the figure below, these standards correspond most strongly with 21st century competencies in the cognitive domain. The two most prominent areas of overlap are in the themes of argumentation/reasoning and problem solving. These themes are central to mathematics and have long been viewed as key leverage points in efforts to teach mathematics for understanding. The theme of argumentation/reasoning is explicitly stated in two of the standards for mathematical practice: "Reason abstractly and quantitatively" and "Construct viable arguments and critique the reasoning of others". The standards also deal explicitly with problem solving; the first standard in the category of mathematical practice is "make sense of problems and persevere in solving them".

Unlike competencies in the cognitive domain, those in the intrapersonal and interpersonal domains are not particularly prominent in the standards. However, the standards for mathematical practice give some attention to the intrapersonal competencies of self-regulation, persistence and the development of an identity as someone who can do mathematics.

Figure 10.2. **Mathematics**

Overlap between Common Core State Standards in Mathematics and 21st Century Skills



Deeper learning in science

As with the English language arts and mathematics, how best to teach science has often been a matter of controversy. Conflicts over science education have traditionally been about the relative importance of content (facts, formulas, concepts and theories) versus process (scientific method, inquiry and discourse). Historically, science teaching in American classrooms has placed a heavy emphasis on content— generally in the form of memorising isolated facts. In an attempt to correct this overem-phasis, reformers in the 1990s shifted the focus to "inquiry." This reform effort, however, led to unintended consequences due to insuf-ficient understanding of the nature of scientific inquiry, which came to be associated primarily with hands-on science. While hands-on activities can be effective if they are designed with clear learning goals and are thoughtfully integrated with the learning of science content, such integration is not typical in American high schools. Instead, overemphasis on hands-on activities has led to the neglect of other aspects of scientific inquiry such as critical reasoning, analysis of evidence, development of models and written and oral discourse.

In addition, some advocates for hands-on science have tended to treat scientific methodology as divorced from content. Many students, for instance, are introduced to a generic "scientific method", which is presented as a fixed linear sequence of steps that students are often asked to apply in a superficial or scripted way, designed to produce a particular result. This approach to the scientific method often distorts the processes of inquiry as they are actually practiced by scientists. In the work of scientists, content and process are not disconnected. Rather, they are deeply intertwined: Scientists view science as both a body of established knowledge and an ongoing process of discovery that can lead to revisions in that body of knowledge. Sophisticated science learning involves students' learning both content knowledge and process skills in a simultaneous, mutually reinforcing way.

Science in current classrooms

As with mathematics, today's science classrooms generally do not reflect the research on how students learn science. The standard curriculum has been criticised as being "a mile wide and an inch deep". Large science textbooks cover many topics with little depth, providing little guidance on how to place the learning of science concepts and processes in the context of meaningful real-world problems. As teachers try to cover the broad curriculum, they give insufficient attention to students' understanding and instead focus on superficial recall-level questions.

Similarly, at the high school level, laboratory activities that typically take up about one science class period each week are disconnected from the flow of science instruction. Instead of focusing on clear learning objectives, laboratory manuals and teachers often emphasise procedures, leaving students uncertain about what they are supposed to learn. Furthermore, these activities are rarely designed to integrate the learning of science content and processes. During the rest of the week, students spend time listening to lectures, reading textbooks and preparing for tests that emphasise recall of disparate facts.

Making matters worse, during the past decade, time and resources for science education in the US have often been cut back because of the No Child Left Behind law. Since this legislation does not count science test scores when measuring the yearly progress of schools, the emphasis has been on English and mathematics.

Deeper learning in the K-12 science education framework

An attempt to better integrate scientific content and processes and to focus on depth rather than breadth of knowledge began with the 2012 release of the National Research Council's *Framework for K-12 Science Education*. The framework explains in detail what all students should know and be able to do in science by the end of high school. Standards based on the framework have been developed by a group of states, coordinated by the non-profit organisation "Achieve". An overarching goal expressed in the framework is to ensure that all students—whether or not they pursue careers in the fields of science, technology, engineering and mathematics (STEM)—have "sufficient knowledge of science and engineering to engage in public discussions on related issues, are careful consumers of scientific and technological information related to their everyday lives, and are able to continue to learn about science outside of school". In other words, the goal is the development of transferable science knowledge.

The framework has three dimensions, which are conceptually distinct but are integrated in practice in the teaching, learning, and doing of science and engineering:

1. **Disciplinary core ideas**. By identifying and focusing on a small set of core ideas in each discipline, the framework attempts to reduce the long and often disconnected catalogue of factual knowledge that students currently must learn. Core ideas in physics include energy and matter, for example, and core ideas in the life sciences include ecosystems and biological evolution. Students encounter these core ideas over the course of their school years at increasing levels of sophistication, deepening their knowledge over time.
2. **Cross-cutting concepts**. The framework identifies seven cross-cutting concepts that have importance across many disciplines, such as patterns, cause and effect, and stability and change.
3. **Practices**. Eight key science and engineering practices are identified, such as asking questions (for science) and defining problems (for engineering); planning and carrying out investigations; and engaging in argument from evidence.

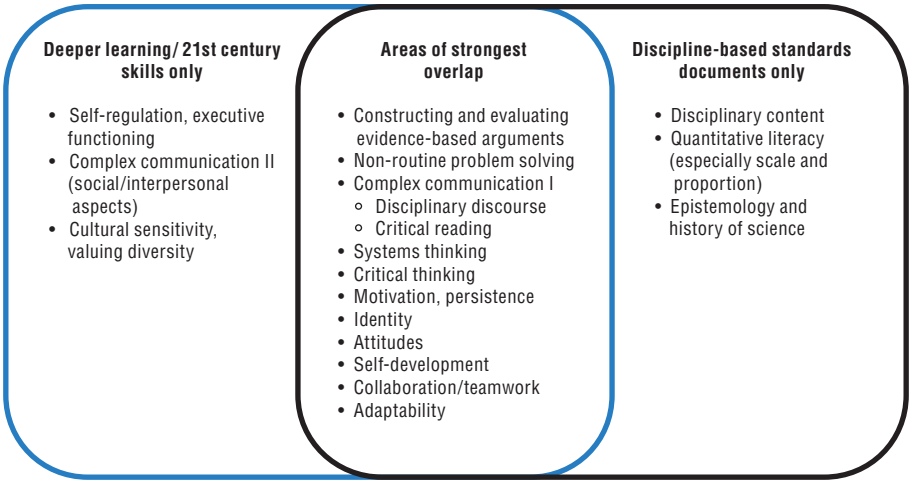
The framework emphasises that disciplinary knowledge and scientific practices are intertwined and must be coordinated in science and engineering education. By engaging in the practices of science and engineering, students gain new knowledge about the disciplinary core ideas and come to understand the nature of how scientific knowledge develops.

The figure below shows areas of overlap between the framework and 21st century skills. Cognitive skills—especially critical thinking, non-routine problem solving, and constructing and evaluating evidence-based arguments—are all strongly supported in the framework, as is complex communication. In the domain of interpersonal skills, the framework provides strong support for collaboration and teamwork; a prominent theme is the importance of understanding science and engineering as a social enterprise conducted in a community, requiring well-developed skills for collaborating and communicating. The framework also supports adaptability, in the form of the ability and inclination to revise one's thinking or strategy in response to evidence and review by one's peers.

In terms of intrapersonal skills, the framework gives explicit support to metacognitive reasoning about one's own thinking and working processes, as well as the capacity to engage in self-directed learning about science and engineering throughout one's lifetime. Support for motivation and persistence, attitudes, identity and value issues, and self-regulation is weaker or more indirect.

Figure 10.3. **Science and engineering**

Overlap between *A Framework for K-12 Science Education* and 21st Century Skills



The foregoing summary of the alignment between the Common Core Standards in English language arts, mathematics and the National Research Council Framework for Science Education with concepts of deeper learning and 21st century competencies highlights that in all three cases the standards focus on key disciplinary ideas and practices of the type that promote deeper learning that in turn can support transfer. While they have a decided bias towards cognitive competencies, as one might expect given the disciplinary focus, they do not ignore nor do they contradict an emphasis on integration of the cognitive competencies with those in the interpersonal and the intrapersonal domains.

Teaching for transfer

While the evidence indicates that various cognitive competencies are teachable and learnable in ways that promote transfer, such instruction remains rare in American classrooms; few effective strategies and programmes to foster deeper learning exist. Research and theory suggest a set of principles that can guide the development of such strategies and programmes, as discussed below. It is important to note that the principles are derived from research that has focused primarily on transfer of knowledge and skills within a single topic area or domain of knowledge.

How can teachers aid students' deeper learning of subject matter and promote transfer? Addressing this seemingly simple question has been a central task of researchers for more than a century, and in the past several decades they have made progress toward evidence-based answers. Applying the instructional principles below will aid students' deeper learning of subject-matter content in any discipline. Because deeper learning takes time and repeated practice, instruction aligned with these principles should begin in preschool and continue across all levels of learning, from kindergarten through college and beyond. Teaching in these ways will make it more likely that students will come to understand the general principles underlying the specific content they are learning and be able to transfer their knowledge to solve new problems in the same subject area. These principles and practices are based on research in the cognitive domain. They have not been studied in terms of developing transferable competencies in the interpersonal and intrapersonal domains, but it is plausible that they are applicable.

Use multiple and varied representations of concepts and tasks, and help students understand how different representations of the same concept are "mapped" or related to one another. Research has shown that adding diagrams to a text or adding animation to a narration that describes how a mechanical or biological system works can increase students' performance on a subsequent problem-solving transfer test. In addition, allowing students to use concrete objects to represent arithmetic procedures has been shown to increase their performance on transfer tests. This finding has been shown both in classic studies in which bundles of sticks are used to represent two-column subtraction and in an interactive, computer-based lesson in which students move a bunny along a number line to represent addition and subtraction of numbers.

Encourage elaboration, questioning and self-explanation. The techniques of elaboration, questioning, and self-explanation require students to actively engage with the material—going beyond memorising to process the content in their own words. Some specific techniques that have been shown to aid deeper learning include:

- prompting students who are reading a text to explain the material to themselves aloud, in their own words, as they read
- asking students certain questions about material they have just read or been taught—such as why, how, what if, what if not, and so what
- using teaching practices that establish classroom norms of students' questioning each other and justifying their answers
- asking learners to summarise what they have learned in writing
- having students test themselves without external feedback, for example, by asking themselves questions about material they have just read.

Engage learners in challenging tasks, with supportive guidance and feedback. Over 40 years of research has shown that asking students to solve challenging problems in science and other disciplines without appropriate guidance and support is ineffective at promoting deeper learning. In contrast, asking students to solve challenging problems while providing specific cognitive guidance along the way does promote deeper learning. For example, there is no compelling evidence that beginners deeply learn science concepts or processes simply by freely exploring a science simulation or game, but if they receive guidance in the form of advice, feedback, and prompts—for example, completing part of the task for the learner—they are more likely to learn the content deeply.

Teach with examples and cases. Using examples and cases can help students see how a general principle or method is relevant to a variety of situations and problems. One approach is a worked-out example, in which a teacher models how to carry out a procedure—for example, solving probability problems—while explaining it step by step. Offering worked-out examples to students as they begin to learn a new procedural skill can help them develop deeper understanding of the skill. In particular, deeper learning is facilitated when the problem is broken down into conceptually meaningful steps that are clearly explained; the explanations are gradually taken away with increasing practice.

Prime student motivation. Another way to promote deeper learning is to prime students' motivation so that they are willing to exert the effort to learn. Research shows that students learn more deeply when they:

- attribute their performance to effort rather than to ability
- have the goal of mastering the material rather than the goal of performing well or not performing poorly

- expect to succeed on a learning task and value the learning task
- believe they are capable of achieving the task at hand
- believe that intelligence is changeable rather than fixed
- are interested in the task.

There is promising evidence that these kinds of motivational approaches can be fostered in learners through such techniques as peer modelling. For example, elementary school students showed increased self-confidence (an intrapersonal competency) for solving subtraction problems and increased test performance after watching a peer demonstrate how to solve subtraction problems while exhibiting high self-efficacy (such as saying "I can do that one" or "I like doing these").

Use formative assessment. A formative assessment is one that is used throughout the learning process to monitor students' progress and adjust instruction when needed, in order to continually improve student learning. It is different from traditional "summative" assessment, which focuses on measuring what a student has learned at the end of a set period of time. Deeper learning is enhanced when formative assessment is used to:

- make learning goals clear to students
- continuously monitor, provide feedback, and respond to students' learning progress
- involve students in peer- and self-assessment.

These uses of formative assessment are grounded in the research demonstrating that practice is essential for deeper learning and skill development, while practice without feedback yields little learning. Formative assessment involves a change in instructional practice: It is not a regular part of most teachers' practice, and teachers' pedagogical content knowledge may be an impediment to its realisation (Heritage et al., 2009; Herman, Osmundson and Silver, 2010).

Learning goals and targets of assessment

Educational interventions may reflect different theoretical perspectives on learning and may target different skills or domains of competence. In all cases, however, the design of instruction for transfer should start with a clear delineation of the learning goals and a well-defined model of how learning is expected to develop (NRC, 2001). The model—which may be hypothesised or established by research—provides a solid foundation for the coordinated design of instruction and assessment aimed at supporting students' acquisition and transfer of targeted competencies.

Designing measures to evaluate student accomplishment of the particular learning goals can be an important starting point for the development process because outcome measures can provide a concrete representation of the ultimate student learning performances that are expected and of the key junctures along the way, which in turn can enable the close coordination of intended goals, learning environment characteristics, programmatic strategies, and performance outcomes. Such assessments also communicate to educators and learners—as well as designers—what knowledge, skills, and capabilities are valued (Resnick and Resnick, 1992; Herman, 2008). An evidence-based approach to assessment rests on three pillars that need to be closely synchronised (Pellegrino et al., 2001: 44):

- A *model* of how students represent knowledge and develop competence in a domain
- Tasks or situations that allow one to *observe* student performance relative to the model
- An *interpretation* framework for drawing inferences from student performance.

Developing that first pillar—a model of the learning outcomes to be assessed—offers a first challenge in the assessment of cognitive, intrapersonal, and interpersonal competencies. Within each of these three broad domains, theorists have defined and conducted research on a wealth of individual constructs. In the previous sections we noted that the research literature on cognitive and non-cognitive competencies has used a wide variety of definitions, particularly in the intrapersonal and interpersonal domains. Questions remain, however, about the implications of these definitions. For example, the range of contexts and situations across which the learning of these competencies should transfer remains unclear.

A second challenge arises from the existing models and methodologies for observing and interpreting students' responses relative to these constructs. It is widely acknowledged that most current large-scale measures of educational achievement do a poor job of reflecting deeper learning goals in part because of constraints on testing formats and testing time (Webb, 1999). While a variety of well-developed exemplars exist for constructs in the cognitive domain, those for inter- and intrapersonal competencies are less well developed. Below, we briefly discuss examples of measures for each domain of competence (for a fuller discussion of this topic see NRC 2011a).

Measures of cognitive competence. Promising examples of measures focused on important cognitive competencies can be found in national and international assessments, in training and licensing tests, and in initiatives currently underway in American grades K–12. One example is the computerised problem-solving component of the Programme for International Student Assessment (PISA), which was operationally administered in 2012 (National Research Council, 2011b). In this 40-minute test, items are grouped in units around a common problem, which keeps reading and numeracy demands to a minimum. The problems are presented within realistic, everyday contexts, such as refuelling a moped, playing on a handball team, mixing a perfume, feeding cats, mixing elements in a chemistry lab, and taking care of a pet. The difficulty of the items is manipulated by increasing the number of variables or the number of relationships that the test taker has to deal with.

Scoring of the items reflects the PISA 2012 framework, which defines four processes that are components of problem solving: (1) information retrieval, (2) model building, (3) forecasting, and (4) monitoring and reflecting. Points are awarded for information retrieval, based on whether the test taker recognises the need to collect baseline data and uses the method of manipulating one variable at a time. Scoring for the process of model building reflects whether the test taker generates a correct model of the problem. Scoring of forecasting is based on the extent to which responses to the items indicate that the test taker has set and achieved target goals. Finally, points are awarded for monitoring and reflecting, which includes checking the goal at each stage, detecting unexpected events, and taking remedial action if necessary.

Another promising example of assessment of complex cognitive competencies, created by the National Council of Bar Examiners, consists of three multi-state examinations that jurisdictions may use as one step in the process of licensing lawyers. The three examinations are the Multi-state Bar Exam (MBE), the Multi-state Essay Exam (MEE), and the Multi-state Performance Test (MPT). All are paper-and-pencil tests that are designed to measure the knowledge and skills necessary to be licensed in the profession and to ensure that the newly licensed professional knows what he or she needs to know to practice. These overarching goals reflect an assumption that law students need to have developed transferable knowledge that they will be able to apply when they become lawyers.

These and other promising examples each start with a strong model of the competencies to be assessed; use simulated cases and scenarios to pose problems that require extended analysis, evaluation, and problem solving; and apply sophisticated scoring models to support inferences about student learning. The PISA example, in addition, demonstrates the dynamic and interactive potential of technology to simulate authentic problem-solving situations.

The PISA problem-solving test is one of a growing set of examples that use technology to simultaneously engage students in problem solving and assess their problem-solving skills. Another example is "SimScientists", a simulation-based curriculum unit that includes a sequence of assessments designed to measure student understanding of ecosystems (Quellmalz, Timms and Buckley, 2010). The SimScientists summative assessment is designed to measure middle-school students' understanding of ecosystems and scientific inquiry. Students are presented with the overarching task of describing an Australian grassland ecosystem for an interpretive centre and respond by drawing food webs and conducting investigations with the simulation. Finally, they are asked to present their findings about the grasslands ecosystem. SimScientists also includes elements focusing on transfer of learning, as described in a previous NRC report (National Research Council, 2011b; 94).

To assess transfer of learning, the curriculum unit engages students with a companion simulation focusing on a different ecosystem (a mountain lake). Formative assessment tasks embedded in both simulations identify the types of errors individual students make, and the system follows up with graduated feedback and coaching. The levels of feedback and coaching progress from notifying the student that an error has occurred and asking him or her to try again, to showing the results of investigations that met the specifications.

Students use this targeted, individual feedback to engage with the tasks in ways that improve their performance. Practice is essential for deeper learning, but knowledge is acquired much more rapidly if learners receive information about the correctness of their results and the nature of their mistakes.

Combining expertise in content, measurement, learning, and technology, these assessment examples employ evidence-centred design and are developing full validity arguments. They reflect the emerging consensus that problem solving must be assessed as well as developed within specific content domains (as discussed in the previous section; also see National Research Council, 2011a). In contrast, many other current technology-based projects designed to impact student learning lack a firm assessment or measurement basis (National Research Council, 2011b).

Project and problem-based learning and performance assessments that require students to engage with novel, authentic problems and to create complex, extended responses in a variety of media would seem to be prime vehicles for measuring important cognitive competencies related to transfer. What remains to be seen, however, is whether the assessments are valid for their intended use and if the reliability of scoring and the generalisability of results can achieve acceptable levels of rigor, thereby avoiding validity and reliability problems that have existed in the past with complex performance assessments (e.g. Linn et. al., 1995; Shavelson, Baxter and Gao, 1993).

Measures of interpersonal and intrapersonal competence. There are few well-established practical assessments for interpersonal competencies that are suitable for use in schools, with the exception of tests designed to measure those skills related to formal written and oral communication. Some large-scale measures of collaboration were developed as part of performance assessments during the 1990s, but the technical quality of such measures

was never firmly established. The development of those assessments revealed an essential tension between the nature of group work and the need to assign valid scores to individual students. Today there are examples of teacher-developed assessments of teamwork and collaboration being used in classrooms, but technical details are lacking.

Most well-established instruments for measuring interpersonal competencies have been developed for research and theory-building or for employee selection purposes, rather than for use in schools. These instruments tend to be one of four types: surveys (self-reports and informant reports), social network analysis, situational judgment tests, or behavioural observations (Salas, Bedwell and Fiore, 2011). Potential problems arise when applying any of these methods to large-scale educational assessment, to which stakes are often attached. Stakes are high when significant positive or negative consequences are applied to individuals or organisations based on their test performance – consequences such as high school graduation, grade to grade promotion, specific rewards or penalties and special programme placement. Stakes attached to large-scale assessment results heighten the need for reliability and validity as well as attention to concerns such as security and feasibility in terms of cost and administration conditions. Each of the instrument types has limitations relative to these criteria. Self-report, social network analysis, and situational judgment tests, which can provide relatively efficient, reliable, and cost-effective measures, are all subject to social desirability bias, the tendency to give socially desirable and socially rewarded rather than honest responses to assessment items or tasks. Some situational judgment tests used for employee selection are carefully designed to correct for social desirability bias. However, if any of these three types of assessment instruments were used for educational purposes, where high stakes consequences were attached to the results, social desirability bias would likely be heightened.

Behavioural ratings, in contrast, present challenges in assuring reliability and cost feasibility. For example, if students' interpersonal skills are assessed based on self, peer, or teacher ratings of student presentations of portfolios of their past work (including work as part of a team), a number of factors may limit the reliability and validity of the scores. These include differences in the nature of the interactions reflected in the portfolios for different students or at different times, differences in raters' application of the scoring rubric, differences in the groups with whom individual students have interacted, and other differences. This lack of uniformity in the sample of interpersonal skills included in the portfolio poses a threat to both validity and reliability (National Research Council, 2011a). Dealing with these threats to reliability takes additional time and money, beyond that required for simply presenting and scoring student presentations.

Collaborative problem-solving tasks currently being evaluated by PISA offer one of the few examples today of a direct, large-scale assessment targeting social and collaboration competencies; other prototypes are under development by the ATC21S project and by the military. The quality and practical feasibility of any of these measures are not yet fully documented. However, like many of the promising cognitive measures, these rely on the abilities of technology to engage students in interaction, to simulate others with whom students can interact, to track students' ongoing responses, and to draw inferences from those responses.

As is the case with interpersonal skills, many of the existing instruments for the measurement of intrapersonal skills have been designed for research and theory development purposes and thus have the same limitations for large-scale educational uses as the instruments for measuring interpersonal skills. These instruments include

surveys (self-reports and informant reports), situational judgment tests, and behavioural observations. As with the assessment of interpersonal competencies, it is possible that evidence of intrapersonal competencies could be elicited from the process and products of student work on suitably designed complex tasks. For example, project or problem-based performance assessments theoretically could be designed to include opportunities for students to demonstrate metacognitive strategies or persistence in the face of obstacles. Student products could be systematically observed or scored for evidence of the targeted competencies and then these scores could be counted in student grades or scores on end-of-year accountability assessment. To date however, strong design methodologies, interpretive frameworks, and approaches to assuring the score reliability, validity, and fairness have not been developed for such project or problem-based performance assessments.

In summary, there are a variety of constructs and definitions of cognitive, intrapersonal and interpersonal competencies, and a paucity of high-quality measures for assessing them. All of the examples discussed above are measures of maximum performance, rather than of typical performance (see Cronbach, 1970). They measure what students *can* do rather than what they *are likely to* do in a given situation or class of situations. While the cognitive domain usually focuses on measures of maximum performance, typical performance (i.e. what students are likely to do) may be the primary focus of measures for some inter and intrapersonal competencies. For example, measures of dispositions and attitudes related to conscientiousness, multi-cultural sensitivity and persistence could be designed to assess typical performance. In comparison to measures of maximum performance, measures of typical performance require more complex designs and tend to be less stable and reliable (Paltry, 2011).

By way of summary, the variety of definitions of constructs across the three domains of competence, and the lack of high-quality measures pose challenges for teaching, assessment and learning 21st century competencies. Some of these challenges are further considered in the next section.

Implications and challenges

Current teaching practices in many classrooms in the US and elsewhere across the globe do not encourage deeper learning of subject matter. Helping students develop the full range of 21st century competencies— including those in the interpersonal and intrapersonal domains—will require changes across many elements of the education system, including curriculum, instruction, assessment, and teacher education and professional development.

In the area of curriculum and instruction, further research and development is needed to create more specific instructional materials and strategies that can help develop transferable competencies. Future curricula, inspired by the concept of deeper learning, should integrate learning across the cognitive, interpersonal and intrapersonal domains in whatever ways are most appropriate for the targeted learning goals. Multiple stakeholder groups should actively support the development and use of curriculum and instructional programmes that include research-based teaching methods to support deeper learning, such as those discussed earlier in this chapter.

In the area of assessment, research has shown that assessment and feedback play an essential role in the deeper learning of cognitive competencies. In particular, ongoing formative assessment by teachers can provide guidance to students that supports and extends their learning, encouraging deeper learning and development of transferable competencies. Current educational policies, however, focus on summative assessments that

measure mastery of content and often hold schools and districts accountable for improving student scores on such assessments. Although this focus on summative assessment poses a challenge to the wider teaching and learning of 21st century competencies, recent policy developments do appear to open the window for a wider diffusion of interventions to develop such competencies. For example, a previous section of this chapter noted that the new Common Core State Standards and the *Framework for K–12 Science Standards* include facets of 21st century competencies.

While new national goals that encompass 21st century competencies have been articulated in the Common Core State Standards for English language, arts and mathematics, and in the NRC's science standards framework, the extent to which these goals are realised in educational settings will be strongly influenced by their inclusion in district, state and national assessments. Because educational policy remains focused on outcomes from summative assessments that are part of accountability systems, teachers and administrators will focus instruction on whatever is included in state assessments. Thus, as new assessment systems are developed to reflect the new standards in English language arts, maths, and science, significant attention will need to be given to the design of tasks and situations that call upon a range of important 21st century competencies as applied in each of the major content areas.

Although improved assessments would facilitate a wider focus on teaching approaches that support the development of 21st century competencies, there are a number of challenges to developing such assessments. First, research to date has focused on a wide variety of different constructs in the cognitive, intrapersonal, and interpersonal domains. Although the taxonomy presented earlier offers a useful starting point, further research is needed to more carefully organise, align and define these constructs. There are also psychometric challenges. Although progress has been made in assessing cognitive skills, much further research is needed to develop assessments of intrapersonal and interpersonal skills that are suitable for both formative and summative assessment uses in educational settings. Experiences during the 1980s and 1990s in the development and implementation of performance assessments and assessments with open-ended tasks can offer valuable insights, but assessments must be reliable, valid, and fair if they are to be widely used in formal and informal learning environments.

A third challenge involves political and economic forces influencing assessment development and use. Traditionally, policy makers have favoured the use of standardised, on-demand, end-of-year tests for purposes of accountability. Composed largely of selected response items, these tests are relatively cheap to develop, administer and score; have sound psychometric properties; and provide easily quantifiable and comparable scores for assessing individuals and institutions. However, such standardised tests have not been conducive to measuring or supporting the process of deeper learning nor to the development of 21st century competencies. In the face of current fiscal constraints at the federal and state levels, policymakers in the US may seek to minimise assessment costs by maintaining lower-cost, traditional test formats, rather than incorporating into their systems relatively more expensive, richer performance- and curriculum-based assessments that may better measure 21st century competencies. The fourth challenge involves teacher and administrator capacity to understand and interpret the new assessments. The features of instruction and assessment discussed earlier in this chapter are not well known to teachers, students or school administrators.

In the areas of teacher education and professional development, current systems and programmes will require major changes if they are to support teaching that encourages deeper learning and the development of transferable knowledge and skills. Changes will need to be made not only in the conceptions of what constitutes effective professional practice but also in the purposes, structure and organisation of pre-service and professional learning opportunities (Darling-Hammond, 2006; Garrick and Rhodes, 2000; Lampert, 2010; Webster-Wright, 2009). For example, Windschitl (2009) proposed that developing 21st century competencies in the context of science will require ambitious new teaching approaches that will be unlike the science instruction that most teachers have participated in or even witnessed.

To address these teacher learning challenges, Wilson (2011), Windschitl (2009) and others have recommended replacing current, disjointed teacher learning opportunities with more integrated continuums of teacher preparation, induction, support and ongoing professional development. Within such a continuum, Windschitl (2009) proposed that teacher preparation programmes should centre on a common core curriculum grounded in a substantial knowledge of child or adolescent development, learning and subject-specific pedagogy. It was suggested that such programmes should also provide future teachers with extended opportunities to practice under the guidance of mentors (student teaching), lasting at least 30 weeks, that reflect the programme's vision of good teaching and that are interwoven with coursework.

Research to date has identified other characteristics of effective teacher preparation programmes, including extensive use of case study methods, teacher research, performance assessments and portfolio examinations that are used to relate teachers' learning to classroom practice (Darling-Hammond, 1999). Deeper learning and the acquisition of 21st century skills—for both teachers and their students—might also be supported through preparation programs that help new teachers make effective use of study groups, peer learning, managed classroom discussions and disciplined discourse routines (Ghousseini, 2009; Monk and King, 1994). Wilson (2011) and others have noted that one of the most promising practices for both induction and professional development involves bringing teachers together to analyse samples of student work, such as drawings, explanations or essays, or to observe videotaped classroom dialogues. Working from principled analyses of how the students are responding to the instruction, the teachers can then change their instructional approaches accordingly.

Windschitl (2009) identified a number of features of professional development that could help science teachers implement new teaching approaches to cultivate students' 21st century skills in the context of science. These features are:

- active learning opportunities focusing on science content, scientific practice and evidence of student learning (Desimone et al., 2002)
- coherence of the professional development with teachers' existing knowledge, with other development activities, with existing curriculum and with standards in local contexts (Garet et al., 2001; Desimone et al., 2002)
- the collective development of an evidence-based "inquiry stance" by participants towards their practice (Blumenfeld et al., 1991; Kubitskey and Fishman, 2006)
- the collective participation by teachers from the same school, grade or subject area (Desimone et al., 2002)
- adequate time, both for planning and enacting new teaching practices.

More broadly, across the disciplines, pre-service teachers and in-service teachers will need opportunities to engage in the kinds of teaching and learning environments envisioned in this chapter and in the 2012 NRC report. Experiencing instruction designed to support transfer will help them to design and implement such environments in their own classrooms. Teachers will also need opportunities to learn about different approaches to assessment and the purposes of these different approaches. As noted earlier, most teachers are not familiar with formative assessment and do not regularly incorporate it in their teaching practice (Heritage et al., 2009; Herman, Osmundson and Silver, 2010).

In thinking about the implications of the work discussed in this chapter, it is worth reminding ourselves that 21st century competencies support learning of school subjects in particular and educational attainment more generally. Thus, more explicit attention to the development of these skills in school curricula could potentially reduce disparities in educational attainment and allow a broader swathe of young people to enjoy the fruits of workplace success, improved health and greater civic participation. However, important challenges remain for attaining such outcomes. For educational interventions focused on developing transferable cognitive, intrapersonal and interpersonal competencies to move beyond isolated promising examples and to flourish more widely, larger systemic issues and policies will need to be addressed, including new types of assessment systems, new curricula that incorporate research-based features such as those described above and new approaches to teacher preparation and professional development.

Notes

1. This non-profit organisation includes business, education, community, and governmental groups.
2. We use English language arts to exemplify developing competency in language arts in whatever is an individual's first language and their primary language of learning and instruction.

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Chapter 11

Knowledge-based teaching and the evolution of a profession

by
Sonia Guerriero and Nóra Révai
OECD

This chapter brings together the theoretical and empirical evidence presented in this volume to draw conclusions on how teacher quality can be measured. First we look at the main elements of the teaching profession as the context for investigating teachers' knowledge. Second, we provide a brief overview of the evidence of the impact of teachers' knowledge and motivation and conclude with future directions for research. Next, we present a new conceptual framework of teachers' professional competence that builds on the evidence gathered in this volume and is developed to feed into an international comparative study. Last, we conclude with implications on governing teachers' knowledge and formulate three main challenges teacher policies should address in the future.

The purpose of this book has been to review theoretical and empirical research on what constitutes quality teaching thus contributing to the conceptual development of the *Innovative Teaching for Effective Learning* (ITEL) project of the Centre for Educational Research and Innovation of the OECD. This chapter draws on the research presented in this volume and proposes a new conceptual framework of teachers' professional competence that can be the basis for further investigations.

Understanding what exactly characterises a profession and how teaching is seen among professions provides a rationale for investigating teachers' knowledge. The first part of this volume looked at some key characteristics of this knowledge and how it manifests in teachers' professional standards. The second part explained how teachers' competence can be modelled by bringing together components of knowledge as well as affective and motivational characteristics, and reviewed empirical evidence on how these models are applied to measure the quality of teaching. The third part considered how emerging evidence can potentially be incorporated in teachers' knowledge to facilitate 21st century teaching and learning.

The context of teacher knowledge: the teaching profession

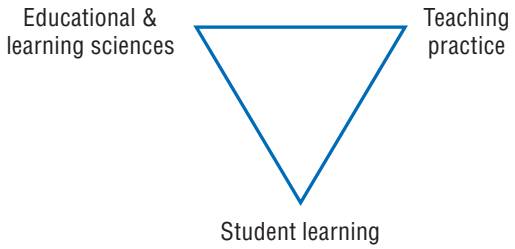
Evidence of the key role teachers play in the success of school systems is growing (e.g. Barber and Mourshed, 2007; Darling-Hammond, 2000; OECD, 2005, 2015a), while at the same time expectations regarding teachers are becoming increasingly more complex. Teachers are no longer merely expected to transmit information, rather they need to facilitate that all students acquire the knowledge and skills and adopt the attitudes that enable them to become citizens who live a life they value and who can effectively contribute to the 21st century society (Hargreaves, 2000; OECD 2015b; Lumby, 2013). As education needs to adapt to an environment characterised by changes in society, the labour market, technology etc., teachers are required to revisit and update their skills continuously (Eurydice, 2015). New requirements and challenges formulated in various policy documents and reports (e.g. OECD, 2010; Eurydice, 2003, 2015; Education and Training 2020 Schools Policy, 2015) include:

- adapting to technological development and using information and communication technologies
- meeting the individual needs of increasingly heterogeneous groups of students
- stimulating and managing student learning processes
- promoting human rights and civic education
- developing transversal competencies, or 21st century skills
- helping students to become lifelong learners
- collaborating with colleagues and other professionals
- being involved in administrative and school management tasks
- developing and maintaining an approach towards education based on reflection, inquiry etc.

A review of how teachers' competences are described in standards in Chapter 3 revealed some common characteristics and requirements of the profession. These standards understand competence as a broad concept referring to the capacity to use and adapt knowledge. Teacher competences involve encouraging diversity in practice and addressing innovation in teaching. Being able to adapt to different students and environments, engaging students, using various forms of evaluation and classroom management are shared elements of teachers' competence across the professional standards. Standards that distinguish different professional stages describe increasingly more complex requirements as teachers progress in their careers.

The nature and variety of these demands imply that teachers must now become lifelong learners to be able to make professional judgements in their daily practice based on knowledge that is updated and robust, in order to facilitate student learning. This depiction of teaching corresponds to how Brante (2010) describes a profession, based on a Foucauldian approach as a triangle of three elements. Teaching would thus be described as the ensemble of educational and learning sciences that constitute the "scientific discourse" shaped by scientists; teaching practice, that is, the "treatment" applied by professionals; and students, i.e. the "object" or "client". Relations among these elements refer to the process whereby educational and learning sciences study student learning through observation, manipulation and discussions, and teachers apply this science so as to induce learning. The professional triangle of teaching is depicted in Figure 11.1.

Figure 11.1. **The professional triangle of teaching**



Source: Based on Brante, T. (2010), "Professional Fields and Truth Regimes: In Search of Alternative Approaches".

Building and grounding practice in a coherent and integrated knowledge base is a fundamental characteristic of professions and, as the review of the first two chapters suggests, teaching still lacks such a knowledge base. Going beyond the trait approaches to defining a profession, reviewed in Chapter 1, Brante (2010) attempts to describe the type of scientific knowledge that distinguishes professions from other occupations. He argues that science and professional practice are linked by a common "ontological model", i.e. basic assumptions about the elements of the system and their relations that constitute the foundational theoretical concepts shared by science and practice. Translated for teaching, this would comprise pedagogical mechanisms that are accounted for by educational and learning sciences and applied by teachers. Following Brante's argument, teachers therefore possess knowledge of mechanisms of teaching and learning but have to make judgements about which ones and how they should use in a given context, or how to alter the context to make the right mechanisms work. This implies that teachers also refer to their tacit knowledge in a professional situation.

However, scientific knowledge, or more generally cognitive competence, is only one aspect of a profession. As we have seen in the first three chapters, the professional triangle is embedded in a social field and its elements are influenced by a range of social processes (e.g. Brante, 2010; Freidson, 2001; Hoyle, 1995; Howsam et al., 1985). Teachers are socialised to professional values through both formal training and other forms of competence development. Teachers' knowledge is dynamic and transforms as a result of various processes including mediation between research and practice, and interactions between actors of the socio-professional field. Moreover, a number of social technologies such as accountability systems, instruments like qualification and standard frameworks also influence teachers' professionalism.

Many of these aforementioned social processes are connected to teacher learning and the different settings in which it takes place. Initial teacher education is usually situated in an institution where educational and learning researchers and teacher educators – these are often overlapping roles – meet, transfer and, in some cases, co-create knowledge with teacher candidates. These institutions can also accommodate professional development for in-service teachers and provide opportunities for facilitating interaction between research and practice. We have also seen in Chapter 2 that knowledge-to-action processes can take a variety of forms including teachers' active involvement in research, professional collaboration or networking. Reviews in the first part of this volume clearly demonstrate that its social "embeddedness" is a determining factor of the profession.

The contextual overview suggests that the teaching profession would benefit both from more consciously governed social processes and from a strengthened knowledge base. To understand how these can be facilitated, the second part of this book "zoomed in" on the professional triangle that Figure 11.1 depicts, to investigate more deeply its different elements and the relationships between them. It looked at conceptualisations of teachers' knowledge and, more broadly, their competence, what content exactly constitutes these concepts as well as how they relate to student learning. The following consists of a brief summary of the evidence presented in Part II of this volume and, proposes a conceptual framework of teachers' professional competence.

Theoretical and empirical evidence on teachers' competence

Much research has been devoted to exploring the impact of the teacher on student achievement. These studies explore the concept of "teacher quality" by hypothesising that improving teacher quality will by consequence improve student achievement. The research to date shows that teacher quality is an important factor in determining gains in student achievement, even after accounting for prior student learning and family background characteristics (e.g. Darling-Hammond, 2000; Hanushek, Kain and Rivkin, 1998; Muñoz, Prather and Stronge, 2011; Wright, Horn and Sanders, 1997). Predictors of teacher quality have included factors such as certification, type of qualification, degrees earned or years of experience.

Why investigate teachers' pedagogical knowledge?

Research has however also investigated quality beyond measuring distal factors. These studies look more specifically at teachers' competences directly. One way to do this is to measure the underlying knowledge of teachers. In his seminal work on the structure

and content of teacher knowledge, Shulman (1986, 1987) categorised teachers' knowledge base into seven categories, among which were the concepts of:

1. **general pedagogical knowledge** (principles and strategies of classroom management and organisation that are cross-curricular)
2. **content knowledge** (knowledge of subject matter and its organising structures)
3. **pedagogical content knowledge** (the knowledge which integrates the content knowledge of a specific subject and the pedagogical knowledge for teaching that particular subject).

This latter was considered as the most fundamental element of teachers' knowledge because it gave rise to the idea that teachers held a unique form of "technical" knowledge available only to the profession of teachers (Ball, Thames and Phelps, 2008; Depaepe, Verschaffel and Kelchtermans, 2013). As demonstrated in Chapter 4 by Guerriero, Shulman's conceptual framework heavily influenced research conducted on teachers' knowledge and it has been further developed in various ways. Much of the empirical studies built on some form of this framework focused on the pedagogical content knowledge (PCK) of mathematics or science teachers. In contrast, general pedagogical knowledge has not been the object of many research studies even though several studies indicate that it is essential for developing quality teachers.

Some of the most important implications of the few empirical studies are summarised in Table 11.1.

Table 11.1. **The impact of teachers' knowledge on student achievement and instruction**

Main finding	Details
A higher level of teachers' content knowledge is related to higher student achievement.	While a significant relationship was evidenced between the quality of teachers' content knowledge of mathematics and student achievement gains, teachers' certification and mathematics courses taken were not significantly related to this letter nor to the mathematical content knowledge for teaching (Hill, Rowan and Ball, 2005).
A higher level of teachers' pedagogical content knowledge is related to higher student achievement (Baumert, Kunter, Blum, et al., 2010)	
Teachers' pedagogical content knowledge has more of an impact on student achievement than content knowledge alone (Baumert, Kunter, Blum, et al., 2010).	
Only pedagogical content knowledge (in comparison to content knowledge) seems to have an impact on the quality of instruction.	PCK of mathematics was found to influence the • cognitive level • curricular level (being able to align the material with the curriculum) and • learning support (that teachers are able to provide when learning difficulties occur) dimensions of instructional quality. Content knowledge predicted the curricular level of tasks. Higher levels of content knowledge had no direct impact on cognitive activation or on the individual learning support. (Baumert, Kunter, Blum, et al., 2010)
A higher level of general pedagogical knowledge is related to higher quality of instruction.	Students of teachers with higher general pedagogical knowledge reported • higher cognitive activation • better instructional pacing • better student-teacher relationships • fewer disruptions and • higher teacher awareness of students' comprehension problems (Voss, Kunter and Baumert, 2011).

Evidence reviewed in this volume suggests that despite the considerable history of discussion and debate around the connection between teacher knowledge and instructional quality, empirical research is still scarce in this area. While further research is needed to support this relationship, existing evidence suggests that teachers' pedagogical knowledge is relevant to understanding quality teaching as understood by its impact on student learning outcomes. On the other hand, evidence also shows that the quality of instruction requires not only knowledge about teaching and learning, but is also influenced by teachers' affective, motivational and self-regulatory characteristics.

Why investigate teachers' affective-motivational characteristics?

Teachers' motivation represents a relatively new field of research, which started to build on established theoretical frameworks of motivational processes only recently. As the review of research in Chapter 8 by Lauermann shows, teachers' motivations have important implications for the profession, among others, for professional commitment, well-being as well as instructional practices. Studies also suggest that teacher motivation is central to student motivation and academic success. Although various approaches to the conceptualisation of motivation exist, a general definition of motivation, is "the process whereby goal-directed activity is instigated and sustained" (Schunk, Pintrich and Meece, 2008, p. 4). According to this definition, motivation is a process, and as such it needs to be inferred from actions rather than products. The goal-oriented nature of the motivational process implies awareness of something that individuals would like to attain or avoid. In the context of teaching, motivation is oriented towards teaching-related activities, tasks and outcomes that teachers strive to attain or avoid (Lauermann, this volume).

A review of the conceptual and empirical literature on teacher motivation is showing the following implications:

Table 11.2. **The various impacts of teacher motivation**

Main finding	Details
Teacher motivation is related to their pedagogical knowledge and decision-making strategies enabling the use of high-quality instructional practices.	The following has been reported: • A positive association between teacher motivation and general pedagogical knowledge (König and Rothland, 2012). • Positive associations between teacher motivation and the teacher or student-reported use of certain instructional practices (those emphasising student learning, mastery-oriented instruction, cooperative learning and student differentiation) (e.g. Ciani, Summers and Easter, 2008; Lauermann, 2015; Thoonen et al., 2011a; Thoonen et al., 2011b). • A positive relationship is between teacher motivation and teacher or student-reported cognitive activation of students, classroom management, individual learning support by the teacher and positive teacher-student relationships (e.g. Butler, 2012; Butler and Shibaz, 2014; Holzberger, Philipp and Kunter, 2013, 2014; Kunter and Baumert, 2006; Kunter et al., 2008)
Teacher motivation is related to teachers' willingness to take advantage of learning opportunities and to engage in professional development. As such, teacher motivation can be conceptualised as both an antecedent and a concomitant of professional knowledge.	Teacher motivation is positively related to: • willingness for professional learning, keeping up-to-date and a positive attitude toward professional development (e.g. Nitsche et al., 2013; Thoonen et al., 2011a). • positive perceptions of seeking help and a preference for receiving help (e.g. Butler, 2007; Nitsche et al., 2011).
Teacher motivation is related to the motivation, performance and well-being of students.	Positive relationships were reported between the following: • teachers' motivational characteristics and students' self-reported enjoyment and achievement in mathematics as assessed by the 2003 cycle of PISA. reported a positive relationship between (even after controlling for prior achievement) (Kunter et al., 2013); • teacher motivation and student-reported well-being in the school (Thoonen et al., 2011b)
Teacher motivation is related to teachers' professional and psychological well-being and job satisfaction.	• Motivation is related to indicators of teachers' well-being, such as burnout, stress, job satisfaction, positive work environment, as well as persistence in teaching.

The studies reviewed above indicate that teacher motivation is an important factor in high-quality instruction and is positively related to student achievement. While the research on teacher motivation is still relatively new, the theoretical constructs are based on established and empirically-tested theories of motivation used in research on student achievement (Lauermann, this volume). Most importantly, research is beginning to show that teacher learning that is designed to support teachers' motivational characteristics is more successful in changing teacher behaviour for implementing new instructional strategies (e.g. Tschannen-Moran and McMaster, 2009).

Challenges and directions for future research

Studies reviewed in Part II of this volume clearly demonstrate the value of conceptualising teachers' competence as a multidimensional construct. Besides their subject-specific and pedagogical knowledge, teachers' affective-motivational characteristics, such as motivation play a role in teacher quality. Furthermore, a comprehensive model of teachers' competence includes the transformation of knowledge into practice. Situational perception, interpretation and decision-making skills are such mediating processes. While accumulating evidence shows the significant impact of teachers' knowledge on the quality of instruction and student achievement, empirical data that allows cross-country comparisons on these relationships are still scarce (Blömeke, this volume). Similarly, research on teacher motivation is to date underdeveloped, and many questions remain to be addressed in future work.

Although we still lack data and evidence, prior research provides a good basis for future studies. Existing research provides theoretical frameworks that capture the main components of teachers' competence and on which further research can be built. Reliable and valid instruments to assess teachers' cognitive resources such as their pedagogical knowledge and to measure their motivational characteristics are available. As Blömeke argues, building on existing comparative studies and instruments also has the advantage of connecting new results to existing ones. Nonetheless, several methodological and theoretical challenges have been highlighted in this volume.

Methodological challenges, described in Chapter 8 by Lauermann and Chapter 5 by Blömeke, include various issues. Firstly, establishing clear cause and effect relationships is difficult for several reasons. The majority of available evidence is correlational and cross-sectional. Also, different aspects of teachers' professional competence can be highly interrelated, causing further difficulties in disentangling their effects. Similarly, social and psychological phenomena and outcomes are typically interrelated, resulting in mutual influence rather than clear predictors and outcomes. This is especially problematic in the absence of sufficiently large samples and longitudinal data. Secondly, analyses of the impact of teachers' professional competence on the instructional process and on student outcomes necessitate linking teacher and student data. Such study designs and analyses are challenging and costly. Thirdly, the assessment of situation-specific skills entails methodologies such as direct observation of behaviour or video-based assessments that require considerable resources. Furthermore, whether such approaches work across different cultures is an open question.

Theoretical challenges include the direct adaptation of certain frameworks from other domains. For example, as Lauermann argues, research on teacher motivation has largely been inspired by research with students. Assuming that that motivational factors that influence students' performance on academic tasks are the same as those influencing performance of teaching tasks is not entirely justified because of clear differences between the two groups.

It is clear that further research on teachers' competences as an indicator of teacher quality is needed. Existing frameworks and instruments provide stable grounds for further development to address research gaps and challenges.

Conceptual framework of teachers' professional competence

This volume will feed into an international comparative study to be conducted in the OECD's ITEL project that will investigate teachers' knowledge as a crucial component of teacher quality. Based on the evidence reviewed here, this section presents a conceptual framework of teachers' professional competence that serves as the basis for the international study. Although the scope of the study will be narrowed in comparison to what is presented here, it is important to develop a broad framework that incorporates main research findings in the field.

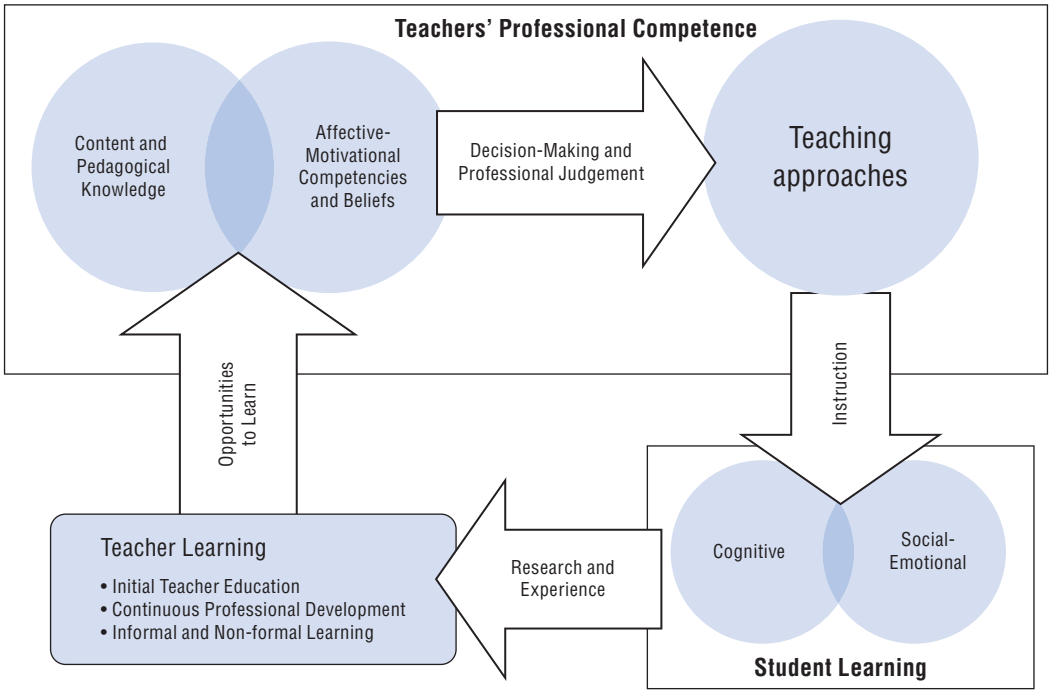
Scholars have conceptualised knowledge and learning in various ways. The cognitive psychological approach understands knowledge as a property of an individual mind, and learning as growth in knowledge, i.e. constructing or acquiring knowledge (Mulcahy, 2012; Paavola, Lipponen and Hakkarainen, 2004). Another approach originates in social constructivism and views knowledge as being distributed over groups of individuals and their environment, and emphasises the situated nature of learning. For teachers this would mean a co-construction of knowledge through the interaction of their prior knowledge and beliefs, and the events and activities in which they participate (Hardy, 2010; Mulcahy, 2012). Learning in this sense is participatory and is situated in teachers' activities. Literature in the field is vast including work on communities of practice, professional learning communities and learning organisations (e.g. Lave and Wenger, 1991; Gherardi, 2006; Kools and Stoll, 2016). Finally, a more recent approach to conceptualising knowledge and learning is a socio-material perspective, which, instead of only focusing on human interactions, also takes into account the material environment. This is a whole system approach that understands knowledge and learning as embedded in the action and interaction of human actors, teachers for example, and material elements such as texts, instruments or technologies. Knowledge is inherently dynamic and emerges together with, as well as in the activities and practices of teachers (Fenwick, Nerland and Jensen, 2012; Mulcahy, 2012).

In an effort to investigate teachers' knowledge, the different approaches would require different methodologies. For example, exploring socially constructed knowledge can benefit from qualitative case studies conducted in professional learning communities, or social network analysis that can provide a visual map and analytical understanding of the structure of teachers' knowledge exchange mechanisms. Since some of these methods would require considerable resources when applied large scale in international context, the ITEL study chose to focus on individual teachers' characteristics as a first step towards exploring teachers' knowledge.

As a result of the scope of the ITEL study, namely to explain student achievement by individual teachers' characteristics, the evidence reviewed here focused on the knowledge and competences of the individual teacher following a predominantly psychological approach combining cognitive and motivational theories. The conceptual framework we are proposing is based on the body of work reviewed in this book, grounded in the empirical and conceptual research in the areas of pedagogical knowledge, the instructional process and the professional competences underlying quality teaching.

The conceptual framework (Figure 11.2) is positioned within a larger framework of teachers' professional competence. We define competence, similarly as in Chapter 3, as a broad term referring to the ability to meet complex demands in a given context by mobilising various psychosocial (cognitive, functional, personal and ethical) resources. In this sense competence is dynamic and process-oriented, and includes the capacity to use and to adapt knowledge.

Figure 11.2. **Conceptual framework of teachers' professional competence**



In fact, the framework expands the professional triangle presented above by focusing on the relationships between the three elements: science, practice and student learning. Educational and learning sciences construct knowledge by investigating, among others, how students learn, and what characterises teaching and learning processes. The dynamic knowledge base is transferred to and co-constructed by teachers through their individual and collective learning. This is denoted by the node "teacher learning".

Teacher learning

The framework is founded on the basis that high-quality initial teacher education is just the first step in a continuous process of professionalisation which also involves continuous professional development and the regular updating of teachers' knowledge and skills through informal and non-formal learning. Initial teacher preparation is a crucial site to initiate teachers into the foundations of knowledge and skills about teaching and learning. Further to the scientific content taught in teacher education programmes, this would also include opportunities for pre-service teachers to actively participate in the process of research and inquiry, to learn how to interpret, validate and apply research. This latter is guaranteed through access to experiential opportunities that allow applying knowledge in practice. It is initial preparation that provides teacher candidates with the opportunity to

observe professionals in their teaching roles, to practice teaching accompanied by mentors and to learn reflecting on their practice.

However, as argued above, teachers need to be lifelong learners in order that they can meet the complex expectations set in a rapidly changing environment. Formal continuous professional development courses provide them with opportunities to broaden and update their knowledge base regularly. Moreover, non-formal learning, such as national or international conferences and seminars, school-based knowledge sharing workshops, structured professional collaboration are key for teachers to build and also adapt knowledge and skills to their particular context. Informal learning, such as practical experiences in teaching, has been shown as essential in acquiring as well as interiorising knowledge. To include all the different forms and scenes of teacher's opportunities to learn, the framework uses the broad term of "teacher learning".

The above opportunities to learn shape teachers' professional competences on a continuous basis. Competence, as in Chapter 3, is viewed as comprehensive and flexible that comprises the complexity of teachers' action and is able to capitalise on learning opportunities that happen in different contexts. We now look at the specific elements that constitute teachers' professional competence based on the evidence reviewed in the volume.

Teachers' competence

The framework models teachers' professional competence as a multi-dimensional construct. Evidence clearly indicates that mastering the complex tasks of a teacher necessitates different types of psychosocial resources (Weinert, 2001). Based on the model proposed in Chapter 5, we distinguish between cognitive resources and affective-motivational factors. The former refers to the professional knowledge base of teachers and includes content and pedagogical knowledge. These elements of knowledge encompass the three categories of Shulman described above: (i) knowledge of the subject, (ii) knowledge of the teaching and (iii) learning processes particular to that specific subject and general knowledge of teaching and learning that is cross-curricular. While the framework acknowledges the importance of all of these, evidence seems the scarcest on the third element. It is therefore recommended that an international study on teachers' knowledge should focus most strongly on general pedagogical knowledge.

Besides knowledge, a range of affective-motivational and self-regulatory characteristics also influence teachers' instructional practices and their professional behaviours and are related to student achievement (Blömeke and Delaney, 2012; Lauermann, this volume). While research is still underdeveloped in this area, initial results summarised above suggest that motivational factors contribute to quality teaching. For example, motivation has implications for teachers' well-being, instructional practices and students' academic and socio-emotional outcomes. Affective-motivational competencies include different dimensions of teacher motivation such as career choice motivation, achievement motivation and goal orientation, but also teachers' beliefs about their subject area, about teaching and learning, as well as their perceptions of teaching and of the profession (e.g. Blömeke and Delaney, 2012; König and Rothland, 2012; Lauermann, this volume). Another strand of research presented in Chapter 5 shows relationships between teachers' self-efficacy and their professional responsibility on the one hand and instructional practices on the other. These need to be taken into account when investigating teacher quality, and are included under the broad category of affective-motivational competences and beliefs in the framework.

Decision-making and professional judgement

Professional knowledge base and affective-motivational competences alone do not account for the complexity of the teaching activity. A teacher must be able to use their pedagogical knowledge to make rapid decisions in the classroom. Evidence suggests that in order to make informed pedagogical decisions, teachers must be able to analyse and evaluate specific learning episodes, in combination with contextual and situational factors (e.g. students' prior knowledge, ability level, motivational factors, lesson objectives, curriculum goals) and to be able to connect all this information to their technical knowledge of the teaching-learning process in order to guide subsequent teaching actions (Blömeke, Gustafson and Shavelson, 2015).

In an international study the characteristics of the context may vary strongly across countries, thus situation specific skills that mediate between teachers' knowledge and teaching practices must be taken into consideration (Baumert et al., 2010; Blömeke, Gustafsson and Shavelson, 2015). These skills are referred to under the broad term of decision-making and professional judgement in the conceptual framework.

Theoretical frameworks developed in the field of expertise research, reviewed in Chapter 4, 5 and 6, use the concepts of noticing, perception, reasoning, interpretation, decision-making and professional vision to describe these situation-specific skills. Teacher's ability to identify classroom situations that are decisive for instructional practice is often referred to as "noticing" or "perception". Once, the specific situation is identified, teachers need to process and interpret the events to which their attention is directed. "Reasoning" refers to the process and act of interpretation based on their knowledge of teaching and learning. Three facets of the reasoning process were summarised in Chapter 4 based on the work of Seidel and colleagues (Seidel et al., 2011):

1. *the ability to describe what has been noticed*
2. *higher-order processes to connect the observed classroom event to prior knowledge and understanding of teaching and learning*
3. *knowledge-based reasoning processes to evaluate and predict what might happen as a result of connecting the observed situation to prior knowledge of teaching and learning.*

Teachers make pedagogical decisions as a result of various contextual elements including wider school policies, the students in question as well as specific classroom events based on their knowledge. In order that such decisions result in instructional practices that effectively facilitate student learning, noticing and reasoning require a high level of pedagogical knowledge about effective teaching and student learning processes on the one hand, and the ability to apply such knowledge for planning and implementing instruction to the current situation on the other (Stürmer, Könings and Seidel, 2013). Shalem (2014) also highlights the importance of theoretical knowledge in teacher's judgement and argues that locating teachers' judgement in their practice would mean neglecting the role of a formal and systematic knowledge base. Therefore the conceptual framework represents decision-making and professional judgement as the link between formal knowledge and competencies and teaching.

Teaching approaches and instruction

Teaching approaches include the strategy a teacher decides to adopt as a result of his or her professional judgement. These are understood here as particular ways of organising and managing the teaching and learning process. They are not limited to what actually

happens in the classroom, rather encompass the broad strategies on curriculum and lesson planning, selecting and applying sets of teaching methods, ways of classroom management, student assessment and so on. Instruction or teaching practice is, in turn, the concrete implementation of the teaching approaches. It refers to the way the pedagogical approaches are manifested in the teacher's interactions with the students, his or her behaviour, as well as in the tools and materials used in the classroom. It is through instruction that the complex assemblage of teaching competences finally reach students.

Student learning

Preserving the primarily psychological approach to describe the teaching and learning process, the framework highlights two interconnected aspects of student learning: their cognitive and socio-emotional development. High quality teaching should allow students to acquire the competences they need to achieve their life goals and become active and happy members of society. While cognitive skills are important in attaining a high-level of qualification, finding a job and earning a good salary, social and emotional skills are crucial for a broad range of social outcomes including achieving goals, working with others and managing emotions (OECD, 2015c).

A framework developed in the *Education and Social Progress* project within the OECD describes some of the most important functions of the two main domains of skills. Cognitive skills, including domains of literacy, numeracy and problem-solving, incorporate basic skills such as recognising patterns and memorising; the ability to access, extract and interpret knowledge; and the ability to reflect, reason and conceptualise novel ways of dealing with a particular problem. Social and emotional skills include the domains of achieving goals, working with others and managing emotions (OECD, 2015c). The conceptual framework (Figure 11.2) shows that cognitive and socio-emotional skills are not distinct, they mutually influence each other. For example, some of the "21st century skills" such as creativity and critical thinking have both cognitive and socio-emotional dimensions (OECD, 2015c).

A complex framework

Evidence presented in this volume demonstrates the complexity of the teaching and learning process. It is important to underline that our proposed framework does not represent a series of linear relationships between its elements. In fact, the different pieces are in a continuous and dynamic interaction with one another. Teachers' learning about practice is enhanced through their consciousness of the interaction between teaching and learning in classroom practice (Loughran, 2013). For example, teachers' professional judgements are influenced real time as they consciously observe and reflect on student learning in the classroom. This dynamic process itself is part of their informal learning. Teachers' knowledge both informs teaching strategies and is being generated as a consequence of an active and ongoing process (Loughran, 2013).

Naturally, capturing such complex and non-linear relationships through an international comparative study is very challenging. However, contributing to a better understanding of what the specialised knowledge of teachers is like, how their opportunities to learn exactly relate to their knowledge, and in what ways motivational factors relate to it would be an important first step in unfolding the complexity of the teaching profession.

Governing teacher knowledge – a policy perspective

Teachers are facing new challenges and new requirements to be able to adapt to an environment characterised by changes in society, the labour market, technology etc. In an effort to make the education system more effective and equitable, it is particularly important that governments reflect on strengthening the teaching profession. We have illustrated the complexity of teaching and learning and how this is embedded in a system characterised by multiple levels, actors, processes and mechanisms. Ensuring that teachers are able to tackle these new challenges and equip all children with the competences they need thus requires a deep understanding of how such a complex system can be governed.

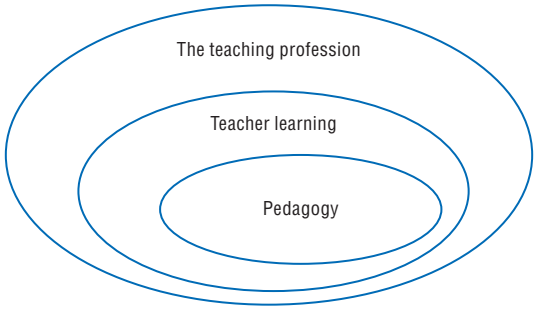
Governance needs to aim at strengthening both the cognitive and the social aspect of the teaching profession. The former involves facilitating the creation of an integrated and robust knowledge base for teachers capable of renewing and adapting to new circumstances. Part III of this volume illustrated that research and evidence that may potentially be relevant for teaching is growing in various fields. Learning sciences include emerging evidence in educational neurosciences and how concepts such as brain plasticity and structural brain development could have implications for teacher development as well as student learning outcomes (Ansari et al., this volume). At the same time research is also emerging through studies focusing on so-called 21st century skills. Helping students acquire skills such as innovation, creativity and creative problem-solving are seen as developing transferable knowledge that can be applied to solve new problems or respond effectively to new situations (Pellegrino, this volume). Growing evidence on how to create learning environments that support the development of these competencies can also be pertinent for teachers.

What exactly of this emerging evidence proves to be relevant for teachers and how it becomes integrated in teachers' knowledge is dependent to a large extent on the social side of the profession. Creating opportunities for the different actors – teachers, educational and learning researchers, teacher educators – to interact and co-operate in a purposeful and constructive manner, facilitating participatory action and continuous reflection and evaluation are important features of the effective governance of the social aspect of the teaching profession (Best and Holmes, 2012; Burns and Köster, 2016). Self-organisation is a fundamental characteristic of complex systems, which implies that rather than creating strong central structures it is more beneficial to facilitate self-governing processes in the teaching profession (Davis and Sumara, 2009; Snyder, 2013).

Self-organisation within a profession can relate to the regulation of various phenomena and processes, some of the main features including controlling access to the profession by setting requirements for initial training and professional development, establishing a code of conduct, etc. This often involves an independent professional body responsible for managing and revising these requirements, and regulating processes of selection, registration and accreditation of programmes. Accountability mechanisms such as evaluation and inspection can also fall under the responsibility of the profession itself. As illustrated in Chapter 2, countries and economies differ regarding the extent of responsibility of the state versus that of independent bodies responsible for regulating the teaching profession. Scotland was mentioned as an example where a truly independent professional body exists. While some argue that the status of a profession depends also on its self-regulatory power (e.g. Whitty, 2000), others acknowledge that it is not a universal solution for every challenge of the profession (Monteira, 2015). In this volume we have focused on teachers' knowledge base and have argued that governance should empower the profession itself to govern teacher knowledge.

Applying a whole system approach rather than focusing on isolated elements has been identified as one of the main elements of effective governance (Burns and Köster, 2016). For teaching this means addressing all levels of the system: the level of the classroom, that of the school as an organisation and the systemic level of the whole profession. It was suggested in Chapter 2 that teacher learning is a key node that is connected to many others and is thus central for governing teachers' knowledge. Figure 11.3 shows the nested nature of some elements. The inner circle, pedagogy refers to the teaching and learning process at the classroom and school level, which is cultivated by teacher learning, again understood broadly. The whole is embedded in the system of the profession. A study aiming to support teacher policies should target all three levels.

Figure 11.3. **Nested elements of the teaching profession**



As demonstrated above, more evidence and research is still needed to inform policies on teaching. Such research should take into consideration the different levels and address both the social and the cognitive dimensions of the teaching profession. It is in this quest that the ITEL project was conceived. The study aims at the same time to improve teacher learning through investigating opportunities to learn and to improve the knowledge base by looking at pedagogical knowledge. The three policy challenges to which ITEL will contribute are:

- How we can improve pedagogy for more successful learning?
- How we can improve teacher education for more successful teaching?
- How we can improve the selection, retention and professional development of teachers?

Developing a teacher knowledge survey

In addressing the above challenges, the next phase of the project is to develop and test an instrument that is capable of contributing to the empirical evidence base in this field. A survey aiming to answer the policy challenges should look at different aspects of teachers' competence. First, to provide guidance in improving pedagogy, it needs to look at teachers' knowledge of teaching and learning and how teachers learn to adapt their practice to new educational demands. A future survey should thus be designed to explore the nature of teachers' pedagogical knowledge and understand the extent to which teachers have the knowledge and skills for teaching 21st century skills. It should also be able to explore the dynamics of knowledge in the teaching profession, in particular whether and how new pedagogical knowledge is incorporated into the profession.

Second, to address challenges of improving teacher education, the future study should explore the quality of learning opportunities in teacher education and how these relate to teacher candidates' learning outcomes. In particular, it should provide insight into whether teacher education programmes actually offer teachers opportunities to attain the knowledge

and skills in order to effectively teach students and prepare them for 21st century society. Furthermore, such a survey needs to unfold the relationship between pedagogical knowledge and learning opportunities in teacher education, including specific characteristics such as the quality of field experiences and qualifications of teacher educators.

Third, to understand how the best candidates can be selected and retained, as well as how they can become expert teachers, a future study needs to understand teachers' motivation and how this relates to professional competence. It is important to select candidates who not only show potential for the teaching profession, but who are driven to continue to develop their practice. It is thus crucial to better understand how teachers' motivational characteristics relate to the quality of pedagogical knowledge, as well as the relationship among the institutional characteristics of teacher education, opportunities to learn pedagogy and teachers' motivational characteristics.

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Contributors

Sonia Guerriero

Sonia Guerriero conceptualised and headed the *Innovative Teaching for Effective Learning* project and developed the *Teacher Knowledge Survey* which is the focus of the second volume in this series. She holds a PhD in Experimental (Research) Psychology from McGill University in Canada, with specialisation in cognitive science and developmental psychology. Her PhD and post-doctoral research investigated the relationships among children's learning environments, language development, and reading difficulties in monolingual and bilingual children. Before joining the OECD, she worked at the Canadian Council on Learning and was a founding partner at Directions Evidence and Policy Research Group undertaking research and policy analysis in education, social services, employment, culture, immigration, justice and health. Sonia Guerriero recently joined UNESCO and continues to investigate teachers' motivation, well-being and professional teaching competences, and how neuroscience can be used to improve teaching and learning. She works with member countries to develop policies to increase the supply of qualified teachers as part of UNESCO's Education 2030 Agenda and Sustainable Development Goals for Education.

Karolina Deligiannidi

Karolina Deligiannidi is a consultant in the *Innovative Teaching for Effective Learning project* of the OECD. Her studies include a BSc in Philosophy, Education and Psychology from the University of Athens, a MEd in Psychology of Education from the University of Bristol and an MSc in Research for Public Policy and Practice from the Institute of Education, University College London. Her MSc research explores whether systematic reviews of teacher induction programmes provide sufficient evidence that fit policy needs. She has worked at the Prime Minister's Cabinet Office in Greece at the International Affairs Office and at the Ministry of Education. Her research interests include international large-scale assessments, policy and intervention evaluations, skills development, neuroscience and education, and translating research evidence for policy making and practice.

Nóra Révai

Nóra Révai is an analyst in the *Teacher Knowledge Survey* project of the OECD. She holds an MSc in Mathematics and a BA in English Teaching. She is currently pursuing doctoral studies at the University of Strasbourg, in which she is exploring the knowledge dynamics in the teaching profession. Nóra Révai was involved in the management of EU-funded international projects on school leadership at the Knowledge Centre of Tempus Public Foundation in Budapest, Hungary.

She was engaged in the development of a competency framework for school leaders and was responsible for leading knowledge management activities in the European Policy Network on School Leadership. She has also worked as a secondary school teacher.

Diana Toledo-Figueroa

Diana Toledo Figueroa is an education policy analyst at the OECD. She is currently the project manager of the Education Policy Outlook series and leads country reviews such as the OECD Reviews of National Policies for Education: Chile (2004-2016). She has participated in a number of OECD projects on policy implementation including preventing drop out in Iceland, the quality of lower secondary education in Norway, as well as the OECD-Mexico project to improve the quality of Mexican schools. She also contributed to the review of Evaluation and Assessment in Mexico and to the Getting it Right: Mexico report. Diana Toledo Figueroa holds a PhD in Development Socio-Economics and an MSc in Comparative Development Studies. She also holds a BA in Political Science.

Sigrid Blömeke

Sigrid Blömeke is the Director of the Centre for Educational Measurement at the University of Oslo (CEMO), Norway, and Professor of Instructional Research at the Leibniz Institute for Science and Mathematics Education at Kiel University and Humboldt University of Berlin. She studied sociology, history, education and psychology and did her PhD in education. She received a post-doctoral qualification (habilitation) in 2001 with a thesis on modelling and assessing teacher competencies. She was a professor in Hamburg, Berlin and at Michigan State University (USA) before moving to Norway. In 2016, she received the Distinguished Research Award of the German Educational Research Association (DGfE). Her research interests include the assessment of competencies in international large-scale assessments. She was the national research coordinator of the TEDS-M study in Germany.

Kathleen Stürmer

Kathleen Stürmer is a Full Professor for educational effectiveness and educational trajectories at the Hector Research Institute of Education Sciences and Psychology at the University of Tübingen. Her research focuses in particular on linking the research on teaching and learning effectiveness with the research for professional learning in and for the teaching profession. She works on issues of conceptualisation, measurement, development and promotion of various aspects of teacher competence with a special emphasis on the development of new multimedia tools and survey methods for assessing prospective teachers' competencies in the context of teacher education.

Tina Seidel

Tina Seidel is a Full Professor at the School of Education at the Technical University of Munich (TUM). She is the author of numerous books and articles on the topics of classroom research, teacher and teaching effectiveness, and teacher learning and teacher professional development. Her special interest is in video-based analysis of classrooms, teacher-student interaction and the development of multi-media based tools in teacher research. Her research has been distinguished by several awards. In 2008 she received the Review of Research Award of the American Educational Research Association.

Johannes König

Johannes König is a Full Professor of Empirical School Research, Quantitative Methods at the University of Cologne in Germany. He received a Dr. Phil. at Freie Universität, Berlin in 2006 and a post-doctoral qualification (habilitation) at Humboldt University of Berlin in 2011. His current work includes school research, teacher education research, teacher competencies, teacher knowledge – with a special focus on general pedagogical knowledge – and international comparisons. He has been working in various research projects on assessing teacher knowledge and teacher education quality, including for the purpose of international comparisons. He has received research grants for national and international studies in these fields. He has published extensively in national and international journals and books.

Fani Lauermann

Fani Lauermann obtained her PhD in 2013 from the Combined Program in Education and Psychology at the University of Michigan – Ann Arbor, USA. She joined the Gender and Achievement Research Program at the University of Michigan as a post-doctoral researcher until 2014, and then accepted a position as an assistant professor of Education and Psychology at the University of Bonn, Germany. Her research focuses primarily on questions related to teacher and student motivation, including research on teacher responsibility for educational outcomes, as well as research on the motivational underpinnings of students' educational and occupational choices.

Daniel Ansari

Daniel Ansari received his PhD from University College London in 2003. Currently, Daniel Ansari is a Professor and Canada Research Chair in Developmental Cognitive Neuroscience at the University of Western Ontario in London, Ontario. There, he heads the Numerical Cognition Laboratory (*www.numericalcognition.org)*. He and his team explore the developmental trajectory underlying both the typical and atypical development of numerical and mathematical skills, using both behavioural and neuroimaging methods. He has a keen interest in exploring connections between cognitive psychology, neuroscience and education and served as the President of the International Mind, Brain and Education Society (IMBES) from 2014-16. He has received early career awards from the Society of Research in Child Development, the American Psychological Association as well as the Government of Ontario. In 2014, he was named as a member of the inaugural cohort of the College of New Scholars, Artists and Scientists of the Royal Society of Canada and in 2015 he received the E.W.R Steacie Memorial Fellowship from the Natural Sciences and Engineering Research Council of Canada.

Marilyn Leask

Marilyn Leask is co-editor of the major textbook series for secondary teacher training in the UK which she initiated in 1990. Her career spans school teaching, national and local government policy officer roles and she has been a researcher and teacher educator for decades. With Ulf Lundin, from Sweden, she initiated the European Schoolnet in 1995 (*www.eun.org)*. Working with national teacher organisations and teacher educators in a number of countries, she chairs the Mapping Educational Specialist know-how initiative (*www.meshguides.org*) which supports evidence-based teaching by providing updatable practice focused research summaries to teachers anywhere in the world. She has been a

researcher at the University of Cambridge and the UK National Foundation for Educational Research, Professor at Brunel University, Dean of Education at the University of Bedfordshire and is now a visiting professor at De Montfort University, UK.

Tracey Tokuhama-Espinosa

Tracey Tokuhama-Espinosa is an educational researcher affiliated with the Latin American Faculty for Social Science in Quito, Ecuador and teaches a course at the Harvard University Extension School, entitled *The Neuroscience of Learning: An Introduction to Mind, Brain, Health, and Education*. Tracey Tokuhama-Espinosa has written three books on the field of Mind, Brain and Education and is President of Connections: The Learning Sciences Platform, which provides high quality, low cost support to educators. Her office seeks to improve the quality of formal and informal learning experiences through research, teacher training and student support. Formerly, she was the Dean of Education at the Universidad de las Américas in Quito, Ecuador and Director of the Institute for Teaching and Learning (IDEA) in the Universidad San Francisco de Quito.

James W. Pellegrino

James W. Pellegrino is Liberal Arts and Sciences Distinguished Professor and Co-director of the Learning Sciences Research Institute at the University of Illinois at Chicago. His research and development interests focus on children's and adult's thinking and learning and the implications for assessment and instructional practice. He has published over 300 books, chapters and articles in the areas of cognition, instruction and assessment and has chaired several U.S. National Academy of Sciences study Committees, including the Foundations of Assessment, Defining Deeper Learning and 21st Century Skills, and Developing Assessments of Science Proficiency in K-12. He served on the Board on Testing and Assessment of the U.S. National Research Council and is a member of the U.S. National Academy of Education and the American Academy of Arts and Sciences.

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