Educational Research and Innovation

Teaching as a Knowledge Profession

STUDYING PEDAGOGICAL KNOWLEDGE ACROSS EDUCATION SYSTEMS

Edited by Hannah Ulferts

OECD

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BETTER POLICIES FOR BETTER LIVES

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Foreword

In today's complex world, our quality of life depends on the knowledge and skills of professionals. The COVID-19 pandemic has hit the world in a dramatic way, with millions of casualties and a lot of human suffering, but how much more disastrous would it all have been without the professional expertise, dedication and indefatigable diligence of medical doctors, nurses and biomedical researchers who provided the world with effective vaccines? In everyday life, when we cross a bridge we unreservedly trust the knowledge and skills of the civil engineers who designed and constructed it, or when we consume our daily meals we implicitly put confidence in the farmers and the bio-engineers who produce and process the food. Scientific knowledge has penetrated many spheres of life and has transformed work into knowledge-intensive professional activity.

Likewise, when we entrust schools with what is dearest to us, our children, we are not only confident that they will be looked after as careful as possible, but also that they are educated to fulfil our dreams and reach their full potential. That's not a simple task. It also requires sophisticated knowledge and skills. And, much like for many other professions, the increasing complexity of the task and the amount of scientific knowledge available require ever higher levels of knowledge and skills. Yet, that's not a universally shared view. Many people, even those in the policy field, still see teaching as a kind of 'art', driven by some vague inborn ability. Or they still hold to the view that with a minimal of training every person can become a qualified teacher. It is disappointing that the status of teaching as a profession has long been under scrutiny. Critics have commonly argued that teaching is not a full profession as teachers are unable to speak in a uniform voice about "what works, when and why" in teaching. According to them, teaching lacks a common body of knowledge that informs professional judgements, decision-making and action in the classroom.

This publication collates many good arguments rebutting such criticism. It sets out for an in-depth exploration of teaching as a knowledge profession, in particular by focusing on general pedagogical knowledge. To successfully promote student learning, socio-emotional development and well-being, teachers need to mobilise a highly specialised body of knowledge in their daily practice. Effective teachers are not only experts of the subject matter they teach but also of how students learn, how to assess learning progress and how to design engaging and enriching learning experiences for students. This type of knowledge – pedagogical knowledge – distinguishes the teaching profession from other professional knowledge (e.g. a maths teacher from a mathematician).

General pedagogical knowledge, which informs teaching independent of the subject taught, is unique as it provides teachers from different subjects with a common reflection ground on teaching and learning. It represents, therefore, a powerful tool for reflecting on how to improve teaching as well as learning experiences of students across subjects. The COVID-19 pandemic has demonstrated yet again the power of collaboration within and among schools and of jointly creating solutions in times of uncertainty. The COVID-19 pandemic has also shown how vital a strong and updated knowledge base is for autonomous decision-making and adaptive, flexible teaching. Constant change and uncertainty, including abrupt transformational challenges similar to the one resulting from the pandemic, are likely scenarios for

the future of education. To master the challenges of teaching now and in the future, teachers need to be owners of deep professional knowledge.

There is, therefore, a high pressure on teachers to enlarge and enrich their knowledge to be more effective in their daily practice, and on policy- and decision-makers to improve the support systems enabling this. Acquiring pedagogical knowledge and keeping it updated is challenging: It requires teachers to learn about established pedagogical theories and principals while keeping abreast of emerging research on teaching and learning, and adapting this knowledge to the context of their classrooms. Teachers need to know how to engage students from diverse backgrounds and how to best integrate the latest educational tools and technologies in their teaching. To enable this, education systems need to offer teachers effective learning opportunities during initial teacher education and beyond. Systems also need to motivate teachers to continuously learn and reflect on effective pedagogies - independently as well as jointly in their professional communities.

In the next cycle of the Teaching and Learning International Survey (TALIS), the optional Teacher Knowledge Survey (TKS) assessment module will provide impetus for an evidence-based reflection on teacher knowledge and teachers' opportunities to acquire and refine pedagogical knowledge. The Survey assesses teacher knowledge and investigates how it relates to teachers' professional learning, their competences and their teaching across education systems. It was originally designed as a stand-alone survey by the Centre for Educational Research and Innovation (CERI)'s Innovative Teaching for Effective Learning (ITEL) project.

To support the Survey's implementation as an optional module in TALIS, this publication brings together leading experts on teacher knowledge and large-scale assessments to share their ideas on how to study general pedagogical knowledge across education systems. It provides arguments for considering teaching a profession with teachers' pedagogical knowledge as its main pillar, and emphasises the role of empirical data, in particular of international comparative data, in guiding attempts to strengthen the knowledge among the teaching profession.

This publication was edited by Hannah Ulferts from the OECD Centre for Educational Research and Innovation (CERI) and emerged from the Innovative Teaching for Effective Learning (ITEL) project. Tracey Burns was the leader of the project and supported this publication. The work on the Teacher Knowledge Survey (TKS) and its integration into the into the Teaching and Learning International Survey (TALIS) was guided by the CERI and TALIS Governing Boards, which were also invited to a meeting to discuss the topics covered in this publication. Alison Burke, Matthew Gill and Leonora Lynch-Stein contributed to the final stages of preparation for publication.

Dirk Van Damme
Former Head of the Centre for Education Research and Innovation (CERI)

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Hannah Ulferts

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Executive Summary

The COVID-19 pandemic has demonstrated yet again how vital a strong and updated knowledge base is for tackling transformational challenges. Constant changes, including abrupt transformations, are a likely scenario for the future of education. As societies and technologies constantly evolve, teachers must innovate teaching methods and pedagogies. Teachers need to be empowered to keep up with these changes and to use educational transformations to innovate teaching. For this, teachers need to be owners of deep professional knowledge, who constantly update their knowledge and skills.

Teaching as a Knowledge Profession: Studying Pedagogical Knowledge across Education Systems explores professional knowledge, in particular teachers' general pedagogical knowledge, as a resource for mastering the challenges of teaching in the 21st century. It also discusses policies and practices that are aimed at improving the knowledge base of the teaching workforce. The publication underlines the importance of using data to guide such improvement efforts and the particular value of international surveys of teacher knowledge. The OECD Teacher Knowledge Survey (TKS) assessment module will focus on teacher knowledge, providing an innovative theme and set of indicators for the next cycle of the Teaching and Learning International Survey (TALIS). In support of this challenging endeavour, the publication also includes proposals for measuring this knowledge across countries using cutting-edge methodologies.

Studying pedagogical knowledge as a main pillar of teacher professionalism

The status of teaching as a profession has long been under scrutiny. There are, however, convincing arguments for considering teaching a full profession with teachers' pedagogical knowledge as its main pillar (**Chapter 1**). Teaching is in fact, the mother of all professions. It is the starting point for successful professionals, engaged citizens and influential leaders. Teachers are also key agents of educational equity and inclusion. To fulfil these roles, teachers need to be learning experts who base their everyday practice on a regularly updated and integrated knowledge base, informed by research and practice.

Education systems have enacted various policies and reforms but ensuring a solid and updated knowledge base among the profession at large remains a concern for many education systems. The new OECD Teacher Knowledge Survey (TKS) Assessment Module will collect international comparative data on teacher knowledge in the next cycle of the Teaching and Learning International Survey (TALIS), providing valuable insights for policy makers, practitioners and researchers (**Chapter 2**).

Knowledge for teaching in the 21st century

The pandemic-induced school closures have once more highlighted not only the crucial and irreplaceable role of teachers in education but also the particular challenges associated with teaching in the 21st century: an effective use of digital technologies (**Chapter 3**) and ensuring an inclusive and equitable learning experience for an increasingly diverse student body (**Chapter 4**). There is no doubt that tackling these challenges requires professionalism from teachers, in particular a strong body of knowledge to draw from in their daily work.

Different approaches to measure teachers' technology- and diversity-related knowledge and skills exist, which come with different strength and limitations, especially for an international study on teacher knowledge. These knowledge and skills need to be explored in the broader context of the national and school context as well as teachers' attitudes and instructional practices. The embedded nature of the TKS Assessment Module into the broader context of the well-established TALIS study allows for this contextualisation.

Bridging the theory-practice gap: Exploring and supporting research-based practice and the context-adequate use of knowledge in schools

A major barrier to the use of scientific knowledge and research evidence is the "theory-practice gap": Teachers struggle to apply the theories, principals as well as teaching and learning approaches acquired in training into their classrooms. This is particularly visible for novice teachers transitioning from initial teacher education to schools (often referred to as the "practice shock").

To draw on research and knowledge in their practice, teachers need practice-based knowledge and situation-specific skills. Measuring such knowledge and skills requires contextualised measurements (**Chapter 5**). To learn about the context-adequate use of research and knowledge, education systems have provided teachers with opportunities to probe knowledge in practice, reflect on their teaching and to receive expert guidance (**Chapter 6**). Understanding differences in teachers' practical knowledge and skills requires a comparable measurement of the opportunities offered to teachers in different systems for aquiring and improving their pedagogical knowledge.

Pushing forward research and policy agendas and strengthening the knowledge base

With the push for evidence-informed education policies and practices, the interest in researching teachers has increased. In light of the increased survey burden and teachers' limited time for extra tasks, innovative testing designs such as multidimensional adaptive testing (MAT) become more important (**Chapter 7**). Such designs help reduce the length of teacher surveys and optimise the estimation precision and difficulty level of assessments, which is key for maintaining the test-taking motivation of participating teachers high. A Monte Carlo simulation study demonstrates how the use of such a design for the Teacher Knowledge Survey (TKS) assessment module could lead to a substantial increase in test efficiency.

Studying teaching as a knowledge profession, especially in an international survey, is as important as it is challenging. This publication summarises the existing research on key topics relating to the study of teacher knowledge and provides many suggestions and ideas to make such a challenging endeavour a success. There are important takeaways from these discussions but more research is needed to understand the complex nature of the knowledge teaching in the 21st century required in education systems around the globe (**Chapter 8**). In the end, the success of any research endeavour is also determined by the contributions made to improving policy and practice. Research on teacher knowledge can be used for informing teacher policy and strengthening professional exchange and knowledge-based practice in schools. Tackling these issues requires enormous efforts from everyone: researchers, policy-makers and practitioners. Given the importance of a strong knowledge base of teachers for the well-being and thriving of students and societies, the effort is worth it.

1 Teachers as knowledge professionals

The status of teaching as a profession has long been under scrutiny. Critics have commonly argued that teaching lacks a common body of knowledge that informs practice. This chapter sets the scene for an in-depth exploration of teaching as a knowledge profession. It presents arguments for considering teaching a full profession with teachers' pedagogical knowledge as its main pillar. The chapter also provides some examples of policies and practices that education systems have implemented to improve the knowledge base among the profession. It emphasises the role of empirical data in guiding such improvement processes and the need to go beyond the existing evidence. The final section explains the choice of topics covered in this publication.

Introduction

The ever-accelerating changes reshaping our economies and societies are major challenges for education systems and teachers. Modern teachers are expected to develop students' "21st century skills" in increasingly diverse classrooms. To be effective teachers need to base their practice on established theories and principals and the latest research on teaching and learning (Guerriero, 2017[1]). As societies and technologies constantly evolve, teachers must innovate teaching methods and pedagogies and continuously update their knowledge and skills.

The COVID-19 pandemic has demonstrated yet again how vital a strong and updated knowledge base is for tackling transformational challenges: It enabled teachers to swiftly change to online teaching and to adapt lesson plans, teaching approaches as well as their communication with students, parents and colleagues (OECD, 2020[2]). Constant changes, including abrupt transformational challenges similar to the COVID-19 pandemic, are a likely scenario for the future of education. Teachers need to be empowered to keep up with these changes, and to use educational transformations to innovate instructional methods and update their teaching skills. For this, teachers need to be owners of deep professional knowledge. A continuous renewal of the knowledge base is critical to teacher professionalism and the mastery of adaptive and transformative challenges.

This book sets out for an in-depth exploration of teaching as a knowledge profession with a particular focus on teachers' general pedagogical knowledge (i.e. teachers' specialised knowledge of teaching and learning independent of the subject taught). It brings together leading experts on teacher knowledge and large-scale assessments to share their ideas on how to study this knowledge across countries. This chapter sets the scene for the in-depth exploration: It presents arguments for considering teaching a profession with teachers' pedagogical knowledge as its main pillar. The chapter further emphasises the role of empirical data in guiding attempts to strengthen teacher knowledge across countries, in particular of international comparative data obtained through an assessment of teacher knowledge. It closes by explaining the choice of topics covered in the expert chapters.

Teaching is the mother of all professions

The categorisation of teaching as a profession, similar to medicine or law and other professions, has long been debated [see Guerreiro (2017[1]) for an overview of the discussion]. This is surprising as "teaching is in fact, the mother of all professions" (McDonald, 1956, p. 8[3]). Teaching builds the foundation and is the starting point for all professionals (Goodwin, 2011[4]). Teachers also shape society's future citizens and leaders, helping societies to thrive and individuals to reach their potential.

Effective teaching can be a real enabler of future academic and job careers. Teachers have been identified as the main contributors to student learning in schools and they are crucial for students' socio-emotional development and well-being (Burroughs et al., 2019[5]; Clinton, 2016[6]; OECD, 2021[7]). After all, the teachers are responsible for designing enriching learning environments, creating a classroom climate favourable for learning and personal growth, and facilitating the individual learning of students as well as the learning in groups. Teachers are also key agents of educational equity and inclusion. They are responsible for creating inclusive learning environments, and providing struggling students with the extra support needed to catch up with learning and integrate well in the school community (Ulferts, 2019[8]). To fulfil their roles as career enablers and equity agents, teachers need to be learning professionals, who base their everyday practice on an updated, coherent and integrated knowledge base (Guerriero, 2017[1]).

The pandemic-induced school closures have highlighted once more the crucial and irreplaceable role of teachers in education around the world. They have also made already existing challenges of teaching more visible, such as how to use technology effectively in teaching and how to ensure an inclusive and equitable

learning experience for an increasingly diverse student body. There is no doubt that tackling these challenges requires professionalism from teachers, in particular a strong body of knowledge.

For a long time, however, teaching was seen as a semi-profession (Guerriero, 2017[1]). The reasons for this are manifold but critics commonly argued that teaching lacks a common body of knowledge, practices and skills that constitute the basis for professional expertise and decision making. In their view, teachers have been unable to speak in a uniform voice about "what works, when and why" in teaching and how to define and identify quality teaching (Goodwin, 2011[4]).

For a while now, the focus of debates have shifted to a clear acknowledgement that teaching must be regarded a profession, with all that this implies for the knowledge, professional learning and status that is expected of a profession (see Box 1.1). However, it remains a major challenge in many countries to ensure teacher professionalism at large. A major concern is that too few teachers use existing scientific knowledge and evidence in their practice or base their teaching upon validated principles and theories. Nonetheless, there is a wide agreement that a common body of specialised knowledge exists that should inform teaching and should form part of teacher education and professional learning.

Box 1.1. The professional pillars of teaching in TALIS

Teacher professionalism is a changing concept, its meaning is tied to the social, historical and political context (Demirkasimoglu, 2010[9]; Snoek, 2010[10]; Wu, Cheung and Chan, 2017[11]; Goodwin, 2011[4]). Discussions around professionalism are often closely tied to the professional status and prestige of teaching (Guerriero, 2017[1]). The OECD Teaching and Learning International Survey (TALIS), for example, has recently defined five professional pillars of teaching (OECD, 2019[12]):

- **the knowledge and skills base**, including shared and specialised knowledge, as well as standards for entry into the profession and development of specific skills through initial teacher education and professional development
- **the status and standing of the profession**, captured through the ethical standards expected of teachers, the intellectual and professional fulfilment of the job, and the working regulations applying to teaching (such as competitive reward structures on par with professional benchmarks and room for career progression)
- **peer control**, which relies upon self-regulated and collegial professional communities that provide opportunities for collaboration and peer feedback to strengthen professional practices and the collective identity of the profession
- **responsibility and autonomy**, captured through the degree of autonomy and leadership that teachers and school leaders enjoy in their daily work, to make decisions and apply expert judgement and to inform policy development at all levels of the system, so that professionalism can flourish
- **the perceived prestige and societal value of the profession.**

The definition is based on the attributes of professionalism measured in the TALIS but also the policies and practices that support and enhance them. Though varying to some extent, other definitions commonly refer to a profession-specific, systematised and scientific body of knowledge that informs the daily activities of practitioners as a constituent characteristic of teacher professionalism (Demirkasimoglu, 2010[9]; Snoek, 2010[10]; Wu, Cheung and Chan, 2017[11]; Goodwin, 2011[4]; Guerriero, 2017[1]). Thus far, TALIS has relied on indirect measures of teacher knowledge through self-reports, for example teachers' feeling of preparedness for different teaching tasks, their participation in professional development and their need for further training. Such indirect measures of teacher knowledge have important limitations (further discussed in the section Going beyond the existing international evidence on teacher knowledge).

Pedagogical knowledge as a main pillar of teacher professionalism

As professionals, teachers have to base their judgements, actions and work-related decisions on a specialised and systematised body of knowledge, informed by research and practice (Guerriero, 2017[1]). Teachers need to use scientific knowledge and evidence to design and implement effective lessons. To justify decisions professional teachers use validated principles and theories. It is important that teachers regularly update their knowledge to the state-of-the-art on teaching and learning, as new insights emerge from practice and research or are shared through professional communities (Révai, 2020[13]; Boeskens, Nusche and Yurita, 2020[14]; OECD, 2019[15]).

There are good arguments for considering teacher knowledge, especially pedagogical knowledge, a main pillar of teacher professionalism. Firstly, existing definitions commonly refer to a specialised body of knowledge as a constituent characteristic of teacher professionalism, while other characteristics vary (see Box 1.1). Secondly, a profession-specific body of knowledge that informs practice is also used as a criterion to separate other professions such as doctors or lawyers from non-professions (Snoek, 2010[10]; Demirkasimoglu, 2010[9]; Guerriero, 2017[1]). Thirdly, a strong knowledge base and expertise are prerequisites for other elements of professionalism. For example, professions may be entrusted with higher levels of autonomy over their work, if they can assure a high level of expertise and knowledge and, thus, a high quality of practice and decisions (Goodwin, 2011[4]; Guerriero, 2017[1]).

Teaching is a complex task only mastered by a skilled and knowledgeable workforce. Teachers need to perform multiple tasks simultaneously: They monitor the class, encourage and provide feedback to individual students and groups and calm down disruptive or noisy students during group work. Naturally, the knowledge base this requires is also complex (see Box 1.2). To design and implement effective teaching and learning environments, teachers need to draw on various types of knowledge, including content knowledge (knowledge of the content and subject matter in mathematics, history, art etc.) and pedagogical knowledge (knowledge of how to create effective teaching and learning environments for students).

The importance of general pedagogical knowledge for teaching and professional exchange

There are also convincing arguments for a particular focus on teachers' pedagogical knowledge, in particular general pedagogical knowledge when exploring teaching as a knowledge profession. Pedagogical knowledge is unique to teaching and, therefore, distinguishes teachers from content specialist (e.g. a science teacher from a scientist or an art teacher from an artist) (Depaepe, Verschaffel and Kelchtermans, 2013[16]; Shulman, 1987[17]). Other than pedagogical content knowledge, which is subject-specific (e.g. the knowledge of creating effective teaching and learning environments in history, mathematics or biology), general pedagogical knowledge is the shared knowledge base of teachers across different subjects. General pedagogical knowledge refers to "the specialised knowledge of teachers for creating effective teaching and learning environments for all students independent of subject matter." (Guerriero, 2017, p. 80[1]). It, therefore, provides teachers with a common reflection ground and language to discuss their students' learning progress as well as well-being and ways to improve the teaching and learning support across subjects. Results from TALIS 2018 showed that across the OECD 61% of lower secondary teachers discuss the learning development of specific students at least once a month (OECD, 2020[18]). General pedagogical knowledge represents a powerful foundation for such discussions and professional exchange in general (OECD, 2019[12]).

Equally important, teachers' general pedagogical knowledge is a crucial resource for effective teaching and learning: An international review and meta-analysis found that general pedagogical knowledge relates to a higher teaching quality and better student outcomes (Ulferts, 2019[8]). Results indicated that more

knowledgeable teachers achieve a three-month additional progress for students. General pedagogical knowledge is also important for teacher well-being and job satisfaction (Voss et al., 2015[19]).

Box 1.2. Shulman's description of the knowledge base of teaching and further development

While different models exist, the most influential model describing the knowledge base of teachers was developed by Shulman in the late 80s (1987[17]; 1986[20]). Shulman divided teacher knowledge into seven categories:

- **General pedagogical knowledge** describes the knowledge of principles and strategies of classroom management and organisation that transcend subject matter.
- **Content knowledge** comprises the knowledge of subject matter and its organising structures.
- **Pedagogical content knowledge** represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised for instruction. It was described by Shulman as "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (1987, p. 8[17])
- **Curriculum knowledge** includes the subject- and grade-specific knowledge of materials and programmes designed for the teaching of particular topics and subjects.
- **Knowledge of learners and their characteristics** subsumes the knowledge about cognitive, physical, emotional, social, historical and cultural factors, which account for students' needs and interests.
- **Knowledge of educational contexts** ranges from an understanding of teaching contexts and the social dynamics of classes and groups to a wider understanding of the governance and financing of schools and the characteristics of the school and community culture.
- **Knowledge of educational purposes, ends and values and their philosophical and historical foundations** includes teachers' knowledge about the wider purposes of school and the perceived needs of learners as well as the potential value of education to society as a whole.

The first three knowledge categories (i.e. general pedagogical knowledge, content knowledge and pedagogical content knowledge) have been widely used in the scientific literature but have been further developed over time (König, 2015[21]; Ulferts, 2019[8]; Fernandez, 2014[22]; Guerriero, 2017[1]). For instance, further research used slightly different terminologies and expanded the definition of general pedagogical knowledge to also include knowledge about learners and their characteristics or ways of assessing student's learning and outcomes. Guerreiro (2017[1]) proposed a definition broad enough to cover the areas of general pedagogical knowledge proposed by further research, defining it as "the specialised knowledge of teachers for creating effective teaching and learning environments for all students independent of subject matter" (p. 80[1]).

Beyond these three knowledge categories, little consensus exists. For example, Grossman (1990[23]) and Carlsen (1999[24]) include contextual factors as additional knowledge categories to stress the context boundedness of the teacher knowledge. While Carlsen distinguishes *knowledge about the general educational context* (factors relating to the wider context such as the nation and state, the community and school) from *knowledge about the specific educational context* (the contextual knowledge focused on the classroom and the students to be taught), Grossman subsumes both into a single category. Baumert and Kunter (2013[25]), on the other hand, propose *organisational knowledge* and *counselling knowledge* as additional knowledge categories.

Pedagogical knowledge for teaching in the 21st century and its context-adequate use

General pedagogical knowledge is also crucial for mastering emerging challenges in today's classroom such as the continuing digital transformation of education. Teachers' general pedagogical knowledge, in particular Technological Pedagogical Knowledge [TPK, plays an important role in designing effective online teaching and learning environments (see Chapter 3 for an in-depth discussion) (Lachner, Backfisch and Stürmer, 2019[26]; Mishra and Koehler, 2006[27])]. The COVID-19 pandemic has made the key role of general pedagogical knowledge for effective online teaching more visible than ever: Teachers that were more knowledgeable adapted their online teaching more to student needs and maintained frequent contact with students and parents during school closure (König, Jäger-Biela and Glutsch, 2020[28]). The increasing diversity in classroom is another enormous challenge of teaching in the 21st century and many education systems are striving towards greater inclusiveness (Schleicher, 2014[29]). More than ever, teachers need to know how to meet diverse needs and manage multicultural classrooms (König et al., 2017[30]; Wasonga, 2005[31]; Ulferts, 2019[8]).

Expert teachers are not simply owners of deep professional knowledge, they also know how to apply knowledge adequately in different pedagogical contexts and situations (Ulferts, 2019[8]; Guerriero, 2017[1]). Selecting the pedagogical theories, concepts and teaching approaches most relevant in and effective for a given classroom situation requires theoretical-scientific knowledge and practice-based knowledge but also professional judgement and knowledge-based skills (see Chapter 5 for an in-depth discussion):

- **Theoretical-scientific knowledge** summarises the abstract, academic knowledge of teachers (e.g. theories and concepts of teaching-learning processes or facts about effective instruction as well as classroom management).
- **Practice-based knowledge** refers to knowing how and when to apply such knowledge (e.g. a particular instructional strategy) in a given classroom context. This knowledge benefits particularly from experiential and practical learning (Ulferts, 2019[8]; Lenske et al., 2016[32]; Woolfolk Hoy and Schönplug, 2008[33]).
- **Knowledge-based skills** are important for the context-appropriate use of knowledge. Drawing on their knowledge, teachers need to *identify* and *interpret* situations and features in the classroom as decisive for teaching and learning, and, base their instructional *decisions* on such judgements (Stahnke and Blömeke, 2021[34]; Blömeke, Gustafsson and Shavelson, 2015[35]).

Policies and practices to support the pedagogical learning and exchange among teachers

The previous sections discussed that teachers need to acquire and continuously update their knowledge to be and remain effective. In the last few decades, education systems have enacted policies and reforms to ensure a solid knowledge base and a continuous update of knowledge and skills among the teaching workforce, for example:

- **Anchoring pedagogical knowledge in qualifications frameworks and professional standards:** Qualification frameworks and professional standards help signal what is expected from teachers and how they can improve at different stages of their professional careers (Gomendio, 2017[36]; Guerriero, 2017[1]). Knowledge in important pedagogical areas is a requirement or leading principal for designing and accrediting teacher education programmes as well as for entering and progressing in the teaching career and in several countries (e.g. Australia, Brazil, Chile, England, Estonia, Scotland) and even included in the UENSCO/TUAC Global Frameworks of Professional Teaching Standards (Révai, 2018[37]; UNESCO and Education International, 2019[38]; Guerriero, 2017[1]; UNESCO, 2015[39]).

- **Ensuring a sufficient coverage of pedagogical topics in initial teacher education and continuing professional learning:** Initial teacher education and continuing professional learning were restructured to ensure a coverage of important pedagogical content and incorporate new findings and insights into effective teaching and learning (Boeskens, Nusche and Yurita, 2020[14]; Tatto and Menter, 2019[40]; Tatto et al., 2018[41]; OECD, 2019[12]; OECD, 2019[15]). However, certain areas still seem underrepresented. Results from TALIS 2018, for example, showed that on average the use of ICT (information and communication technology) was only included for around half of lower secondary teachers (56%) in their formal education or training and teaching in a multicultural or multilingual setting for one-third of lower secondary teachers (34.8%) across participating OECD countries (OECD, 2019[12]).
- **Creating opportunities to experiment and probe knowledge in practice:** A major barrier to the use of scientific knowledge and research evidence is the "theory-practice gap" (Paniagua and Sánchez-Martí, 2018[42]; OECD, 2019[15]): Teachers struggle to apply the theories, principals and teaching and learning approaches acquired in training into their classrooms. This is particularly visible for novice teachers transitioning from initial teacher education to schools (something that is often referred to as the "practice shock"). Teachers need practical experiences and expert guidance to learn about the context-adequate use of knowledge (Ulferts, 2019[8]). This has been addressed by providing more opportunities to experiment and probe knowledge in practice during initial teacher education (e.g. during teaching practicum, modelling of pedagogical approach, video- and computer-based learning) as well as expert guidance and mentoring when novice teachers enter school (OECD, 2020[18]; OECD, 2019[15]).
- **Enhancing reflective practice and continuous engagement with research among the teaching profession:** Programmes and courses increasingly seek to also enhance teachers' continuous engagement with research (Tatto and Menter, 2019[40]; Boeskens, Nusche and Yurita, 2020[14]; OECD, 2019[15]). The goal is to plant the seed for lifelong learning of knowledge and skills in the profession. Many programmes, especially at initial teacher education institutions conducting research, teach skills and knowledge to identify and interpret relevant research and data adequately and to make it usable in their own classroom contexts. Programmes aim to stimulate reflective processes and systematic inquiry so that teachers actively shape their own professional learning and validate, affirm, and improve their practice A few institutions and initiatives have tried to promote "knowledge brokering" in education and translate knowledge and pack the information in ways that are user-centred (Wollscheid and Opheim, 2016[43]; Malin and Brown, 2019[44]). Others have tried to establish various forms of partnerships between research institutions and schools as a means to promote the use of research and data in schools and to increase the usability of research and to make scientific knowledge more actionable (OECD, 2019[45]; OECD, 2019[15]).
- **Supporting the knowledge exchange and collective reflection** among **teachers and schools:** Another approach to enhancing professional knowledge among the profession consists in promoting pedagogical exchange and co-operative learning among teachers and schools. Education systems have supported mutual exchange among teachers and schools and promoted regular joint discussions and reflections about pedagogical topics and experiences through various means [e.g. research learning networks, video study clubs, communities of practice and learning, lesson studies, learning walks, digital teaching networks, professional Facebook groups and instructional rounds, classroom visits and peer-coaching (OECD, 2020[46]; Révai, 2020[13])]. Results from TALIS 2018 have shown that the percentage of lower secondary teachers engaging in different forms of exchange and co-ordination for teaching (e.g. discussing the learning of students, exchanging teaching materials, attending team conferences) at least once a month varies between 40% to 60% on average across OECD countries, whereas a regular involvement in deeper forms of collaboration (e.g. joint teaching, collaborative professional learning) is less common (9 % to 28%).

- **Safeguarding the pedagogical preparedness of teachers from alternative routes:** Countries need to increase their efforts to safeguard the pedagogical preparedness of teachers entering into the profession through "alternative" routes (e.g. second career fast-track training, Teach for All). Such routes have been increased in many countries to tackle teacher shortage (OECD, 2019[12]; OECD, 2019[15]). In Queensland in Australia, STEAM (Science, Technology, Engineering and Mathematics and Arts) Teacher Education Centre of Excellence (STEAM TECE), provides with alternative routes to career changers with STEAM degrees in order to obtain the Master of Secondary Teaching. The rationale of the programme is to shorten the training of candidates but at the same time provide high quality trained mentors and a strong practicum and continuous contact with schools that partner with the programme (OECD, 2019[15]). An analysis of 129 alternative route programmes preparing elementary and secondary teachers in the United States revealed a general lack of sufficient support and guided practical experience to allow their students acquire pedagogical skills necessary for teaching (Graham Drake, 2018[47]). The 18 residencies studied, on the contrary, which are most often multiple-year programs that require coursework on par with traditional preparation, received overall positive evaluations.

These overviews demonstrate commonalities but also important differences in policies and practices and their impact on teacher knowledge varies. Thus, ensuring a solid and updated knowledge base among the profession at large remains a concern for many education systems.

Studying teacher knowledge across education systems

The value of an international teacher knowledge study for policy and practice

To ensure that policies have desired effects, their intended outcomes need to be measured. Several studies have assessed teacher knowledge, demonstrating that initiatives such as the ones previously mentioned can be effective in supporting teachers in acquiring and enriching their professional knowledge. For instance, Gess-Newsome and colleagues (2019[48]) showed a growth in teacher knowledge, including general pedagogical knowledge, of high school biology teachers in the United States participating in a two-year professional development intervention that included educative curriculum materials. König (2013[49]) found that the more future primary teachers in Germany advanced in their studies the more general pedagogical knowledge they had acquired. More scientific-declarative knowledge was gained predominantly during the more theoretical first phase of German teacher education and practical knowledge through the practical second phase. Similar results have been obtained for a comparison of different course formats in a teacher education programme in Germany (Stürmer, Könings and Seidel, 2013[50]). Highest gains in terms of declarative general pedagogical knowledge and knowledge-based skills were obtained in a course that used video-based learning as a means to train the application of knowledge in different teaching contexts. Despite promising results for these and other initiatives [see also (Voss et al., 2015[19]) for an overview], evidence for many initiatives is missing and the existing evidence is often drawn from rather small samples. It is unclear if such initiatives can be scaled-up on a national- or region-level with similar results. Not least because their transferability to other regions let alone countries with the same effects is uncertain.

Ensuring a solid and updated knowledge base among the teaching profession at large requires large-scale assessments of teacher knowledge, optimally using representative samples. Some education systems use assessments for certifying teachers and ensuring that *all* teachers have acquired sufficient knowledge upon entry into the profession, for example almost all states in the United States (Demonte, 2017[51]; Bonsu, Bowman Carolee Dodge Francis and Eric Larsen Rebecca Polar, 2013[52]). Others use assessments to promote professional growth among in-service teachers. Chile, for instance, implemented a formative teacher evaluation that ties evaluation results to professional development and salary increments (Santiago et al., 2013[53]; Avalos-Bevan, 2018[54]). A few attempts have been made, to use

these national assessments to address key questions regarding teacher knowledge such as evaluating the knowledge gains of teacher education programmes (Darling-Hammond, Newton and Wei, 2010[55]) its relationship to the quality of lesson preparation and practice as well as student outcomes (Santelicesa and Tautb, 2011[56]; Cowan and Goldhaber, 2014[57]).

Expanding the study of teacher knowledge beyond national boundaries promises unique merits:

- An international study allows for a better understanding of the national and regional contexts of teacher knowledge (e.g. the system of initial teacher education and continuous professional learning), and, thus, the context boundedness of results obtained through national assessments or research studies.
- Through participation in an international study on teacher knowledge, countries and economies become part of an international education community that aims at globally improving teacher quality informed by evidence on the strength and weaknesses of teachers' knowledge base. Through participation, schools and teachers become part of a professional community that inspires learning on how schools and practitioners in other countries and regions support knowledge exchange and co-construct. They make a valuable contribution to the education community both nationally and internationally and help improve teacher policy and decision making in schools and institutes involved in teacher education and professional learning.
- Domestically, such a study can provide information on how well systems are providing schools in different geographic areas (e.g. urban and rural areas, including remote areas) as well as socioeconomically advantaged vs. disadvantaged schools with highly skilled and knowledgeable teachers.
- An international study that highlights the complex nature of teaching and the specialised knowledge it requires has the potential to strengthen the professional status and the societal value of teachers. Results from international studies are distributed internationally and discussed widely by different stakeholders of school education.

Going beyond the existing international evidence on teacher knowledge

The OECD Teaching and Learning International Survey (TALIS) has increased the public attention for the key role of teachers for quality education. It gave impetus to an evidence-based reflection on teacher professionalism and collective efforts to increase teacher quality across countries (OECD, 2020[18]). TALIS defines the knowledge and skill base of teachers as one of the five pillars of teacher professionalism (see Box 1.1).

Thus far, TALIS has relied on indirect measures of teacher knowledge through self-reports, for example teachers' feeling of preparedness for different teaching tasks or their participation in professional development and need for further training. Yet, there is evidence suggesting that assessed and self-reported knowledge are measuring distinct teacher characteristics. For instance, König and colleagues (2012[58]) found no significant or only low correlations between pre-service teachers' feeling of preparedness for different teaching tasks and their assessed general pedagogical knowledge in Germany and the United States. Similar results were observed for teachers' assessed vs. self-reported pedagogical knowledge for an effective use of technology in teaching (Baier and Kunter, 2020[59]; Drummond and Sweeney, 2017[60]; Maderick et al., 2016[61]). The accuracy of teachers' judgements about one's own knowledge and skills may be a professional competence in itself that probably grows with experience and expertise of the teacher (Ulferts, 2019[8]).

In the 2024 cycle, a new optional TALIS module will study teaching as a knowledge profession across countries. The Teacher Knowledge Survey (TKS) assessment module will complement the TALIS self-report measures (e.g. teachers' feeling of preparedness for different teaching tasks) with an objective

assessment of the strength and weaknesses of teachers' knowledge across countries, delivering a new, innovative theme and set of indicators for TALIS 2024.

Two international studies on teacher knowledge exist but have important limitations. The international large-scale study Teacher Education and Development Study in Mathematics (TEDS-M), carried out by the International Association for the Evaluation of Educational Achievement (IEA), assessed for the first time teachers' professional knowledge across countries, including content knowledge, pedagogical content knowledge and general pedagogical knowledge (Tatto, 2013[62]). The Study was used as a tool to inform and develop teacher preparation policies for pre-service mathematics teachers (Tatto et al., 2018[41]). Yet, TEDS-M focused on knowledge as an outcome of initial teacher education and, thus, measured the knowledge of pre-service teachers at the end of teacher training. Equally important, general pedagogical knowledge was only assessed for pre-service teachers of mathematics in three education systems (Chinese Taipei, Germany, USA) and results are outdated (data collection took place in 2007/08) (König et al., 2011[63]).

The Service Delivery Indicators (SDI), an initiative launched by the World Bank in partnership with the African Economic Research Consortium and the African Development Bank, collected data on service delivery in schools and health facilities, including teacher knowledge (Bold et al., 2017[64]). The study assessed content and pedagogical knowledge of teachers but only in primary schools in seven Sub-Saharan African countries—Kenya, Nigeria, Mozambique, Senegal, Tanzania, Togo, and Uganda.

The OECD's TKS assessment module will go beyond the existing international evidence by assessing the knowledge of in-service lower secondary teachers. Focusing on general pedagogical knowledge, it enables to study teacher knowledge across not only countries but also subjects, enabling a collective reflection on how to strengthen the acquisition, refinement and exchange of pedagogical knowledge within the profession. The focus on in-service teachers allows insights into how the knowledge base of teachers has been shaped through not only initial teacher education but also subsequent professional learning and teaching experience.

The module can build on substantial prior work within the Centre for Education Research in Innovation (CERI), where it was originally developed as a stand-alone survey as part of the Innovative Teaching for Effective Learning (ITEL) project. The development of the Teacher Knowledge Survey (TKS) was embedded into a broader research agenda on teacher knowledge and quality that informed the survey development (see Box 1.3 for a project overview).

Box 1.3. OECD/CERI Innovative Teaching for Effective Learning (ITEL) project

The OECD/CERI Innovative Teaching for Effective Learning (ITEL) project was designed to provide insights about teaching in the 21st century, and more specifically about teaching as a knowledge profession. The ITEL project has conducted extensive conceptual, development and empirical work on two strands, addressing three main policy challenges:

- How can we improve pedagogy for more effective learning?
- How can we improve teacher learning for more effective teaching?
- How can we improve the selection and retention of teachers?

Strand I: Research on 21st century teaching and learning

Drawing on multiple research perspectives, the ITEL Research Strand examined the complexity and the changing nature of the teaching profession to understand better the different factors underlying high quality teaching in light of 21st century demands. It provided a modern account of teachers' professional competence and a sound conceptual basis for investigating their pedagogical knowledge (Guerriero, 2017[1]). A systematic review and meta-analysis of empirical evidence revealed significant relationships between teachers' general pedagogical knowledge and teaching quality as well as student outcomes (Ulferts, 2019[8]). Révai (2018[37]; 2020[13]) examined how knowledge manifests in teaching standards and in initial teacher education, and investigated the role of networks in the dynamics of professional knowledge. Kuhl and colleagues (2019[65]) showed how recent multidisciplinary research can inform educational practice and policy making, including neuroscience, the social, cognitive and behavioural sciences, education, computer and information sciences, artificial intelligence/machine learning, and engineering. Further publications offered specific examples of the potential of neuroscience in the area of mathematical and spatial cognition, and science, technology, engineering and mathematics (STEM) learning (Newcombe, 2017[66]; Looi et al., 2016[67]).

Strand II: The Teacher Knowledge Survey (TKS)

The OECD/CERI Teacher Knowledge Survey (TKS) was designed as a stand-alone study to explore teaching as a knowledge profession in the 21st century (Sonmark et al., 2017[68]). The TKS aimed at gaining insight into the strengths and weaknesses of teachers' *general pedagogical knowledge* in different contexts. It also sought to explore the scope and quality of their learning opportunities as well as aspects of motivational and affective competencies and their relationship with teacher knowledge. In its original version, the survey sampled teachers from the same schools as well as teacher educators and pre-service teachers from the same initial teacher education institutions to allow for an in-depth analysis of effects of the school context and institutional environment.

The TKS has now been integrated into TALIS as an optional module: the Teacher Knowledge Survey (TKS) assessment module. The module can build on the substantial prior work within CERI. In continuous collaboration with experts as well as countries and economies, the ITEL project has developed, piloted and refined the study design, including the conceptual and assessment frameworks, instruments, sampling framework and recruitment methods (further detailed in Chapter 2).

Overview of this publication

This publication aims to contribute to the discussion of teaching as a knowledge profession and the challenging endeavour of studying teacher knowledge across education systems. It brings together leading experts on teacher knowledge and large-scale assessments to share their ideas on how to explore

teaching as a knowledge profession in international surveys and strengthen their relevance for guiding teacher policies and practices. Each chapter summarises the scientific literature on a particular key topic relating to the research on teacher knowledge:

- **Chapter 2** provides an overview of the new TALIS Teacher Knowledge Survey (TKS) assessment module, including a description of its aims and design as well as its conceptual underpinning and instruments.
- **Chapter 3** discusses the knowledge and skills teachers need to master a major challenge of teachers in today's classrooms: the effective use of technology to facilitate student learning. It includes suggestions for conceptualising and measuring this knowledge in a cross-country survey, as well as for collecting information about the broader context of teachers' technology-related knowledge and skills: Teachers' use of technology in teaching, their self-efficacy and the overall conditions for technology use at school.
- **Chapter 4** focuses on the pressing issue of preparing and supporting the teaching workforce for high quality teaching in increasingly diverse classrooms. This chapter discusses how an international survey can provide deeper insights into teachers' competences for inclusive and multicultural education.
- **Chapter 5** aims to contribute to a better understanding of the theory-practice divide commonly described for teachers: Teachers, especially novice teachers, are often unable to make use of acquired knowledge in their classrooms and to base their professional judgements and decision making on available evidence and best practice. A contextualised assessment of teacher knowledge with an innovative scaling and scoring approach is proposed to understand better the knowledge and skills teachers need for knowledge-based and evidence-informed practice.
- **Chapter 6** highlights the role of initial teacher education, induction and continuing professional development in helping the profession overcome the theory-practice divide. It makes concrete suggestions for measuring such practical opportunities to learn about pedagogy that facilitate knowledge-based instruction in schools.
- **Chapter 7** is dedicated to innovative testing designs for exploring teacher knowledge across countries. The chapter proposes a multidimensional adaptive testing design to reduce the length and optimise the precision of such surveys while increasing the test-taking motivation of participating teachers, which is crucial in light of increased survey burden and teachers' limited time for extra tasks. A Monte Carlo simulation study shows how such an innovative design could increase the test efficiency of the Teacher Knowledge Survey (TKS) assessment module.
- **Chapter 8** outlines the main takeaways from the chapters and embeds the raised issues into a broader discussion around researching and improving the knowledge of the teaching workforce in education systems around the globe. It outlines areas for further research and discusses how teacher policy, professional exchange and knowledge-based practice in schools can be strengthened drawing on teacher knowledge research.

The work on the Teacher Knowledge Survey (TKS) and its integration into the into the Teaching and Learning International Survey (TALIS) was guided by the CERI and TALIS Governing Boards, which were also invited to a meeting to discuss the topics covered in this publication. An expert group in collaboration with participating countries and economies, the TALIS Governing Board (TGB) and important stakeholders will be involved in the further development of the module. The aim of the development process is the design of a survey that provides information on key areas of teacher knowledge meaningful for participating education systems, schools and teachers, while keeping the participation burden limited. The expert reflections of this publication can be used as a stimulus for the joint discussions and collaborative effort of studying teaching as a knowledge profession across countries.

Concluding note

This publication sets out for an in-depth exploration of teaching as a knowledge profession. It aims to contribute to the discussion on the knowledge needed for teaching in the 21st century and the challenging endeavour of studying teacher knowledge across education systems. It summarises the scientific literature on key topics relating to teaching in today's classrooms: the use of research and scientific knowledge in practice, an effective integration of digital technologies in teaching, and ensuring an inclusive and equitable learning experience for an increasingly diverse student body.

The publication also entails specific suggestions for researching these topics across education systems. It provides an overview of the new OECD Teacher Knowledge Survey (TKS) Assessment Module, which will collect international comparative data on teacher knowledge in the next cycle of the Teaching and Learning International Survey (TALIS). Research on teacher knowledge can be used for informing teacher policy and strengthening professional exchange and knowledge-based practices in schools. In the end, the success of any research endeavour is also determined by the contribution made to improving policy and practice.

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2 Studying teaching as a knowledge profession across education systems

A better understanding of teacher knowledge and effective means of promoting it is of value for both education systems and practitioners. An international study of teacher knowledge can play a key role in sparking greater attention for the topic and making education systems, schools and teachers part of a global education community determined to strengthen knowledge-based and evidence-informed practices in schools. This is the ambition of the new Teacher Knowledge Survey assessment (TKS) module. This chapter provides an overview of the module, which will collect international comparative data on teacher knowledge in the next cycle of the Teaching and Learning International Survey (TALIS). The chapter describes its aims and design as well as its conceptual underpinning and instruments.

Introduction

A better understanding of teacher knowledge, in particular general pedagogical knowledge, and effective means of promoting it is of value for both education systems aiming at improving teacher quality and learning outcomes and for practitioners striving continuously to improve their teaching and the support they receive for their work. An international study of teacher knowledge can play a key role in sparking greater attention for the topic and making education systems, schools and teachers part of a global education community determined to strengthen knowledge-based and evidence-informed practices in schools.

In the 2024 cycle of the OECD Teaching and Learning International Survey (TALIS), a new optional TALIS module will explore teaching as a knowledge profession across education systems. The Teacher Knowledge Survey (TKS) assessment module will complement the TALIS self-report measures (e.g. teachers' feeling of preparedness for different teaching tasks) with an objective assessment of the strength and weaknesses of teachers' knowledge across countries, delivering a new, innovative theme and set of indicators for TALIS 2024.

The chapter provides an overview of the Teacher Knowledge Survey (TKS) assessment module. It describes the aims and design of the module as well as its conceptual underpinning and instruments.

Overview of the TALIS Teacher Knowledge Survey (TKS) assessment module

The TALIS Teacher Knowledge Survey assessment module (TKS) aims to shed light on this "black box" of teaching: teachers' professionalism and their knowledge base. More specifically, the module informs teacher policies and practice on:

- whether teachers are sufficiently prepared for 21st century teaching, for example teaching diverse classrooms or using modern pedagogical approaches
- the strengths and weaknesses of teachers' current pedagogical knowledge base
- the ways in which teacher education (including initial education, induction and continuing professional development) can be improved to ensure a robust knowledge base in the profession in line with national policy priorities.

Box 2.1 outlines further the value of the TKS assessment module for policy-making, including examples of key policy questions addressed by the survey.

Box 2.1. Value of the Teacher Knowledge Survey assessment module for policy making

The Teacher Knowledge Survey (TKS) maps out teacher knowledge, enabling to detect the relative strengths and weaknesses of the professional knowledge base of teachers. The module does not intend to report results of individual teachers, but rather gauge relative strengths and weaknesses on the system level. The objective data from the knowledge assessment can be analysed jointly with contextual information (e.g. about teacher education) to help determine where improvements are needed (an overview of the instruments is provided in Table 2.3). This helps, for instance, identify required improvements regarding the pedagogical content transmitted in initial teacher education or the content of professional development activities available to teachers.

It is important to reiterate that this work is not based on normative assumptions. Certain countries/regions might choose to place a particular emphasis on a particular content area, for example instruction and assessment (see section Important areas and types of knowledge for 21st century teaching for an explanation of the content areas).

Examples of key policy questions addressed by the module

What are quality features of different teacher education tracks and how can they be improved?

The TKS allows for the comparison of different teacher education tracks. For example, countries could be interested in revealing the differences between consecutive and concurrent programmes (separate or integrated disciplinary and pedagogical studies). The TKS design allows for the identification of strengths and weaknesses in the content and quality of both programmes types.

What matters for high quality instruction?

The TKS can identify relationships between different teacher profiles and the quality of instruction (measured through self-reported use of effective practices). For example, data can reveal that high levels of knowledge with equally high levels of self-efficacy are linked to higher quality instruction. It can also indicate what kind of profiles are associated with stronger intent to persist in the profession, thus giving valuable information for where support and incentives are needed.

The TKS assessment module is designed to extend and complement the existing OECD TALIS and Programme for International Student Assessment (PISA) surveys. By providing an assessment of teachers' knowledge, it goes beyond self-reports. At the same time, it does not report the results of individual teachers; it aims to report results for all teachers or specific groups of teachers in a country. The TKS therefore positions itself as a useful research and policy tool for system level analysis, which helps identify pertinent challenges to teacher professionalism. It is important to emphasise that the solutions to identified challenges do not necessarily come in a top-down fashion. Rather, the intention is to highlight the importance of empowering teachers to take charge of their own professional knowledge base. Box 2.2 explains in detail the value of the TKS assessment for the profession.

Box 2.2. Value of the Teacher Knowledge Survey assessment module for the profession

The Teacher Knowledge Survey (TKS) assessment module helps better understand how to empower teachers to take charge of their professional growth and knowledge construction. Empowering the teaching workforce requires understanding how knowledge is co-constructed in the teaching community, among new and experienced teachers within schools. The module studies teaching communities from different countries and regions, and maps out their knowledge about instructional methods, student learning and, ways to evaluate student learning and research (see section Important areas and types of knowledge for 21st century teaching). It provides insights into teachers' opportunities to learn and share knowledge in initial teacher education and induction as well as in continuing professional development and schools. The module explains what motivates and enables teachers to build knowledge and navigate successful teaching careers.

The TKS assessment module empowers teachers to take charge of their own professional knowledge base by:

- providing teacher voice in informing teacher policies and decision making; in particular, how to design teacher education programmes and schools that empower knowledge sharing and construction.
- facilitating a collective reflection across countries and teaching communities on professional learning and collaborative knowledge building.
- increasing public awareness for the complexity of teaching and the knowledge and professionalism it requires.

The module focuses on teachers' general pedagogical knowledge. A recent systematic review of the international research evidence has shown that general pedagogical knowledge matters for the quality of teaching and student outcomes, indicating that more knowledgeable teachers achieve a three-month additional progress for students (Ulferts, 2019[1]). The module is designed to better understand this specialised knowledge of teachers, and to explore whether this knowledge is up to date with current research as well as adapted to 21st century societal needs. It also looks at how this relates to learning opportunities in teacher education and, equally, to professional competence.

Target participants of the TALIS Teacher Knowledge Survey assessment module are teachers in ISCED 2 (lower-secondary) level varying in teaching experience. This will provide valuable insights into the evolution of teachers' knowledge with growing teaching experience. The optional module will sample teachers from the same school, aiming for representative samples that allow studying the role of the school context for teachers' knowledge.

Originally, the TKS was developed as a stand-alone study in the OECD's Centre for Education Research in Innovation (CERI). The frameworks and instruments designed for the study were piloted in 2016 in five countries (Estonia, Greece, Hungary, Israel and the Slovak Republic) (Sonmark et al., 2017[2]). To integrate the survey optimally into TALIS, frameworks and instruments will be amended, capitalising on existing synergies and capturing more of the knowledge and skills that teachers need for mastering challenges in today's and future classrooms.

The conceptual underpinning of an international study on teacher knowledge

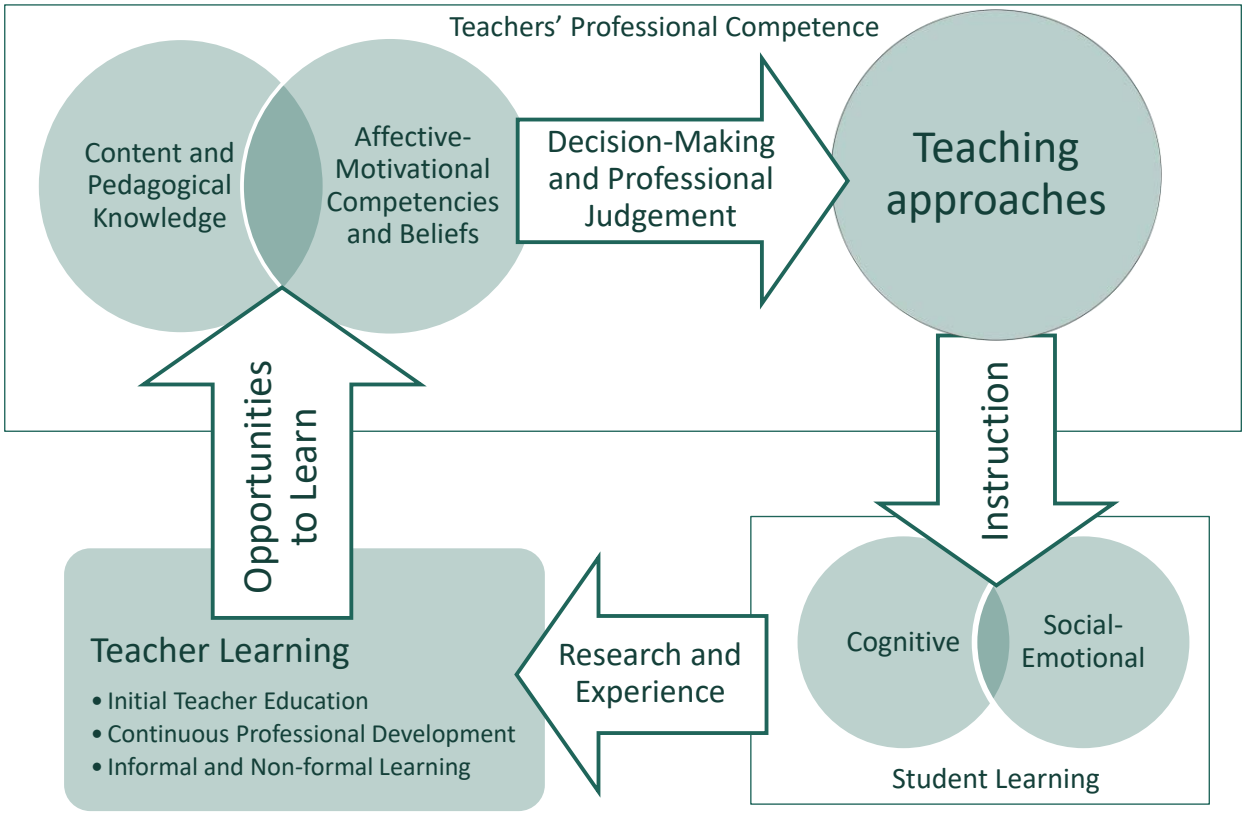
The TKS assessment module aims to contribute to a better understanding of a main pillar of teachers' professionalism: teachers' pedagogical knowledge (OECD, 2019[3]). As explained in Chapter 1, the development of the module's conceptual underpinning can build on the extensive conceptual and empirical work in the area of teacher knowledge conducted in CERI.

With its publication on "Pedagogical Knowledge and the Changing Nature of the Teaching Profession", CERI provided a strong conceptual basis for an international assessment of teacher knowledge (Guerriero, 2017[4]). The book – with contributions of several leading experts in the field – provides an extensive summary of the existing conceptual and empirical work on teachers' pedagogical knowledge. The overview of empirical studies included in the book showed the value of a knowledge assessment for improving teacher policy and practice (as summarised in Box 2.1 and Box 2.2).

Drawing on the conceptual and empirical work, Guerrieiro developed a conceptual framework of teachers' professional competences where competence is defined as "the ability to meet complex demands in a given context by mobilising various psychosocial (cognitive, functional, personal and ethical) resources" (2017, p. 261[4]). As such, teachers' knowledge is part of their competence (see Figure 2.1).

Teachers create and design learning environments by drawing on their knowledge on effective teaching and learning, as well as teaching-related beliefs, and other motivational and affective competences. They base instructional decisions and their professional judgement in the classroom on such knowledge and competences. Professional judgement guides the subsequent teaching approaches, which include curriculum and lesson planning, selecting and applying sets of teaching methods, ways of classroom management, student assessment etc. This then influences both cognitive and socio-emotional aspects of student learning (Ulferts, 2019[1]).

Figure 2.1. Conceptual framework of teachers' professional competence



Note: A detailed description of the framework is provided in (Guerriero, 2017[4]).
Source: (Guerriero, 2017[4])

In light of rapidly changing technology and societies, as well as the expanding research on teaching and learning, teachers must constantly update their knowledge and teaching skills. The nature of teachers' pedagogical knowledge is shaped by the educational context and the scope and quality of their learning opportunities. Research and experience continuously feed into the knowledge base that is transferred to and co-constructed by teachers through individual and collective learning. Teachers' learning opportunities shape not only their knowledge of the subject(s) they teach and pedagogy in general, but also other competences. Though displayed as a series of linear relationships between the elements of the model, the teaching and learning process is highly complex and the different pieces are in continuous and dynamic interaction with one another. For example, during instruction teachers observe and reflect on student learning, which is part of their informal learning.

The TALIS 2024 conceptual framework will retain essential themes and a blend of indicators from previous TALIS cycles to allow for trend analysis, as done for TALIS 2018, but will be expanded to cover issues relevant to the study of teaching as a knowledge profession (Ainley and Carstens, 2018[5]).

Measuring teacher knowledge and its context boundedness

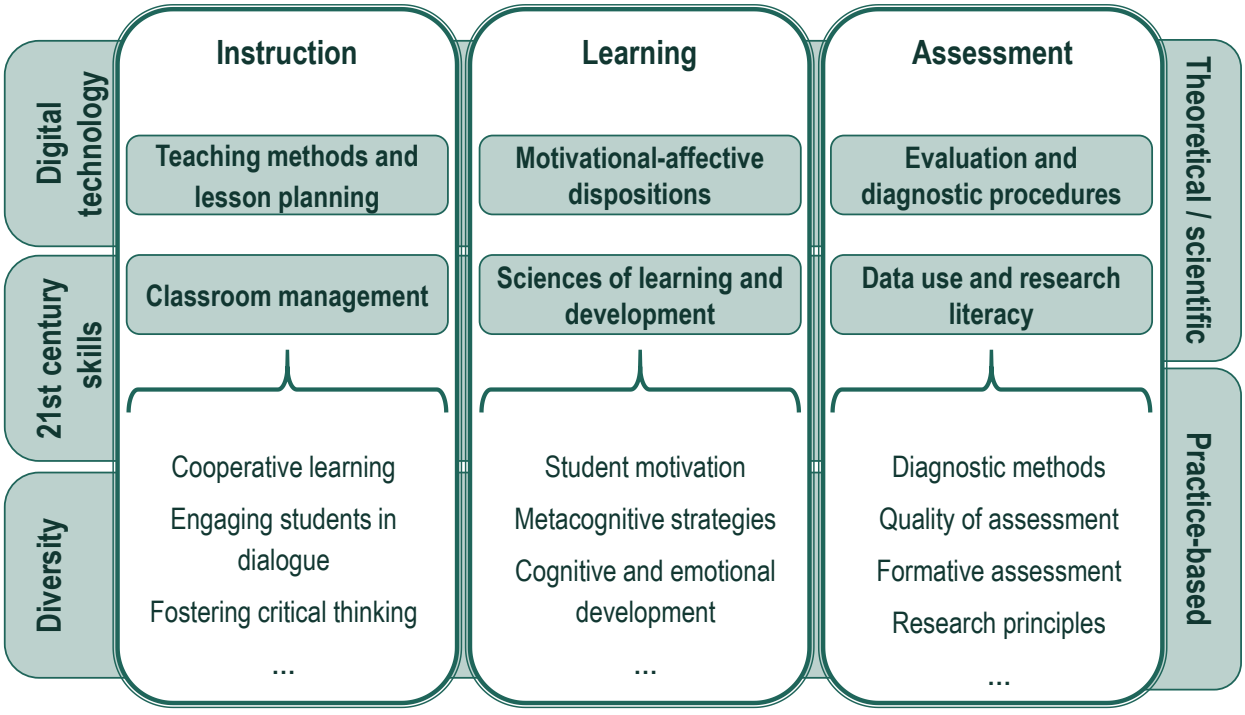
In light of the discrepancy observed for self-rated and assessed knowledge in previous research (Baier and Kunter, 2020[6]; Drummond and Sweeney, 2017[7]; Maderick et al., 2016[8]; König, Kaiser and Felbrich, 2012[9]), it seems crucial to include an assessment of teacher knowledge. This helps gaining a more sophisticated understanding of teaching as a knowledge profession as obtained in previous cycles of

TALIS through self-reports of teachers. Previous studies such as the Teacher Education and Development Study in Mathematics (TEDS-M) (Tatto, 2013[10]), the Service Delivery Indicators (SDI) (Bold et al., 2017[11]) and the TKS pilot study (Sonmark et al., 2017[2]) have shown the feasibility of using an assessment to obtain international comparable data on teacher knowledge (see Chapter 1 for a discussion of these studies).

Important areas and types of knowledge for 21st century teaching

To be valid and informative, an assessment of teacher knowledge needs to cover the content areas and types of teacher knowledge relevant for effective teaching and learning. Drawing on an extensive review of available assessment of teacher knowledge, a framework for assessing teacher knowledge across countries was developed in CERI (the CERI TKS assessment framework, see Figure 2.2).

Figure 2.2. The assessment framework of teachers' general pedagogical knowledge developed in CERI



Note: The list of topics in this figure are illustrative examples for the content measured in the assessment. Note that the framework will be revised for the TALIS TKS assessment module.

The framework postulates three core dimensions of general pedagogical knowledge – *instruction, learning and assessment* –, each of which is further specified into two sub-dimensions (Sonmark et al., 2017[2]):

1. **Teaching methods and lesson planning (sub-dimension of instruction):** Knowing how to productively use instructional time and teaching methods (e.g. direct instruction, discovery learning), when and how to apply methods to foster students' conceptual understanding and learning, how to structure learning objectives, lessons, curricular units and assessment.
2. **Classroom management (sub-dimension of instruction):** Knowing how to maximise instructional time through classroom monitoring, simultaneous handling of multiple classroom events, and appropriate pacing of lessons, knowledge of how to maintain student attention through clear directions and transparent rules.

3. **Sciences of learning and development (sub-dimension of learning):** Knowledge of learning processes and individual differences (including learning strategies, the impact of prior knowledge, memory and information processing), adaptive teaching strategies and the dynamics of individual and group learning.
4. **Affective-motivational dispositions (sub-dimension of learning):** Knowledge of emotional and motivational processes in learning (e.g. achievement motivation) and strategies to motivate and engage individual students and the whole group.
5. **Evaluation and diagnostic procedures (sub-dimension of assessment):** Knowledge of different forms and purposes of formative and summative classroom assessments, and their impact on student motivation and learning, understanding what matters for the quality of evaluations.
6. **Data use and research literacy (sub-dimension of assessment):** Knowledge of how to use research and data to inform the teaching and learning process, understanding how to interpret and assess the quality as well as generalisability of research.

The three knowledge areas of instruction, learning and assessment are all relevant to high quality teaching and student outcomes, as shown in an international review and meta-analysis (Ulferts, 2019[1]).

As discussed in Chapter 1, teachers need general pedagogical knowledge to tackle emerging challenges in today's classrooms. More than ever, teachers need to know how to foster 21st century skills (e.g. critical thinking and collaboration), how to meet the diverse needs and backgrounds of their students and how to design effective online teaching and learning environments (König et al., 2017[12]; Wasonga, 2005[13]; Valanidou and Jones, 2012[14]; Schleicher, 2014[15]; Mishra and Koehler, 2006[16]). Tackling such challenges requires specific knowledge in instruction, assessment and learning. For example, managing diversity requires knowledge about how to tailor pedagogies and instructional methods to various student needs and backgrounds (*instruction*). It also requires knowledge about the sources and implications of individual differences in learning, motivation, behaviours and thinking (*learning*) as well as diagnostic procedures and tools suitable for different student groups and criteria for evaluating their suitability (e.g. fairness and sensitivity of different evaluation tools) (*assessment*). The framework therefore considers teachers' knowledge for fostering *21st century skills*, managing *diversity* in classrooms and using *digital technology* for teaching as transversal knowledge areas across the three main areas.

Teachers also need to be able to apply their knowledge in the context of their classrooms (Ulferts, 2019[1]). Accordingly, the framework considers both types of knowledge: *theoretical/scientific knowledge* (e.g. Formal knowledge of concepts and theories), as well as *practice-based knowledge and knowledge-based skills* (e.g. the ability to apply professional judgement in a given classroom situation and knowledge-based decision making).

An in-depth, updated review of the research literature on teacher professional competence, GPK assessment and national teaching frameworks will determine the cultural validity and coverage of the framework, and identify key areas for further possible development. The refinement and validation will also include a critical review by cross-country and country experts on general pedagogical knowledge and teacher assessment.

This publication aims to contribute to this challenging endeavour by summarising the scientific literature on a particular key topic relating to the study of teacher knowledge. The following chapters also entail specific suggestions for surveys that study teacher knowledge across education systems:

- Chapters 3, 4 and 6 of this publication, for example, provide ideas for capturing teacher knowledge about the effective use of technology in teaching and inclusive teaching in diverse classrooms and for obtaining information on teachers' opportunities to learn about general pedagogy.
- Chapter 5 includes ideas for improving the measurement of practice-based knowledge and knowledge-based skills through revising the item and response format as well as the approach to scoring items.

- Chapter 7 proposes an innovative testing design for studying teacher knowledge across countries (Multidimensional Adaptive Testing, MAT). These designs help increase the assessment precision while reducing the survey length and maximising the test-taking motivation of participating teachers.

Assessing teacher knowledge across countries

Developing an assessment that delivers rich and comparable information for understanding teaching as a knowledge profession is as challenging as it is important. It is important to cover all important areas and types of knowledge for 21st century teaching outlined above. Sufficient attention must be paid to the most pressing challenges in today's classrooms, such as diversity and technology and a use of knowledge that fits the pedagogical context. At the same time, it is vital to limit the length of the survey to avoid survey fatigue and teachers' dropping out of the survey. The development of the assessment for the TKS assessment module can draw on the item bank created for the TKS in CERI (see Table 2.1 for sample items).

Table 2.1. Sample assessment items from the original teacher assessment developed in CERI

Dimension	Sub-dimension	Item example
Instruction	Teaching Methods and Lesson Planning	Ms Johnson has decided to teach a science lesson on tectonic plates using the flipped classroom method. Which of the following will she need to do? Check one box only. a) Plan the learning objectives, structure the lesson, and prepare a presentation on tectonic plates for the first part of the lesson. b) Plan the learning objectives, prepare and assign materials on tectonic plates such as videos and texts for students to review before the lesson, and structure the lesson on the basis of what students should have learned by then. c) Ask one or several students to prepare a presentation on tectonic plates, then plan subsequent activities. d) Prepare a test to evaluate students' knowledge on tectonic plates before the lesson, then plan the lesson on the basis of the results of this test.
Learning	Science of Learning and Development	Which of the following options describe the necessary conditions to facilitate critical thinking in a subject? Check one box only. a) Discovery learning combined with written assignments. b) A deep level of knowledge and practice drills. c) Rote memorisation of facts and collaborative group work. d) Small group discussions of written assignments.
Assessment	Evaluation and Diagnostic Procedures	Mr Chaparro is completing a series of lessons on a topic in her subject area, and would like to assess whether her students will be able to transfer the learning beyond school. Which of the following are best suited for assessing students' ability to integrate into a real life environment? Check one box in each row. [Suited, Not Suited] a) Whether students' can recall the content of the main course book. b) Whether students can evaluate the validity of the various resources available on a certain topic. c) Whether students can make effective use of various information sources and electronic databases to answer a reading assignment. d) Whether students can link the content of the course book to other sources of information they have collected.

Note: These items are illustrative of the nature of the instrument piloted in 2015. Note that significant changes to the TKS assessment are planned for TALIS 2024 (see below for a summary).

The item bank covers the areas specified in the framework (see Figure 2.2) with more than 200 items, which were validated from experts and country representatives from across the OECD. Over 50 items of the bank were additionally piloted in five countries from April to June 2016 (Sonmark et al., 2017[2]). The item bank consists of binary items: either simple multiple choice (MC; e.g. a question with four response options where one is correct and three incorrect) or complex multiple choice items (CMC; e.g. a question

with four or more response options, where each can be answered with “right” vs. “wrong” or “suited” vs. “not suited”).

The development of the assessment for the TALIS TKS assessment module will draw on the items developed in CERI. Yet, significant changes are planned regarding content and also the item and response format as well as the approach used for scoring items. For example, items will be modified and newly developed to allow for an optimal coverage across all knowledge areas and types relevant for 21st century teaching. This means including more items on the transversal knowledge areas (i.e. digital technology, 21st century skills and diversity) and items assessing teachers’ ability to apply knowledge in the context of particular teaching situations and contexts (i.e. practice-based knowledge and situation-based skills). For expanding on the transversal knowledge areas, a review of existing assessments in these areas is helpful, for example a review of instruments that assess diversity-related pedagogical knowledge (see Table 2.2).

Table 2.2. Measurement of diversity-related knowledge in existing assessment of general pedagogical knowledge

Study/assessment and Reference	Scale covering diversity-related knowledge and description	Knowledge areas
Adaptive Teaching Competence (ATC) (Brühwiler and Vogt, 2020[17])	**Adaptive planning and implementation competency:** Checking students’ prior knowledge and learning preconditions (e.g. interests); their understanding during the lesson (e.g. asks questions to evaluate their understanding), enabling the application and deepening of acquired knowledge (e.g. building on prior knowledge, providing differentiation to meet students’ diverse skills and interests, responding to difficulties in understanding).	Assessment, Instruction and Learning
General pedagogical/psychological knowledge (PPK) (Voss, Kunter and Baumert, 2011[18])	**Students’ heterogeneity:** Knowledge of students’ learning processes, individual student characteristics and sources of student heterogeneity, in terms of cognitive, motivational, and emotional characteristics.	Learning
General pedagogical knowledge (GPK) (König et al., 2011[19])	**Adaptivity:** Strategies of differentiation and the use of a wide range of teaching methods.	Instruction
General Pedagogical Knowledge for Inclusive Teaching (GPK-IT) (König et al., 2017[12])	**Entire instrument:** Knowledge of diagnosis (knowledge about learning processes, knowledge about dispositions and differences in learning, methodological knowledge about diagnosis) and intervention (classroom management, structuring, differentiation) that is particularly relevant for inclusive teaching.	Assessment, Instruction and Learning
General Pedagogical Knowledge for Inclusive Teaching focusing Social and Emotional Learning (GPK-IT-SEL) (Gottfried et al., 2021[20])	**Entire instrument:** Knowledge of diagnosis (knowledge about learning, methodological knowledge about diagnosis) and intervention (classroom management, structuring) relating to students with external behaviour problems.	Assessment and Learning (specific to external behaviour problems)
Knowledge of Attention-Deficit Disorder Scale (KADDS) (Sciutto, Terjesen and Bender Frank, 2000[21])	**Entire instrument:** Knowledge of symptoms and diagnosis of attention-deficit/hyperactivity disorder (ADHD), its treatment and about the nature, causes, and outcome of ADHD.	Assessment and Learning (specific to attention-deficit/hyperactivity disorder)
Pedagogical adaptivity in written lesson plans (König et al., 2020[22])	**Entire instrument:** Anticipating and responding to diverse needs of learners in written lesson plans (description of cognitive and motivational learning dispositions of students and teacher plans strategies of differentiated instruction such as planning tasks for different cognitive levels).	Instruction and Learning
PRAXIS II (ETS, 2013[23])	**Principles of Learning and Teaching (PLT):** Effective verbal and nonverbal communication, cultural and gender differences in communication, students as diverse learners.	Instruction and Learning
ProTeach (Cowan and Goldhaber, 2014[24])	**Professional growth and contributions:** advocating for curriculum, instruction and learning environments that meet the diverse needs of each student **Curriculum, instruction, and assessment:** using a variety of assessment strategies and data to monitor and improve instruction, designing and/or adapting a challenging curriculum that is based on the diverse needs of each student, integrating technology into instruction and assessment.	Assessment and Instruction

Note: Though not comprehensive, the table provides a review of the most prominent assessments of teachers’ general pedagogical knowledge and how they consider diversity-related knowledge.

The refinement of the assessment can draw on these instruments as well as on the few objective assessments of teachers' technology-related pedagogical knowledge that have been developed [e.g. (Baier and Kunter, 2020[6]; Drummond and Sweeney, 2017[7]; Maderick et al., 2016[8])]. Most studies use, however, self-rating via qustestionnaires. Table 2.2 also shows that most objective assessments focus on diversity-related knowledge in certain knowledge areas or cover knowledge about specific student characteristics such as attention-deficit/hyperactivity disorder (ADHD) and external behaviour problems.

To assess teachers' ability to apply their knowledge in context, so-called contextualised or situation-based items will be used, that confront teachers with typical and challenging classroom situations, for example short written descriptions of classroom situations ("text vignettes"). Chapter 5 provides a detailed description of this approach and provides examples of contextualised items for the assessment of teacher knowledge.

When measuring teachers' application of knowledge, it is also important to acknowledge that teaching in real classroom settings is often not about making the right choice but the most adequate one for a given situation. Teaching approaches, for instance, may not be correct or incorrect but vary in effectiveness, depending on the situational context. It is, therefore, necessary to also innovate the response format and approach to scaling of the assessment developed in CERI. As displayed in Table 2.1, the original assessment used multiple choice items that require one correct answer that is clearly justifiable based on research evidence. While this can be suited to assess theoretical/scientific knowledge, the revised assessment will include items with Likert scales (e.g. asking teachers to judge the effectiveness or utility of certain teaching approaches on a continuum from "not at all effective" to "very effective" etc.). Such methods allow for mapping the spectrum of options for teaching in the classroom and measuring teachers' practice-based knowledge and knowledge-based skills. In addition, it seems promising to consider an approach to scaling such items that compares teachers' answers to the answers of a designated board of experts. Chapter 5 explains the use of Likert scales and expert ratings as a scoring approach for an assessment of teacher knowledge.

Measuring the context boundedness of teacher knowledge

As displayed in Figure 2.1, the conceptual and empirical work conducted in CERI underlines that teacher knowledge needs to be understood in the context of national policies and the education system, as well as the broader context of teacher professionalism, such as:

- teachers' opportunities to learn (OTL) pedagogy (in initial teacher education, induction and continuous professional development)
- teachers' approaches to teaching and their instruction in the classroom
- motivational-affective characteristics of teachers (e.g. self-efficacy, self-responsibility).

In line with the approach of the original Teacher Knowledge Survey, the TKS assessment module will include indicators and constructs that are necessary to provide the context for the assessment results. Since the module will be embedded within the 2024 cycle of TALIS, indicators and constructs from TALIS can be used to provide context. To the extent necessary, other indicators and constructs necessary for providing context information will be added to the module.

For designing the questionnaire, the module can draw on the battery of questionnaire instruments. Table 2.3 provides an overview of the instruments. A detailed description of the instruments including results of the pilot study can be found in Sonmark et al. (2017[2]). Additionally, the expert chapters make suggestions for additional scales to obtain context information and adjusting the TALIS 2018 questionnaire to the new theme on teacher knowledge, for example items for obtaining more detailed insights into teachers' opportunities to learn about general pedagogy (see Chapter 6).

Table 2.3. Overview of the original TKS teacher instruments providing context information

Instrument component	Sub-component	Content description
Opportunities to learn	Pedagogical content	Provides a detailed picture of the extent to which specific topics of general pedagogy were covered in initial teacher education and professional development. The topics correspond to the knowledge assessment items and cover the three knowledge areas of instruction, learning and assessment.
	Quality of learning opportunities	Refers to the quality of formal professional development courses within the last 12 months (including the quality of instruction and feedback as well as guidance for improving teaching).
	Teaching practicum	Covers the quantity and variety of practical experiences as well as the professional support received in teaching practicum.
	Research activities	Measures teachers' individual engagement in and with research and whether the school encourages teachers to engage in and with research (existence of a "research culture" at school).
	Professional collaboration	Asks teachers for the extent to which they collaborate with colleagues and other teaching professionals, researchers as well as policy-makers.
Affective-motivational characteristics	Teacher self-efficacy	Captures teachers' confidence regarding various teaching tasks, including fostering student engagement and learning, delivering instruction of high quality, accommodating diversity.
	Motivations for teaching	Measures teachers' motivation for choosing teaching as a career, including perceived ability as well as intrinsic, extrinsic and social career values.
	Teacher self-responsibility	Indicates whether teachers feel responsible for the outcomes and quality of teaching and maintaining good relationships with students.
	Commitment to teaching	Captures teachers' commitment to the teaching profession, including their interest in professional development, their work-related well-being as well as whether they plan to stay in teaching.
Teaching practices	Teacher withitness	Captures different indicators of high-quality and effective teaching such as teachers' monitoring and awareness of classroom activities as well as their support of student learning and social support of students.

Note: Includes only the instrument components from the TKS developed in CERI that could be used for teachers participating in the TALIS TKS assessment module (i.e. instrument parts that were designed for teacher educators are not listed here). To reduce the response burden, only a limited number of questions will be included in the module.

Outlook

Teaching involves the design of effective online, offline and hybrid learning environments in increasingly diverse classrooms. Teachers also have an important role in guiding and shaping students' use of digital tools and optimising the educational benefits of their digital experiences. They are agents of inclusive, equitable education and ambassadors of embracing diversity as an enriching element of our societies.

To fulfil this education mission teachers need to be experts of teaching and learning, who base their practice on a specialised, integrated and updated body of knowledge. However, there is a great need for a better understanding of the specialised knowledge and skills that teaching in the 21st century requires. This is the ambition for the next cycle of the OECD Teaching and Learning International Survey (TALIS) and its new Teacher Knowledge Survey (TKS) assessment module. The module will explore teaching as a knowledge profession across education systems and provide international comparable data on teachers' general pedagogical knowledge.

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3 Teachers' technology-related knowledge for 21st century teaching

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This chapter addresses the questions of how to explore the knowledge and skills teachers need for effectively integrating technology in their teaching in an international study. It begins by underlining the importance of including technology-related knowledge in an assessment of teachers' pedagogical knowledge for teaching in the 21st century. Then, it outlines the type of knowledge and skills teachers need for effectively integrating technology in their teaching and how these can be measured across countries. Drawing on previous research, different measurement approaches will be discussed. Despite a focus on teacher knowledge, the chapter includes suggestions for exploring teacher knowledge in the broader context of teachers' overall conditions, attitudes, and application of technology in teaching practice.

Background

The digitalisation of society and school do not merely support (or in worse case inhibit) learning. It transforms learning and how teaching and learning is interpreted (Billett, 2006[1]; Bergöö, 2005[2]; Säljö, 2010[3]). For decades, there has been extensive investment both in technology and professional development initiatives to promote digitalisation (Agyei and Voogt, 2012[4]; Howell, 2012[5]; Egeberg et al., 2012[6]; Olofsson et al., 2011[7]). Nevertheless, integrating technology in teaching has proven to be a complex process (Erstad and Hauge, 2011[8]; Mishra and Koehler, 2006[9]). Despite decades of investments, many studies show that the high expectations on how this would change teaching practices were not fulfilled (Cuban, 2013[10]; Olofsson et al., 2011[7]). According to the large-scale assessment of the Teaching and Learning International Survey (TALIS), many teachers feel unprepared to use technology in teaching and there is inequality regarding access to, and use of, technology in teaching (OECD, 2020[11]).

In addition to issues of equality, the outcome of technology usage is unclear. The introduction of technology in teaching has been reported as having positive effects on students' engagement, motivation and achievements, as well as on teachers' teaching methods (Apiola, Pakarinen and Tedre, 2011[12]; Bebell and Kay, 2010[13]; Cristia et al., 2017[14]; Keengwe, Schnellert and Mills, 2012[15]; Martino, 2010[16]; Azmat et al., 2020[17]; Azmat et al., 2021[18]). Yet, many studies also report how technology use can have negative effects by causing additional distraction and therefore interfering with learning (Bate, MacNish and Males, 2012[19]; Islam and Grönlund, 2016[20]). Educational technology has been described as an 'intellectual and social amplifier' which can help make ''good'' schools better but also increase problems at low achieving schools (Islam and Grönlund, 2016[20]; Warschauer, 2006[21]). Thus, there is clear evidence that technology use by itself does not improve teaching and learning outcomes. Instead, only its effective pedagogical use can guarantee improvements (Burroughs et al., 2019[22]; Mishra and Koehler, 2006[9]; Islam and Grönlund, 2016[20]). Thus, an informed and conscious use of technology for educational purposes is crucial.

The focus of research and practice should therefore be on what technology ought to be used for, and what type of teaching and learning activities technology can enhance. To make sure technology use improves education on a large-scale, many scholars have highlighted the need for support and active leadership (Kafyulilo, Fisser and Voogt, 2016[23]; Dexter, 2008[24]; Islam and Grönlund, 2016[20]; Kafyulilo, Fisser and Voogt, 2016[23]). An important part of support initiatives is about identifying teachers' existing knowledge, usage and learning needs at large. Although a lot has been learned from international surveys, such as TALIS, there is more to learn about teachers' technology-related knowledge to support effective teaching in the 21st century.

This chapter sets out for an exploration of how to better understand teachers' technology-related knowledge and skills. First, ideas for conceptualising these skills are provided, then different measurement approaches compared. Finally, the chapter lists concrete recommendations for exploring teachers' knowledge and effective use of technology in an international large-scale survey.

Conceptualising knowledge to integrate technology in teaching

Numerous attempts have been made to elaborate on what digital competence is needed for teaching in a digitalised school (Ferrari, 2012[25]; Hatlevik and Christophersen, 2013[26]; Kivunja, 2013[27]; Krumsvik, 2008[28]; Howell, 2012[5]). Scholars commonly stress that teachers' digital competence is embedded into complex organisational systems. Therefore, it denotes a more multifaceted set of competencies compared to 'digital competences' needed in other areas of society (Instefjord and Munthe, 2016[29]; Krumsvik, 2008[28]; Pettersson, 2018[30]). Teachers need more than fundamental technological skills to be digitally competent, as it is about applying technological skills in an educational context, as a pedagogical resource. For example, Kivunja (2013, p. 131[27]) described such digital competence as 'the art of teaching,

computer-driven digital technologies, which enrich learning, teaching, assessment, and the whole curriculum.

Krumsvik (2008[28]) suggests that teachers' digital competence entails teachers' proficiency in using technology in a professional context, with good pedagogic-didactic judgement and awareness of its implications for learning strategies. From these perspectives, technologies are considered as a way to support pedagogical knowledge and methods. However, most of the widely used technology is not designed to operate in educational contexts. Many of the popular software programmes are not primarily intended for educational purposes but rather business purposes. In the same way, web-based services are primarily designed for entertainment, communication and social networking (Koehler, Mishra and Cain, 2013[31]). This means that teachers need to develop methods, strategies and applications of technology which are suitable in a teaching and learning context (Kivunja, 2013[27]; Krumsvik, 2008[28]; Mishra and Koehler, 2006[9]). This can partly explain why many teachers experience difficulties in integrating technology into teaching. A framework that highlights such complexity and that has reached great impact both in research and in practice is discussed below.

TPACK: A framework on technology integration and its relation to teachers' general pedagogical knowledge

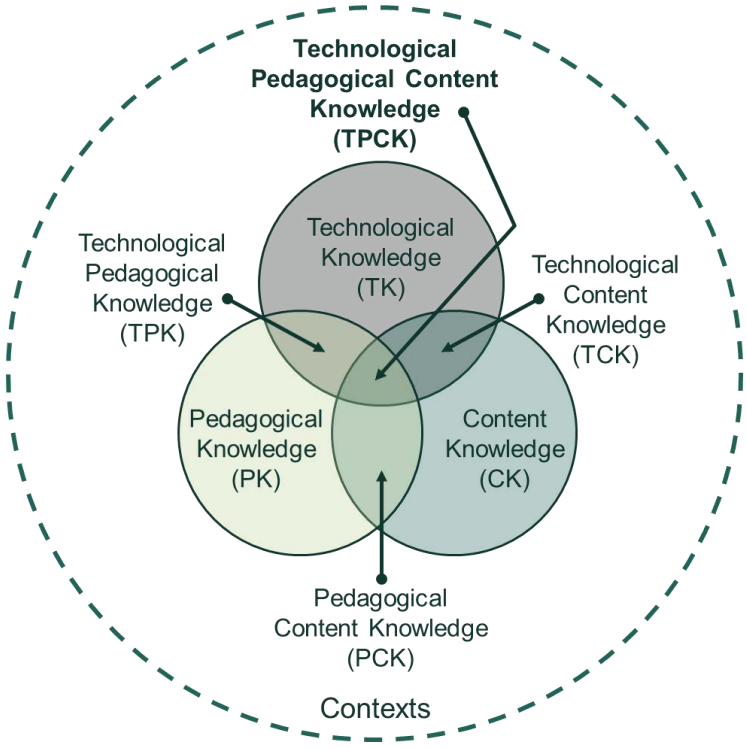
TPACK, denoting Technological Pedagogical and Content Knowledge, has emerged as a theoretical framework aiming at specifying what knowledge is required for teaching in the 21st century. It has attracted much attention within the educational field (Willermark, 2018[32]). TPACK constitutes the development of Shulman's Pedagogical Content Knowledge model (PCK) (Shulman, 1986[33]). In the original work, Shulman stressed the importance of integrating teachers' content knowledge with pedagogical knowledge. Shulman defined PCK as going beyond content or subject matter knowledge to include knowledge about how to teach a particular content.

In Mishra and Koehler's (2006[9]) development of the work, the aspect of Technological Knowledge (TK) was added. The work refers to TK as the knowledge of how to work with and apply technological recourses. The framework stresses the complex intersection of technological, pedagogical and content knowledge within given contexts. The framework suggests that apart from considering these components in isolation, it is necessary to look at them in pairs as "Pedagogical Content Knowledge" (PCK), "Technological Content Knowledge" (TCK), "Technological Pedagogical Knowledge" (TPK), and finally, all three taken together, as "Technological Pedagogical and Content Knowledge" (TPACK) (see Figure 3.1).

From this point of view, teaching entails developing a nuanced understanding of the complex relationship between technology, pedagogy and content, and using this understanding to develop suitable context-specific strategies and representations of content. The great impact of TPACK may be because it constitutes a theoretical framework that focuses on how technology is integrated into teaching. TPACK represents a holistic view of the knowledge teachers need to effectively apply technology in teaching (Willermark, 2018[32]; Mishra and Koehler, 2006[9]).

The framework has received criticism for not being practically useful. In particular, the technology domain has been criticised for being vague (Cox and Graham, 2009[34]; Graham, 2011[35]). The argument of this chapter, however, is that TPACK constitutes a fruitful framework to explore technology integration in teaching practices. This is due to the holistic approach to technology integrating into teaching, within a specific context. It stresses the qualitative aspects of technology usage and goes beyond a simplified approach to technology as having an intrinsic value. It is consistent with previous research that highlights the complexity of technology use in teaching (Burroughs et al., 2019[22]; Islam and Grönlund, 2016[20]; Willermark and Pareto, 2020[36]).

Figure 3.1. The TPACK framework



Source: (TPACK ORG, 2012[37])

TPK: Teachers subject-independent knowledge and skills to effectively use technology

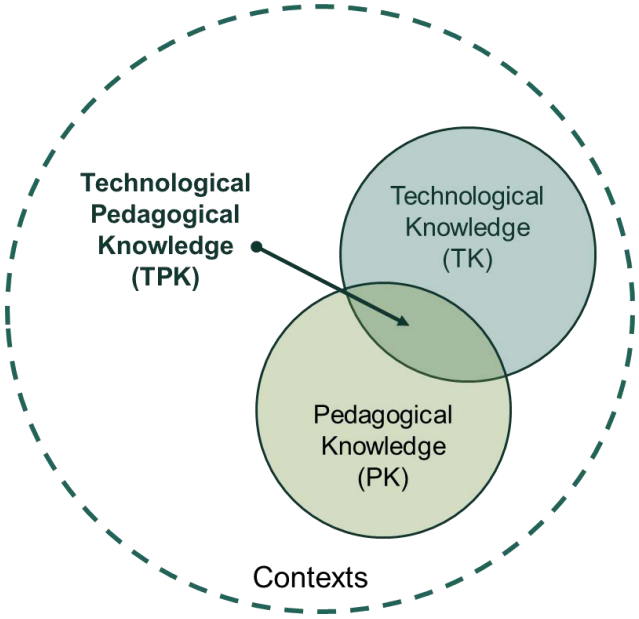
General pedagogical knowledge has been highlighted as an important ingredient for high-quality teaching. In a recent review of research on the relevance of general pedagogical knowledge, it has been identified that deep and broad knowledge about general pedagogy allows for successful teaching-learning events. It includes greater efficacy in teaching and the successful management of multicultural classrooms (Ulferts, 2019[38]). Studies to date, however, provide little insights into the subject-independent knowledge that teachers need for the effective use of technology in their work. Based on these findings, there are reasons to explore teachers' abilities to use technology to support their general pedagogical knowledge.

In the TPACK framework, the “Content Knowledge” constitutes a basic component together with “Pedagogical Knowledge” and “Technological Knowledge”. However, the construct of “Technological Pedagogical Knowledge” (TPK) captures the subject independent knowledge teachers need as a foundation to effectively use technology in their teaching. It stresses the relationship between general *pedagogical knowledge*, i.e. the specialised knowledge of teachers for creating effective teaching and learning environments for all students independent of subject matter (Guerriero, 2017[39]), and general *technological knowledge*, i.e. a basic understanding of technology use, skills required to operate particular technologies and the ability to learn and adapt to new technologies. “Technological Pedagogical Knowledge” is knowledge of the existence and capabilities of various technologies that are used in teaching and learning settings, and knowing how teaching can transform when using particular technologies. This is based on an understanding that a range of tools exists for a particular task.

The framework illustrates the skills needed to select a suitable tool and strategies for using the tool’s affordances, i.e. the possibilities and permissions that a technological artefact invites to. It also includes knowledge of pedagogical strategies and the ability to apply those strategies along with technology (Mishra

and Koehler, 2006[9]). Such a broad definition is necessary to capture teacher's "Technological Pedagogical Knowledge" across disciplines and educational levels. Furthermore, as technology is constantly evolving, the meaning of "Technological Knowledge" needs to be in constant motion, since a narrow definition risks becoming quickly outdated. Since change and development are part of the theoretical framework, it also has the opportunity to stay relevant over time.

Figure 3.2. Teachers' subject-independent knowledge to effectively use technology in teaching



Source: (TPACK ORG, 2012[37])

The next section discusses ways to measure teacher's knowledge based on the TPACK framework. The focus is on "Technological Pedagogical Knowledge" (see Figure 3.2). Even though the intersection of technology and pedagogy is in focus, it can also be of interest to explore each component separately, in order to investigate the strengths and weaknesses of teachers' knowledge base. Such an identification can be important to be able to identify the type of support that teachers may need.

Measuring teachers' technological knowledge and skills in an international survey

There are two ways which are most commonly used to evaluate teachers' knowledge and skills of using technology in teaching; through *self-reporting* or though *performance-analysis* of teaching-related activities (Willermark, 2018[32]). In addition to these approaches, tests can also be used to measure teachers' knowledge (Maderick et al., 2016[40]; Drummond and Sweeney, 2017[41]). The approaches offer different opportunities and challenges, which will be discussed below, followed by an overview of existing instruments.

Opportunities and challenges of different measurement approaches

Self-reporting via questionnaires and objective knowledge assessments

The most frequently used approach to measure teachers' technology-related knowledge and skills consists of self-reporting via questionnaires but studies have also used interviews and diary entry questions, in which teachers document and reflect upon their performance (Archambault and Crippen, 2009[42]; Schmidt et al., 2009[43]; Chai et al., 2013[44]; Lux, Bangert and Whittier, 2011[45]). The approach has obvious advantages, such as enabling efficient, comprehensive and comparable studies from a large amount of data (Bryman, 2015[46]). Furthermore, self-reporting questionnaires offer an opportunity of highlighting teachers' perspectives, as well as offering opportunities for reflection on teachers' own technology-related knowledge and skills.

Due to the limitations of self-reporting there are also disadvantages. Studies show that making accurate evaluations of one's own abilities is a difficult task. There is a risk of 'socially desirable responding', which has been described as the tendency of people to answer in a way that is more socially acceptable (Nederhof, 1985[47]), and the tendency to give overly positive self-descriptions (Paulhus, 2002[48]). People can be unaware of their lack of technology-related knowledge and/or under- or over-estimate their abilities. In an educational context, Lawless and Pellegrino (2007[49]) show that gains in teachers' self-reported knowledge over time reflect their increased confidence rather than their actual increased knowledge in practice.

This phenomenon has been recognised in research on TPACK as well. For example, a study by Drummond and Sweeney (2017[41]) showed that self-reported TPACK of pre-service teachers revealed only a weak correlation with knowledge test. In another study, Maderick, Zhang, Hartley and Marchand (2016[40]) came to similar conclusions. Various factors can affect the difficulty of making a realistic assessment of one's own ability, such as how important the knowledge is to the self-reporter but also how well the questions are specified (Ackerman, Beier and Bowen, 2002[50]). Thus, the ecological validity of self-report can be questioned as it is hard to tell what is measured: the desired personal characteristic, or how much respondents can stretch the image of themselves; respondent's self-confidence or actual knowledge?

Still, self-reports tend to detect teachers' self-efficacy, which is a crucial component of teachers' technology-related knowledge and a predictor of actual teacher behaviour (Tschannen-Moran, 2001[51]). Thus, teachers need positive beliefs, motivation and knowledge to effectively integrate technology in teaching. It makes self-efficacy a relevant, but an insufficient, aspect to explore when measuring teachers' technological knowledge and skills of using technology in teaching.

Socially desirable responding and self-awareness aside, there is additional difficulty linked to standardised measurement instruments such as questionnaires to measure teacher technology-related knowledge. Thus, questionnaires usually reflect a simplified approach towards knowledge as something stable that the individual possesses, regardless of situation or context (Willermark, 2018[32]). Yet, knowledge cannot be considered exclusively as a static embedded capability nor a stable disposition of actors. Instead, it constitutes a situated ongoing accomplishment that is constituted and reconstituted as one engages in practice (Orlikowski, 2002[52]). Thus, what it means to be technologically knowledgeable is complex.

Studies show that although teachers may have technological knowledge, it does not automatically mean they are capable of using them in teaching practice (So and Kim, 2009[53]; Tatto, 2013[54]). To address these issues of transfer, it becomes important to use *contextualised questionnaires* that use statements or questions that refer to concrete teaching tasks and situations. That is, to not just ask questions of the character if/how the respondent feels technologically knowledgeable in general, but rather in what situations and in relation to what activities. Contextualised self-reports have been shown to yield on average more moderate results than self-reports of a general nature (Ackerman, Beier and Bowen, 2002[50]). Designing a questionnaire where questions are of specific and context-bound character, rather

than of general nature, is a way to get closer to measuring teachers' knowing in practice (Willermark, 2018[32]).

In addition to measurement based on self-reporting, there is also the possibility of using *assessments that test teachers' technology-related knowledge*. This approach can be used to collect more objective data of teachers' TPACK than self-reporting. Although the approaches offer more objective data than self-reporting, it still involves several challenges. First, there is a lack of existing instrument which have been widely applied and validated in different contexts. Second, existing instruments provide a rather narrow picture of technology use in teaching and technology-related knowledge of teachers (see the Section Overview of existing instruments and synthesis for examples). Similar to self-reporting on questionnaires, assessments do not capture how teachers' knowledge and skills are manifested in practice. For example, even though teachers know the strict definition of an artefact, it does not mean that they are capable or motivated to use it in practice, or vice versa. It becomes especially difficult to capture the complex knowledge that the intersection of knowledge domains constitutes and how these are manifested in a given context. Furthermore, questions on teachers' technological knowledge risks becoming quickly dated, due to rapid technological development (therefore making the instrument subject to temporal limitations).

Performance-analysis of teaching activities

Performance-analysis on different teaching-related activities is often carried out as tasks in which teachers are asked to perform teaching actions, such as planning or implementing teaching in a fictional or authentic setting, and where the performance is documented and analysed (Curaoglu et al., 2010[55]; Graham, Cox and Velasquez, 2009[56]; Graham, Borup and Smith, 2012[57]; Harris, Grandgenett and Hofer, 2010[58]; Kereluik, Casperson and Akcaoglu, 2010[59]; Suharwoto, 2006[60]; Pareto and Willermark, 2018[61]). Evaluating teachers' technological knowledge via performance-analysis on teaching activities brings the benefit of capturing teachers' manifestation of technology-related knowledge and skills in practice. That is, how knowledge about technology and pedagogy is applied in a teaching situation. Depending on the evaluation design, it can capture how teaching is orchestrated in interplay with students, technology and other elements, which influence the teaching dynamics. The approach is advantageous since teaching involves not only adapting to a range of predictable parameters, such as student group composition or classroom environment and the school's digital infrastructure. It also includes situational aspects, such as timing (to continually make instantaneous decisions regarding what, when and how to provide students with feedback); classroom management, such as balancing the need of the individual with the rest of the student group; and coping with unforeseen events and technological problems (Willermark, 2018[32]).

However, inferring a teacher's technology-related knowledge solely by direct observation entails disadvantages as well. Neither can the decision-making processes that led to the observed actions and interactions be identified, nor can the rationale that undergirds those actions be detected. To compensate for these shortcomings, observations can be supplemented with an analysis of teaching materials, such as instructional plans and student materials. These materials may capture the intention of the teaching design. Qualitatively oriented researchers have developed in-depth coding schemes, models and rubrics to classify material representing authentic teaching. For example, lesson plans, videotaped classroom instruction or teachers' retrospective reflections according to the particular level of teachers' technology-related knowledge (Harris, Grandgenett and Hofer, 2010[58]; Pareto and Willermark, 2018[61]; Schmid, Brianza and Petko, 2020[62]).

The approach to measure teachers' technological knowledge through performance is less common, particularly in the more comprehensive studies (Willermark, 2018[32]). Although the approach can provide valuable insights of teaching quality, performance analysis often means that only one or a few activities are analysed, which is not necessarily representative of the teacher's general competence. Preferably,

teachers' performance should be studied over time. This is, however, resource intensive and can be difficult to realise.

Nevertheless, there are examples of large-scale international studies that use performance-analysis. The OECD Global Teaching InSights (GTI) study involves video-recording of mathematics lessons taught by a representative sample of 85 lower secondary teachers in each participating country. In addition to video-recordings, the study included teacher and student surveys, as well as teaching and learning material such as lesson plans, homework and assessments (OECD, 2020[63]). Thus, follow-up studies or smaller cross-country surveys that evaluate teachers' technological knowledge via performance on teaching activities could yield promising results.

Overview of existing instruments and synthesis

Self-reporting instruments and objective assessments

A literature review shows that questionnaires are the most frequently used approach to measure teachers' TPACK (Willermark, 2018[32]). Often, participants are asked to numerically rate statements on a five or seven-point Likert scale. Teacher's knowledge within the domains of Technology and Pedagogy and Content is measured consistently both individually and within their intersections. Many instruments have been developed and applied in different ways to operationalise teachers' knowledge. The addressed instruments cover several or all seven TPACK components, and scales show overall high reliability (see Table 3.1 for details).

Table 3.1. Overview of selected TPACK questionnaires

Author	Samples	Region	Number of items	Cronbach's alpha
Schmidt et al. (2009[43])	Pre-service teachers	USA	*Overall:* 47; *Subscales:* TK: 7, CK: 12, PK: 7, TPK: 5, PCK: 4, TCK: 4, TPACK: 8	TK = 0.82, CK = 0.81, PK = 0.84, PCK = 0.85, TCK = 0.80, TPK = 0.86, TPACK = 0.92
Chai et al. (2011[64])	Pre-service teachers	Singapore	*Overall*: 31; *Subscales:* TK: 6, CK: 4, TPK: 3, TPACK: 5, TCK: 1, PKML: 13	TK = 0.90, CK = 0.91, TPK = 0.86, TPACK = 0.95, TCK = not reported, PKML = 0.91
Archambault and Cripp en (2009[42])	In-service teachers	USA	*Overall*: 24; *Subscales:* TK: 3, CK: 3, PK: 3, TPK: 4, PCK: 4, TCK: 3, TPACK: 4	TK = 0.88, CK = 0.76, PK = 0.77, PCK = 0.79, TCK = 0.69, TPK = 0. 77, TPACK = 0.78
Lux et al. (2011[45])	Pre-service teachers	Western region	*Overall*: 27; *Subscales:* TPACK: 8, TPK: 5, PK: 4, CK: 3, TK: 4, PCK: 3	TPACK = 0.90, TPK = 0.84, PK = 0.77, CK = 0.77, TK = 0.75, PCK = 0.65
Jang and Tsai (2013[65])	In-service teachers	Taiwan	*Overall*: 30; *Subscales:* CK: 5, PCKCx: 9, TK: 4, TPCKCx: 12	CK = 0.86, PCK = 0.91, TK = 0.89, TPCKCx = 0.97

Note: The instruments by Schmidt et al. (2009[43]) and Archambault and Crippen (2009[42]) are of particular interest for designing an international large-scale survey.

A frequently used questionnaire was developed by Schmidt et al. (2009[43]). The questionnaire was originally developed to assess pre-service teacher knowledge. Participants were asked to rate statements on a five-point Likert scale and the instrument includes 47 items. For example, it includes statements such as *"I can choose technologies that enhance the teaching lesson"* or "*I am thinking critically about how to use technology in my classroom"* or *"I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn"* (reflecting Technological Pedagogical Knowledge). Other examples include *"I know how to solve my own technical problems*" or *"I can learn technology easily* (reflecting Technological Knowledge) or *"I can adapt my teaching style to different learners"* or *"I can assess student learning in multiple ways"* (reflecting Pedagogical Knowledge).

Many scholars have used the instrument in its original form or have somewhat modified it to fit to particular needs, such as translation. The questionnaires have been used in diverse contexts including pre-service and in-service teachers, different teaching grades, different disciplines and different countries [including, for example, France (Azmat et al., 2020[17]; Azmat et al., 2021[18]), Indonesia (Ansyari, 2015[66]), Kuwait (Alayyar, Fisser and Voogt, 2012[67]),Taiwan (Chen and Jang, 2014[68]),Turkey (Calik et al., 2014[69]) and USA (Banas and York, 2014[70]; Doering et al., 2014[71])].

Building on the work of Schmidt et al. (2009[43]), another frequently used questionnaire was developed by Chai, et al. (2011[64]). They used a seven-point Likert scale and suggest a 31-item questionnaire building on items from Schmidt et al.'s (2009[43]) to evaluate Singaporean pre-service teachers TPACK. Revisions of the items have been made, for example, they include items that address web-based competencies, such as *"I am able to teach my student to use web 2.0 tools (e.g. Blog, Wiki, Facebook)"* or *"I am able to use conferencing software (Yahoo, IM, MSN Messenger, ICQ, Skype, etc.)"* (reflecting Technological Knowledge). The instrument has also been applied in different countries and to in-service and pre-service teachers directly or with some modification. Examples include in-service Chinese language teachers' (Chai et al., 2013[44]), pre-service Singapore teachers (Chai et al., 2011[64]) and pre-service Swiss upper secondary school teachers (Schmid, Brianza and Petko, 2020[62]).

Furthermore, Archambault and Crippen (2009[42]) designed a questionnaire to measure American online K-12 teachers TPACK. A total of 24 items was applied to measure each of the seven TPACK dimensions using a 5-point Likert scale. Respondents were asked the overall question: *"How would you rate your own knowledge in doing the following tasks associated with teaching in a distance education setting?"* Items included*: "My ability to moderate online interactivity among students"* (reflecting Technological Pedagogical Knowledge) or *"My ability to determine a particular strategy best suited to teach a specific concept"* (reflecting Pedagogical Knowledge) or *"My ability to troubleshoot technical problems associated with hardware (e.g. network connections)"* (reflecting Technological Knowledge). The instrument has been applied by other researchers as is or with some modifications, including pre-service (Han and Shin, 2013[72]) and in-service (Joo, Lim and Kim, 2016[73]) teachers in South Korea.

There are additional examples of TPACK questionnaires instruments. For example, Lux, Bangert, and Whittier (2011[45]) developed a 45-item questionnaire to address the need for an instrument for assessing pre-service teacher TPACK, referred to as "PT-TPACK". The questionnaires explore to what extent western pre-service teachers perceive to be prepared for teaching based on the different TPACK constructs. The questionnaires were designed so that participants responded to each item by indicating to what extent they agree with the statement: *"My teacher preparation education prepared me with X"*. For example, it includes statements such as *"An understanding that in certain situations technology can be used to improve student learning"* or *"An understanding of how to adapt technologies to better support teaching and learning"* (reflecting Technological Pedagogical Knowledge). This is in line with the teacher survey in TALIS, which asks similar questions about whether certain elements were included in teachers' formal education or training, and to what extent teachers feel prepared for these in their teaching. In TALIS, one item is "Use of ICT (information and communication technology) for teaching". Items from the questionnaire of Lux, Bangert, and Whittier (2011[45]) could provide valuable complementary information. For example, *"An understanding of how technology can be integrated into teaching and learning in order to help students achieve specific pedagogical goals and objectives"* or *"Knowledge of hardware, software, and technologies that I might use for teaching"*.

Furthermore, there are examples of instruments that explore specific technologies or phenomenon. Jang and Tsai (2013[65]) developed a 30-item questionnaire to explore interactive whiteboards in relation to TPACK ("IWB-based TPACK"). The instrument was explored in the context of Taiwanese elementary mathematics and science teachers. Lee and Tsai (2010[74]) developed a 30-item questionnaire, referred to as "Web Pedagogical Content Knowledge", which explores teachers' attitudes toward web-based instruction in the context of elementary to high school level in Taiwan. Besides, many studies explore technology integration in relation to different subject domains. For example, mathematics (Agyei and

Voogt, 2012[4]; Corum et al., 2020[75]), chemistry (Calik et al., 2014[69]), geography (Hong and Stonier, 2015[76]), language (Baser, Kopcha and Ozden, 2016[77]; Hsu, Liang and Su, 2015[78]) and social sciences (Akman and Güven, 2015[79]).

There are also examples of instruments that utilise open-ended questionnaires. Typically, questionnaires contain items that ask teachers to write about their overall experience in an educational technology course or professional development programme that is designed to promote pre-or in-service teachers' Technological Pedagogical Content Knowledge (Koehler et al., 2014[80]). For instance, So and Kim (2009[53]) used the following question: *"What do you see as the main strength and weakness of integrating ICT tools into your PBL (problem-based learning) lesson?"* The authors then coded teachers' responses focusing on their representations of content knowledge in relation to pedagogical and technological aspects of the course. Open-response items could be applied to gain more in-depth knowledge of teachers' motives, reason and actions in different situations. For example, it could involve questions concerning what teachers perceive to be the main opportunities and challenges of integrating technology into their teaching, or in what way the use of technology affects their work. In a large-scale survey, open response items should be used with caution. However, short answer constructed-response could be valuable and used in a few carefully selected cases.

Only few *assessments of teachers' technology-related knowledge* exist. For example, Drummond and Sweeney (2017[41]) developed a test to measure teachers' TPACK. The test included 16 items, in which teachers were asked whether a series of statements about technology use for teaching were true or false. For example; *"Research suggests that technology generally motivates students to participate in the teaching and learning process"* or *"To get the sound to play across multiple slides in Microsoft PowerPoint, you should use commands in the Transitions Menu"*.

In another study, Maderick et al. (2016[40]) designed a test to explore pre-service teachers' digital competence. The test included 48 multiple choice questions, distributed on seven topics: General Computer Knowledge, Word Processing, Spreadsheets, Databases, E-Mail/Internet, Web 2.0. and Presentation Software. For example: *"The process of encoding data to prevent unauthorised access is known as: a) locking out, b) encryption, c) compilation, d) password protection or e) I do not know"* or "*Details of business transactions, which are unprocessed, would be classified as: a) information, b) bytes, c) data, d) files, or e) I do not know"* (reflecting General Computer Knowledge).

The overview of existing *self-reporting instruments* demonstrated that the TPACK framework has been widely applied to measure teachers' knowledge and skills of using technology in teaching via questionnaires in various contexts across countries, disciplines and educational levels. Instruments that can be particularly interesting for an international large-scale questionnaire are Schmidt et al. (2009[43]), as well as Archambault and Crippen (2009[42])[1]. The instrument by Schmidt et al. (2009[43]) has shown particularly widespread use in various contexts and regions, which is an indication of cross-country feasibility. The instruments offer several items to measure teachers' Technological Pedagogical Knowledge that can easily be integrated into a questionnaire of an international survey on teacher knowledge.

Though *assessments that test teachers' technology-related knowledge* exist, they often provide a rather narrow picture of technology use in teaching and technology-related knowledge of teachers. Thus, the development of an objective assessment of teachers' technology-related knowledge requires more effort. As highlighted in Figure 2.2 in Chapter 2, this knowledge is transversal. Teachers can use technology to support their instruction, their assessment practices but also to foster individual and group learning. Consequently, an assessment should include technology-related items for the three content areas ("knowledge dimensions") of instruction, assessment and learning.

Performance-based instruments

There are examples of approaches and instruments that measure teacher's performance on teaching-related activities (see Table 3.2 for an overview). For example, teachers' lesson planning has been explored. Koh, Chai and Tay (2014[81]) examined in-service teachers' conversations during group-based lesson planning sessions. They categorised teachers' comments about ''content'', ''technology'', ''pedagogy'' and the intersections. The unit of analysis was design-talk as a lesson plan product, and teachers' knowledge were measured through analysing teachers' discussions.

Table 3.2. Overview of selected TPACK performance-based instruments

Author	Sample	Region	Activity	Description of measurement approach
Koh et al. (2014[81])	In-service teachers	Singapore	Planning	TPACK is measured via a coding protocol as the frequency with which comments refer to the seven components: subject matter (CK) technologies and their features (TK), processes or methods of teaching (PK), subject matter representation with technology (TCK) using technology to implement different teaching methods, (TPK), teaching methods for different types of subject matter, (PCK) and, using technology to implement teaching methods for different types of subject matter (TPACK).
Graham et al. (2012[57])	Pre-service teachers	USA	Planning	Student rationales were qualitatively analysed for evidence of TPACK including: TK, TPK and TPACK.
Harris et al. (2010[58])	Pre-service teachers	USA	Planning	TPACK is measured via a "Technology Integration Assessment Rubric". The rubric measures four aspects: 1) Curriculum Goals and Technologies, 2) Instructional Strategies and Technologies, 3) Technology Selection(s) and, 4) Fit.
Kafyulilo et al. (2016[23])	Pre-service teachers	Tanzania	Teaching	TPACK is measured via an observation checklist inspired by Technology Integration Assessment Rubric, using a dual response scale of "No" and "Yes".
Maeng et al. (2013[82])	Pre-service teachers	USA	Planning Teaching Evaluation	Participants' use of technology for science inquiry is measured, by content area and investigation type via observations and experimental investigations.
Pareto and Willermark (2018[61])	In-service teachers	Sweden Norway Denmark	Planning, Teaching, Evaluation	TPACK is measured using didactic designs as the unit of analysis. Questions serve for the evaluation of the design qualities of a didactic design regarding the different TPACK components: TK: Which technology usages are present? CK: Which curricula content goals are addressed? PK: Which pedagogical strategies are used? TCK: How are the technology usages aligned with curricula content goals? PCK: How are the pedagogical strategies supporting curricula content goals? TPK: How are the technology usages supporting the pedagogical strategies? TPACK: How do all three components fit together?

Furthermore, Graham, Borup and Smith (2012[57]) explored the instructional decisions that pre-service teachers make before and after completing an educational technology course. Through pre- and post-assessments, pre-service teachers were given a design challenge and were asked to articulate how they would use technology to address specific curriculum criteria. Their responses were analysed by external evaluators of researchers. The evaluation was based on aspects such as how detailed the arguments were and whether there were multiple overlapping reasons for using a particular technology or not.

Moreover, Harris et al. (2010[58]) designed and tested an instrument ("Technology Integration Assessment Rubric") for evaluating pre-service teachers' lesson plan documents. The rubric involved four themes which was graded on a four-point scale. For example: *"technology use optimally supports instructional strategies"* represents the highest score while *"technology use does not support instructional strategies"* represents the lowest score. The instrument has been disseminated in a different context by Kafyulilo, Fisser, Pieters and Voogt (2016[23]). They studied pre-service teachers' process of integrating technology in microteaching sessions via observations and adopted an observation checklist inspired by Harris, Grandgenett, and Hofer (2010[58]). In another study, Maeng et al. (2013[82]) explored pre-service teachers who planned, implemented and evaluated teaching in an authentic setting during student teaching placements. Their teaching activities were analysed based on multiple data sources: observations, lesson plans, interviews

and reflections. The analysis focused on *how* and to *what extent* participants employed TPACK by identifying instances of technology use associated with the facilitation of inquiry instruction.

Stoilescu (2015[83]) explored in-service teacher TPACK. Data included interviews, classroom observations and document analysis. Based on this, a TPACK profile for each teacher was created and the relative extent of each teacher's TPACK domain of knowledge was estimated on a scale: unconvincing expertise, small, medium, large and extra-large. Yet, how TPACK was operationalised was not revealed since the author stated to have intuitively explored the cases in relation to TPACK. A similar approach to study in-service teachers TPACK via multiple data sources in authentic setting was conducted by Pareto and Willermark (2018[61]). A TPACK operational model was developed for designing and evaluating teachers' didactic designs in practice.

The TPACK framework has been used to measure teachers' application of TPACK in teaching situations. Whether it is orchestrated as a study assignment for pre-service teachers or as a way of examining in-service teachers' practice in an authentic setting, it reflects a manifestation of contextualised teacher knowledge in practice. All the discussed instruments can offer inspiration for such an approach. However, two instruments that can be particularly useful are Graham et al. (2012[57]), and Pareto and Willermark (2018[61]). This is because the studies provide: a) explicit operationalisation instruments, b) capture the quality of technology integration, c) are not subject-specific and d) have been applied in different teaching contexts.

Recommendations for an international large-scale survey

Based on what has been discussed in this chapter, implications for an international large-scale survey are discussed below (see Table 8.1 in Chapter 8 for the main takeaways from this expert chapter for TALIS and the TKS assessment module).

Conceptual underpinning through the TPACK framework

The TPACK framework has been applied to conceptualise and measure teachers' technology-related knowledge and skills in various surveys. It avoids a common oversimplification, where technologies are perceived as merely add-on and instead highlight the complex interactions between pedagogy and technology. The framework can be used to explore teachers' subject-independent knowledge and skills to effectively use technology in teaching and could be used as a starting point for specifying the technology-related components that should be measured in an international study on teacher knowledge.

Measuring teacher knowledge through contextualised items drawing on existing instruments

As discussed, an objective assessment of teachers' technology-related knowledge has certain advantages but requires some developmental effort as it cannot draw on existing instruments. However, existing self-reporting and performance-based instruments should be reviewed as they point to important topics for assessment items. Conversely, many TPACK questionnaires exist. They are widely used in large-scale surveys such as TALIS, as they enable the collection of data which provides nuance and insight into teachers' perception of their own competence. It is also an inexpensive approach that is easy to scale up, which therefore allows for an easy analysis of results.

It is recommended to focus on items that are contextualised for the instrument development: Questions and items that are grounded in practice explore teachers' actions in relation to their teaching practice. They should be specific and context-bound, rather than of general nature. Building on the experience from TPACK studies, the instrument should ask teachers to rate statements relating to their technology-related knowledge on Likert scales, which could easily be included into any existing questionnaire that already

uses Likert scales. Although a five-point scale is the most common in TPACK questionnaires, it is suggested to harmonise the scaling to the format used in the existing questionnaire (e.g. for TALIS a four-point scale).

To explore teachers' self-efficacy and self-rated knowledge to use technology as an educational tool, items from TPACK instruments can be used[2]. However, existing instruments need to be adjusted, for example several items need to be excluded and/or modified as:

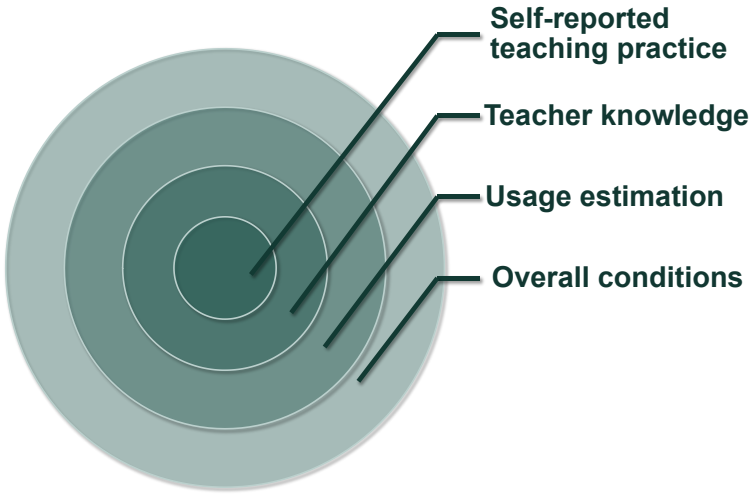
- Existing instruments (both questionnaires and performance instruments) contain items and constructs that are outside the scope of a study on teachers' general pedagogical knowledge, i.e. teachers' content knowledge (and the intersection of pedagogical knowledge and technological knowledge).
- Some items are bound to a particular situation, such as online teaching, or are subject-specific.
- Many of the existing statements are too general. Thus, they need to be supplemented with more situated statements on how teachers manifest their knowledge in practice.

Additionally, new items should be included because the existing questionnaires often exclude certain topics such as knowledge about copyright and personal data law; online ethics and cyberbullying, and safety. It could be of interest to explore teachers' perspectives, experience and knowledge related to these aspects. Here, items could be added, for example; *"I have good knowledge of the rules regarding copyright and what applies to publishing content online"*. Such issues could be linked to the component of "Technological Knowledge".

Additional questionnaires providing context information relating to teacher knowledge

In addition to teacher's assessed and self-rated knowledge of using technology in teaching, three areas are proposed for the questionnaire to provide context information teacher knowledge (see Figure 3.3). These areas are: 1) Self-reported teaching practice, 2) Usage estimation (i.e. the frequency and purpose of technology use of teachers) and 3) Overall conditions for technology use in schools. The areas can be seen as different layers, in which the core consists of self-reported teaching practice that builds on teachers' specialised knowledge of using technology in teaching. To interpret, understand and analyse the results on the interplay between knowledge and practice, the other layers become important. The motivation for the inclusion of each layer or area, as well as suggestions on the type of items to address, are given below. Unless otherwise stated, the suggested items are developed by the author.

Figure 3.3. Aspects of teacher's technology-related knowledge and skills



Self-reported teaching practice

It is crucial to examine how teachers' technological knowledge and skills support their general pedagogical knowledge in practice. One way to address the issue is to link it to the core knowledge areas of teaching, which have been identified in a previous OECD report (König, 2015[84]) (see also Chapter 2), including:

1. **Instruction** (including teaching methods, didactics, structuring a lesson and classroom management). Items linked to this aspect could address whether teachers:
    - apply technology to explain and/or present learning content in a more comprehensible way, for example by making representations visual, multimodal or interactive
    - use technology to apply different teaching methods such as flipped classroom, explore real-world scenarios, student active methods or problem-based learning
    - work with students work in a digital platform
    - use technology to support absentee students' knowledge acquisition by sharing teaching materials and /or interacting with students.
2. **Learning** (including their cognitive, motivational, emotional individual dispositions; their learning processes and development; their learning as a group taking therefore into account student heterogeneity and adaptive teaching strategies). Items linked to this aspect could address whether teachers can use technology:
    - to increase the adaption to students' individual needs
    - in a way that supports students' ability to achieve qualitative goals such as increased motivation and creativity
    - to increase interaction with students and support their learning process.
3. **Assessment** (including diagnosing principles irrespective of the subject, evaluation procedures). Items linked to this aspect could address whether teachers:
    - administer digital exams
    - use technology to increase student feedback and to vary the way they check students' knowledge
    - apply technology to get information about a student's level of knowledge and progress.

The statements must be sufficiently concrete so that teachers are able to make a reasonable estimate of their teaching practice. It is also important to focus on the teaching-related activity rather than the specific

tools, as it is impossible to capture all conceivable technological resources that can be used. Furthermore, it is the ability to use technology as a pedagogical tool rather than knowledge to use the tool itself that is of interest.

Usage estimation

Since previous research shows that the degree of technology use differs greatly between countries, schools and classrooms, it would be valuable to also map simple estimations of usage. That is how often teachers use technology and for what purposes, including: a) planning teaching and learning activities, b) teaching (a resource in teaching and learning activities), c) evaluation (conduct student documentation and assessment) and d) collaboration and communication with legal guardians and colleagues (e.g. sharing documents and lesson materials, communicating via forums, learning platforms, intranets, etc.) Based on the categories, a few items could be formulated such as "*I use technology to plan teaching and learning activities"*. Here it could be useful to apply frequency response scales (e.g. ranging from "daily" to "never"). This would be well suited for many teacher surveys, including TALIS, in which a frequency is applied to indicate how often a particular instructional practice occurs during lessons in a randomly selected target or reference class.

Overall conditions for technology use in schools

Teachers' overall conditions for technology use in schools cannot be overlooked when trying to understand teachers' technological knowledge and skills in practice. Given that there are differences regarding access to technology between and within countries, it is of relevance to identify teachers' overall conditions to using technology, including:

- Infrastructure. Access to robust infrastructure is crucial when integrating technology into teaching practice. For example, usage depends on the number of units (e.g. tablets, computers) per student that are available. This constitutes, therefore, a meaningful indicator of the overall conditions for using technology in teaching in schools. Areas for identification can include: the age and performance of computers or tablets, whether there is sufficient internet connection, the level of power supply, and the level of access to relevant software and adaptive technology (e.g. to what extent students with special needs have access to tailored digital tools).
- Support functions. Local support functions (such as the level of access to [rapid] digital-support and pedagogical IT-support) are also important aspects that can enable or hinder a teacher's implementation of technology in teaching.
- Leadership. Research emphasises the importance of an active leadership in the digitalisation process. Important aspects include concretising policies on digitalisation into realistic goals and providing teachers with appropriate professional development. It would be important to include one or a few questions about whether teachers believe that digitalisation policies are defined within their school in an international survey.

Based on the above, some core questions can be formulated to capture teachers' overall conditions. Examples of items could be: *"I have access to sufficient internet connectivity"* or *"Students with special needs have access to tailored digital technology".*

Complementing the survey with a performance study for ecological validity

As self-reporting and assessments have limitations in terms of capturing teachers applied knowledge, a performance study for ecological validity is suggested as a complement to the survey. This means that a subsample of the teachers participating in the survey should be asked to conduct a performance task, in which they are asked to integrate technology into their teaching. This would provide an opportunity to validate the answers from the questionnaire and assessment with a performance-based measurement of

teachers applied knowledge. Through the Global Teaching InSights (GT) study, the OECD recently gathered experience with the large-scale use of performance measures across countries (OECD, 2020[63]).

To validate results from an international survey on teachers' general pedagogical knowledge, it is suggested to ask a subsample of teachers participating in the survey to make a lesson plan where technology is an integral part. Teachers should also detail the rationale of the design. The design task should be based on teachers' main subject and teaching levels. The lesson plan needs to be written in enough detail so that external evaluators can make well-informed evaluations. More specifically, the plan should address aspects such as: the overall purpose of the lesson, a detailed plan in stages, organisation of the lesson and the motives behind the organisation for each stage, as well as what technologies have been used, for what purposes, and how?

An evaluation template is recommended to support the evaluation, which should reflect the questions in the practice-based questionnaire. For example, whether teachers plan to use the technology for the purpose of instructional design, student learning and/or assessment (relating the aspect of teachers' self-reported practice). Furthermore, teachers' performance could be qualitatively analysed using a standardised TPACK instrument. Here, existing performance measurement instruments can be used with some modification to reflect the focus on teachers' Technological Pedagogical Knowledge.

Existing instruments to draw upon could be Graham, Borup and Smith (2012[57]), Pareto and Willermark (2018[61]), and Harris, Grandgenett and Hofer (2010[58]). This approach demonstrates a way of capturing teachers applied knowledge. Thus, teacher planning involves concretising the learning goals and strategies to reach these goals, as well as considering which approaches to use, what tools to involve and what resources are needed to fulfil the design idea (Willermark, 2018[32]). However, the applicability of such a lesson plan in practice is determined by the implementation in teaching. That is, realising the instructional plan in the highly dynamic and contextualised classroom practice, and when necessary modifying the approach and coping with unforeseen events (Pareto and Willermark, 2018[61]).

To capture teachers' applied knowledge, either *a full-scale evaluation* or a *semi-evaluation* can be carried out. The alternatives capture different degrees of teachers' applied knowledge in practice and require different amounts of resources. In the *full-scale evaluation*, the lesson plan should be realised and evaluated in practice, and documented by video recording. This is in line with the Global Teaching InSights (GT) study (OECD, 2020[63]). The design could be evaluated together with teachers, and be arranged so that the teacher and the observer watch the video recording together. This will allow the teacher to spontaneously comment on events or situations, with the observer having the opportunity to ask well-informed and practice-oriented questions (e.g. "I note that you do *X*, can you describe how you reasoned"). In the *semi-evaluation*, the lesson plan is not realised in practice. Instead it is suggested that teachers conduct a 'light-weight evaluation' of potential challenges of the plan during realisation (i.e. a type of risk assessment of the plan). Hence, it involves a hypothetical evaluation of the suggested approach as an additional step. Such hypothetical evaluation can reveal how aware teachers are of the risks and challenges of conducting technology-based lesson plans in practice, i.e. it can reveal their Technological Pedagogical Knowledge.

Conclusion

Measuring a teacher's knowledge to use technology in teaching is like hitting a moving target. This is because technology is continually changing and the nature of technological knowledge needs to continuously change as well. To be able to make a well-founded measurement that is suitable for a large-scale international survey, a combination of approaches is proposed. This in order to capture different aspects of teachers' technology-related knowledge and skills of using technology in teaching.

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Notes

[1] Link to the questionnaire by Schmidt et al. (2009[43]) [2020-09-29]: https://matt-koehler.com/tpack2/wp-content/uploads/tpack_survey_v1point1.pdf.

Link to the questionnaire by Archambault and Crippen Crippen (2009[42]) [2020-09-29]: https://citejournal.org/volume-9/issue-1-09/general/examining-tpack-among-k-12-online-distance-educators-in-the-united-states/#appendix.

[2] Example of items to include: *Technological Pedagogical Knowledge*, item 29, 35, 36, 38 from Schmidt et al. (2009[43]) and/or item h, n, l and p from Archambault and Crippen (2009[42]). *Technological Knowledge*, item 1-6 from Schmidt et al. (2009[43]) and/or item a, g and q, from Archambault and Crippen (2009[42]). *Pedagogical Knowledge*, item 20-26 from Schmidt et al. (2009[43]) and/or item j, c and r from Archambault and Crippen (2009[42]).

4 Critical teaching in diverse classrooms

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Schools around the world are recognising the importance of preparing teachers for working in culturally diverse classrooms. This chapter first summarises demographic and academic rationales for multicultural education, before presenting an overview of how the movement has evolved with a stronger focus on equity and social justice. Given the importance of teacher preparation in multicultural education, this chapter discusses potential survey questions and key trade-offs with assessments that may need to be considered. This chapter concludes with implications for policy, practice, and research that advocates for critical forms of multicultural education to address inequality.

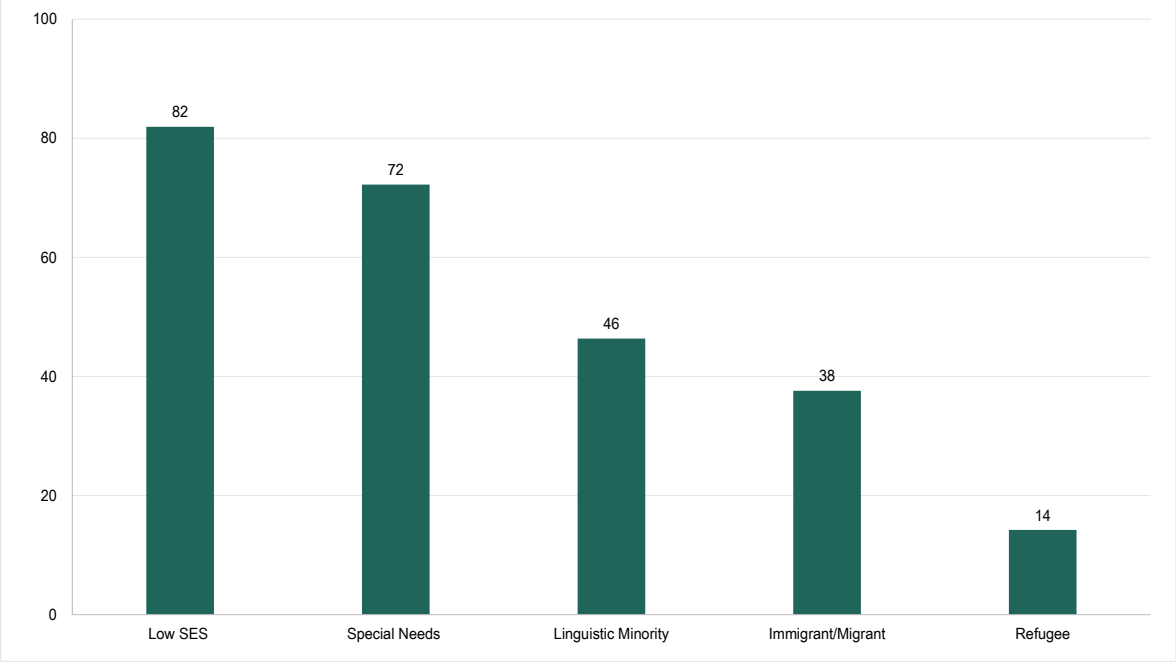
Trends in culturally diverse classrooms

Schools around the world are recognising the importance of preparing teachers for teaching in culturally diverse classrooms. Part of the challenge in this work is that culture and diversity encompass multiple dimensions of social identity and inequality, including but not limited to: race and ethnicity, gender and sexuality, ability and disability, nationality, socio-economic class, language, religion, migration, indigeneity, and geography. This chapter considers each dimension as part of the cultural backgrounds of individuals. Although policies and programmes for teacher education—including initial teacher training and ongoing professional development—vary across and within countries, four key trends in many schools and in the broader research literature motivate a greater urgency to improve the learning experiences of students from culturally diverse backgrounds. These four trends also provide insight into tools for measuring and monitoring teacher attitudes and skills.

First, classrooms today enrol a large proportion of students from marginalised backgrounds. Figure 4.1 illustrates five different categories of student background represented in lower secondary classrooms from the 2018 Teaching and Learning International Survey (TALIS). Most classrooms have at least one student from a socioeconomically disadvantaged household or at least one student with special needs. A smaller but significant percentage of classrooms also have at least one student speaking a first language that is different from the language of instruction or at least one student from an immigrant or migrant background. Also noteworthy is that 14% of all classrooms have at least one student from a refugee background. The growing diversity of the worldwide student population comes also at a time when teachers are less likely to come from similar backgrounds (Cooc and Kim, 2021[1]).

Figure 4.1. Increasing diversity in classrooms around the world

Percentage of lower secondary teachers reporting to have at least one student from each marginalised group in their classroom

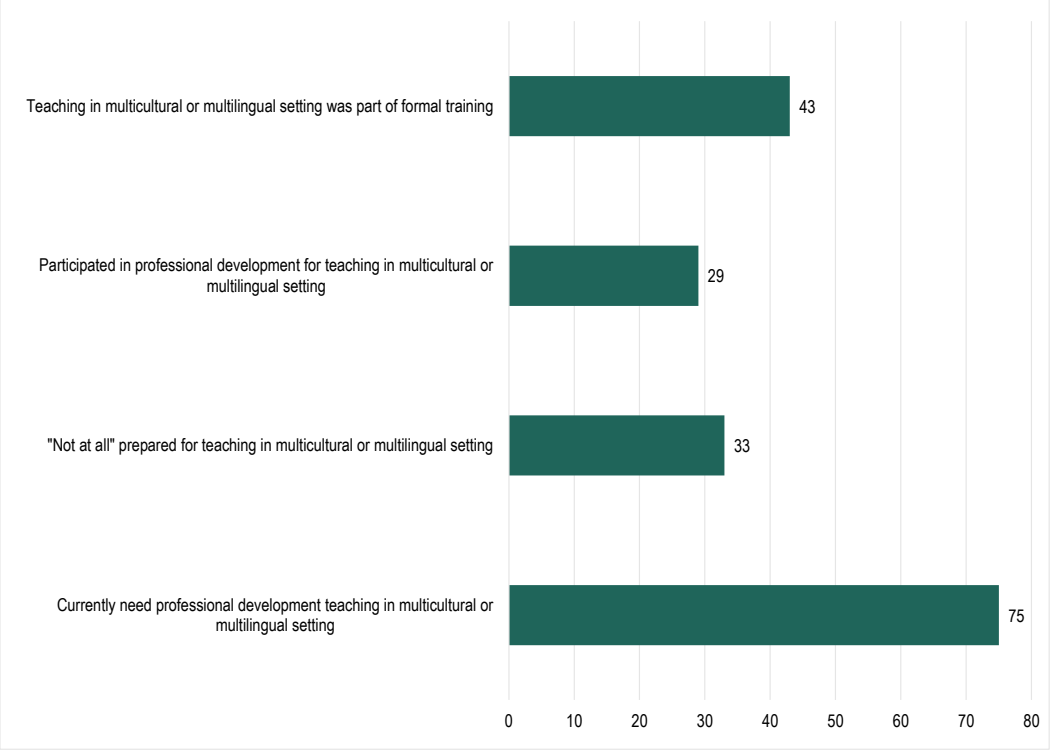


SES = Socio-economic status. Results are based on an analysis of the responses from 145 617 lower secondary teachers from 47 OECD and partnering countries and economies participating in TALIS, using teacher and sample replicate weights.
Source: Authors' calculations (OECD, 2018[2])

Second, teachers internationally are unlikely to have had formal training in teaching diverse classrooms. Figure 4.2 shows the low level of preparation for instruction in multicultural and multilingual classrooms among TALIS 2018 teachers. Less than half of teachers reported any formal training in their tertiary education and less than 30% had attended any professional development for teaching in multicultural or multilingual classrooms in the last 12 months. Not surprisingly, about one-third felt "not at all" prepared to teach in multicultural or multilingual classrooms and 75% reported currently needing professional development in this area. Research shows that among US teachers with some formal training focused on multicultural education or diversity, this work often consisted of a few discussions in classes - an approach that may have negative effects (Pollock et al., 2010[3]). One positive indicator in the TALIS data is that teachers are recognising a gap in their preparation for teaching an increasingly diverse student population and are asking for ongoing professional development in this area. A related component of diversity is students with special needs. Nearly 60% of teachers reported moderate to high need in professional development to teach special needs education (authors' calculations).

Figure 4.2. Low levels of teacher preparation and professional development for multilingual or multilingual classrooms

Percentage of TALIS 2018 lower secondary teachers reporting on past training and current preparedness and need for professional development



SES = Socio-economic status. Results are based on an analysis of the responses from 145 617 lower secondary teachers from 47 OECD and partnering countries and economies participating in TALIS, using teacher and sample replicate weights.
Source: Authors' calculations (OECD, 2018[2])

Third, students from culturally diverse backgrounds have been historically underserved in schools and continue to achieve at lower levels than their peers. Equity does not mean that all students should have the same academic achievement but that differences in outcomes should be not related to student

background. For example, an alarming result from the most recent 2018 Programme for International Student Assessment (PISA) shows the reading performance gap between the 10% most socioeconomically disadvantaged and the 10% least socioeconomically disadvantaged students in France, Hungary, Israel, Peru, and the Slovak Republic is about four years of schooling (Schleicher, 2019[4]). Socioeconomically disadvantaged students have fewer learning opportunities and less access to school-based resources, including qualified teachers. However, PISA results also show some countries appear more effective than others at mitigating the impact of social background on academic achievement as the academic gap in these countries is narrower between socioeconomically disadvantaged and advantaged students. Another area of concern is the academic achievement of immigrant students; across OECD countries, immigrant students score significantly lower than non-immigrant students in reading by an average of 41 points or about 0.41 standard deviations (Schleicher, 2019[4]). Although gender gaps in academic achievement are smaller and depend on the subject (Schleicher, 2019[4]), inequities persist in the labour market in terms of employment and income.

Lastly, increased focus on diversity and equity in teaching is timely because a growing empirical research literature shows that culturally responsive practices, such as integrating the cultural backgrounds of students into the curriculum, have a positive impact on student learning (Cabrera et al., 2014[5]; Cammarota, 2007[6]; Dee and Penner, 2017[7]; Lewis, Sullivan and Bybee, 2006[8]) and school climate (Khalifa, Gooden and Davis, 2016[9]). Research additionally indicates such practices increase student engagement and psychological well-being (Cholewa et al., 2014[10]; Savage et al., 2011[11]), and also reduces the disproportionate representation of culturally and linguistically diverse students in special education (Klingner et al., 2005[12]). It is important to note that although multicultural teaching tends to focus on the learning of historically marginalised student groups, *all* students benefit from a classroom environment where teachers embrace critical pedagogies that acknowledge systemic inequities and the diverse learning styles of students (Kim and Cooc, 2020[13]). In addition, the growing application of culturally responsive practices recognises current inequities within schools and the right of students from diverse backgrounds to receive not only an education equal to their peers, but one that supports their unique identities and developmental needs.

In short, although the persistent gaps in school outcomes among students from diverse cultural backgrounds is concerning, there is strong evidence that teachers with training in critical multicultural education can be part of the solution. Improvement in this area will require monitoring current levels of teacher preparation and gaps in training. The purpose of this chapter is to provide an overview of multicultural teacher education, including common challenges and how the field has evolved. This chapter further argues that preparation and education for teaching in diverse classrooms is not a one-time or add-on component to existing educational programmes and policies. Pedagogies and practices related to multiculturalism raise questions about the purposes of education and which populations are served or underserved in schools. Given the importance of monitoring and addressing gaps in teacher preparation, this chapter also includes a discussion of issues to consider when designing tools and surveys to measure teacher self-reported knowledge and pedagogies in multicultural education, as well as examples of potential survey items. Lastly, the chapter provides implications for education policy and practice, as well as future research.

Multicultural education

Scholars and educators use different terms when describing how to support teachers in creating learning environments that reflect equity, diversity and social justice. The variation in terms partly reflects the evolution of how teacher education programmes have viewed the education of students from different cultural backgrounds. Table 4.1 summarises some of the teacher education strategies used since the 1960s. See Paris (2012[14]) for a more detailed discussion of each.

Table 4.1. Brief overview of common terminology in multicultural education

Time	Description
1960s and 1970s	Deficit Approaches
1970s and 1980s	Differences Approaches
1980s and 1990s	Resource Pedagogies / Funds of Knowledge (Moll et al., 1992[15])
1990s	Culturally Relevant Pedagogy (Ladson-Billings, 1995[16]) Culturally Responsive Pedagogy (Gay, 2000[17])
2010s	Culturally Sustaining Pedagogy (Paris, 2012[14])

Source: Adapted from Paris (2012[14])

Growing teachers' knowledge and skills for working in classrooms comprised of students from diverse cultural backgrounds has become widespread as a priority of education internationally. However, similar to multiculturalism, multicultural education's history and definitions vary across and within national contexts (Torres and Tarozzi, 2020[18]). Some countries use the term "multicultural education", while others prefer the term "intercultural education". Different historical trajectories of multiculturalism may also explain, for example, why some countries focus their multicultural education discussions and programmes primarily on racial and ethnic diversity, while others also include other dimensions of cultural diversity, such as gender and sexual orientation.

As an actualisation of diversity ideologies in the United States, multicultural education has been a part of teacher education since the 1970's and included ethnic studies, multi-ethnic education, antiracist education, critical pedagogy and critical race theory (Hernandez-Sheets, 2003[19]). Ethnic studies and multi-ethnic education grew out of the late 1960s Civil Rights movement to address the rights and needs rights of African American students and students from other racially marginalised groups. In the late 1980's and 1990's, multi-ethnic education became subsumed under the broader multicultural education movement. Across its evolution, multicultural education has been conceptualised as an educational approach that recognises and values the knowledge, perspectives and practices of all cultures as "funds of knowledge" (Moll et al., 1992[15]), especially from marginalised groups (Banks, 2006[20]; Banks, 2009[21]; Gay, 2000[17]).

Interpretations of multicultural education include civic and moral objectives, as well as recommendations for school curricula, pedagogy, and other significant aspects of schooling to create inclusive and equitable education for all students. These efforts have been understood as necessary for educational and social progress. Schools and teachers must be responsive to cultural diversity. At the same time, students must also have educational experiences that help them to grow in their knowledge and value of cultural diversity. For example, the development of empathy and skills to thrive in a culturally pluralistic society are an important and necessary part of education (Banks and Banks, 1997[22]; Banks et al., 2001[23]; Banks, 2006[20]). According to Banks et al. (2001[23]), academic knowledge and skills alone will not guarantee students the ability to participate fully and actively in society; learning how to interact positively with people from different backgrounds is also essential, especially in light of increased migration and globalisation in the 21st century.

Multicultural education has been conceptualised as tied to "citizenship education" (Banks, 2001[24]), which includes supporting students in developing the knowledge and skills to live in a culturally diverse society, as well as maintaining all citizens' rights to their cultural communities and a shared national culture. On an international level, multicultural education's variable definitions and implementations may be understood as bound up in varying ideologies related to national identity and citizenship. Histories of immigration, contemporary policies on migration, redress for Indigenous groups, global economic goals and labour market outcomes, and systems for educational standards are just a few of the ways countries differ that may contribute to their varied approaches to multicultural education.

Common issues related to diversity and inclusion in education

Scholars have examined three common challenges in preparing teachers to address diversity in ways that create more inclusive and equitable education. In order of frequency and priority, these challenges are related to curriculum and instruction, institutional support and socio-political context (Gorski, 2016[25]). A discussion of each challenge is provided in more detail below.

Teacher diversity and orientations

One key challenge and area of research on growing the knowledge and skills for teaching in diverse classrooms has been the diversity of the teacher population. Many studies have documented the need for more teachers from diverse backgrounds in general, and teachers from racial and ethnic minoritised groups, in particular (Quiocho and Rios, 2000[26]; Villegas and Lucas, 2004[27]), especially as research indicates students from historically marginalised groups achieve better academic and social outcomes when they have access to teachers from a similar group (Wells and Cordova-Cobo, 2016[28]). For example, in a study of teachers of colour (TOCs) in South Africa, the teachers' personal experiences related to language, race and migration shaped their social justice pedagogies and teaching practices (Perumal, 2015[29]).

Other studies of TOCs also indicate their greater attention to diversity and issues of social justice, including supporting students from historically disadvantaged groups (Philip, 2014[30]; Quiocho and Rios, 2000[26]; Villegas and Davis, 2008[31]). Diversifying the teacher population is a need in many different national and local contexts, yet this reform alone does not necessarily create more inclusive and equitable schools. All TOCs cannot be assumed to be focused on issues of inclusion and equity in education. Moreover, all teachers need to reflect on their biases and beliefs about themselves and others (Kim and Cooc, 2020[13]; Milner, 2010[32]). Teaching for diversity, inclusion and social justice is the work of not only TOCs and teachers from other disadvantaged groups, but an essential responsibility of all teachers in any school context.

Encouraging teachers' reflections on their own biases and orientations, as well as critical examinations of historical and systemic issues of equity and inclusion, follows a view of multicultural education as challenging the nature of school curriculum. An underlying question for teachers' development of the knowledge and skills for teaching in diverse classrooms is, what is the purpose of education?

Multicultural education's varied definitions and implementations internationally are largely related to differences in national purposes for education. Studies show its take-up as serving political purposes, such as to assimilate immigrants in Spain (Aguado-Odina, Mata-Benito and Gil-Jaurena, 2017[33]) or ethnic minority groups and Indigenous peoples in Taiwan (Liu and Lin, 2011[34]). Within educational policies and programmes that promote inclusion, immigrant and ethnic minority students may still be seen as cultural "others", especially in countries that have prioritised national homogeneity or ethnocentrism, as described in studies of multicultural education in Japan (Okubo, 2017[35]) and South Korea (Mo and Lim, 2013[36]). Çelik and colleagues (2017[37]) detailed the challenges of multicultural education in Turkey as a centralised educational system that has historically promoted a monocultural national identity. Their study highlights how national curriculum and policies marginalise ethnic, linguistic minorities or recognise minorities' rights to maintain practices related to their cultural backgrounds only in particular schools, such as the permitted use of minoritised languages in private schools.

Assimilationist objectives to education frame cultural diversity as a phenomenon to be managed, rather than as a strength and asset. However, citizens who have opportunities to maintain ties to their community cultures and languages are more likely to identify with the nation-state than those who are denied these ties (Banks, 2004[38]; Kymlicka, 2004[39]). Embracing cultural diversity in education is also necessary for changing exclusionary views of who holds knowledge and expertise. For example, reforming education to value the diverse cultural and linguistic resources that students bring into classrooms requires challenging

narrow models of literacy learning that recognise only one language and written alphabetic systems as evidence of advanced, literate individuals or societies (Kim, 2020[40]).

A related challenge to teaching in diverse classrooms is standardised curriculum, which may only feature the perspectives and interests of the dominant group. Standardisation does not usually allow for the building of curriculum and pedagogy based on the cultural frameworks, strengths and experiences of students especially from marginalised groups (Sleeter and Carmona, 2017[41]). Furthermore, as curriculum scholarship has stressed education's role in issues of power within economic, political, and cultural systems (Apple, 2004[42]), teaching in diverse classrooms requires examinations of what is being taught, as well as how and why. In a critique of curriculum standardisation, Sleeter and Carmona (2017[41]) emphasise that there is no single "how" of multicultural curriculum. They propose teachers approach multicultural curriculum design through a guiding framework, comprised of the following questions related to the purposes of curriculum and instruction:

1. What purposes should the curriculum serve?
2. How should knowledge be selected, who decides what is most worth teaching and learning, and what is the relationship between those in the classroom and the knowledge selection process?
3. What is the nature of students and the learning process, and how does it suggest teachers should organise learning experiences and relationships?
4. How should curriculum be evaluated? How should learning be evaluated? To whom is curriculum evaluation accountable?

Textbook analyses have documented ethnic stereotypes, misinformation (Gay, 1983[43]) or the absence of many already marginalised racial and ethnic groups (Brown and Brown, 2010[44]; Stanton, 2014[45]; Noboa, 2013[46]) and sexual minorities (Macgillivray and Jennings, 2008[47]). Revisions to required curricular content, drawing from research and theories that have grown in fields such as disability studies, gender and women's studies, ethnic studies, and Indigenous studies, are a major need in diverse classrooms. Teacher competencies for critical teaching in diverse classrooms does not require demonstrated knowledge in all of these fields but could include developed skills in critically analysing curricula for issues of cultural representation and omission.

Institutional support

In addition to focusing on what type of training teachers need to succeed in diverse classrooms and what the curriculum should be for local schools, scholars have examined why educators may have difficulty implementing multicultural education practices. Research indicates that the extent to which teachers engage in critical approaches may depend on the level of perceived support from their institutions. In a study of teacher educators who teach multicultural education courses in Canada and the United States, Gorski and Parekh (2020[48]) found those who adopted conservative forms of multicultural education that focused on diversity but not inequality tended to perceive greater institutional support for their classes. In contrast, teacher educators who employed a more critical approach that addressed inequality more directly reported, on average, less institutional support. Although no causal links can be drawn between multicultural education implementation and institutional support, it is likely that teachers working with institutional leaders who support multicultural education will engage in more critical classroom practices. It should be noted that while this research focuses on educators preparing future teachers, the results apply to teachers in schools. The lack of supportive school leaders who understand and show commitment to multicultural education is likely to impact the extent to which teachers engage in diversity and equity issues. Other institutional factors, such as time, collaboration with other teachers, national standards, and alignment across classes may also impact whether and how teachers approach multicultural education (Pollock et al., 2010[3]).

Socio-political context

Schools are embedded within larger social and political institutions that can directly influence how teachers view and prioritise multicultural education. For example, Gorski (2016[25]) reported challenges that some US teacher educators faced in practicing multicultural education within a conservative Christian context in which pluralism may be viewed as a threat. Other teachers described how the standards and accountability movement in US schools leaves less time to focus on equity concerns. In South Korea, the prevailing focus on Korean ethnic identity marginalises a growing population of ethnic minorities and immigrants (Kim and Choi, 2020[49]). Critiques of South Korean textbooks point to the ethnocentrism and cultural homogeneity that distort views of multicultural families (Hong, 2010[50]; Jho, 2014[51]). Although the Korean government supported multiculturalism as a major political and educational agenda in 2006, research shows that training is still lacking (Mo and Lim, 2013[36]). In Singapore, multicultural education has emphasised food festivals, where different cultures may be superficially celebrated, and highlighted the advantages of diversity for national cohesion and economic development (Bokhorst-Heng, 2007[52]). Canada has focused on human rights and equality but also view multiculturalism in terms of economic advantages. The socio-political contexts in these countries may strain efforts to adopt more critical approaches to multicultural education.

Teacher education for diverse classrooms

The views, values and prior experiences that teachers bring to their work in diverse classrooms is a critical component of assessing their understanding of what has been discussed as “critical multicultural education” (Sleeter, 1995[53]; May, 1999[54]). As a critical race theory focus on systems of inequity and racial privilege has also become an emphasis in multicultural education (Hernandez-Sheets, 2003[19]), some teacher education research emphasises a need for teachers to develop an “ontological understanding of what constitutes diversity with respect to one’s own identity within White supremacy” (Matias and Aldern, 2019, p. 39[55]).

A review of international teacher education research about cultural diversity identified Whiteness as “an engrained and unexamined area in the discourses produced for teacher education” (Fylkesnes, 2018[56]). For example, in a study of Norwegian teacher education policy and curriculum documents that promote social justice, Fylkesnes (2019[57]) found discourses of racial othering and exclusion. Her study, and others in recent teacher education research, identify the colonial legacy of race and racism in different national contexts as an embedded and critical component of education for cultural diversity. Such studies suggest teacher education research and discussions of cultural diversity must critically examine social structures and ways of being that reproduce a hierarchy of racial groups.

Multicultural education is therefore not only about pedagogical strategies and curriculum for teaching in diverse classrooms, but issues of power, inequalities and equity (Sleeter, 2018[58]). Without attention to these issues, teacher preparation for diverse classrooms contributes to a neoliberal approach to multiculturalism and education (Kymlicka, 2013[59]). Training programmes and experiences that aim to help teachers work with culturally diverse students can reproduce a view of diversity as something to be recognised and managed (Sleeter, 2018[58]). For examples, studies of short-term teaching abroad programmes for pre-service teachers have found some reinforced racial superiority, as well as stereotypes and deficit views of culturally different peoples (Klein and Wikan, 2019[60]; Marx and Pray, 2011[61]; Santoro, 2014[62]).

Preparing teachers to work with culturally diverse students must move past the goals of responding to diversity through cultural sensitivity and tolerance; instead, teacher education for diverse classrooms requires critical examinations of teachers’ own dispositions and historical and structural systems of inequalities, such as the ways in which classroom expectations and testing systems privilege particular types of knowledge usually associated with already advantaged groups. Supporting teachers’ critical

examinations and self-reflections regarding biases can help to mitigate deficit views of students from marginalised groups and superior notions of teaching them as charitable work.

Critical, asset-based approaches to multicultural education for teacher development and student learning are centrally concerned with changing educational systems. Such an approach to teaching in diverse classrooms can be a revitalisation and reclaiming of epistemologies, histories and cultural practices that have been disrupted and displaced by colonisation (McCarty and Lee, 2014[63]). Critical approaches to multicultural education are sensitive to whose knowledge and ways of understanding the world are valued in schools. For example, approaches in North America might involve the teaching of Native American literature in US classrooms (San Pedro, 2017[64]) and the centring of Indigenous communities' frameworks of knowledge and practice, such as the valuing of elder pedagogies and practices (Holmes and Gonzalez, 2017[65]).

Teacher education for diverse classrooms includes questioning dominant educational norms and recognising the effects of colonial histories in schools. This decolonising approach involves inviting the guidance of local communities that might otherwise not be reflected in the school curriculum or partnering with ethnic and cultural studies departments (Dominguez, 2017[66]). In a community-based or "power-sharing approach" (Bishop et al., 2009[67]), teachers learn to co-construct curriculum and instruction with the communities they serve. For example, a large-scale study of this approach found a positive impact on the educational experiences of Māori students (Meyer et al., 2010[68]).

Measuring competencies for teaching in diverse classrooms

Previous studies have developed instruments to examine how teacher educators approach designing courses on multicultural teacher education for pre-service teachers (Gorski and Parekh, 2020[48]). However, these instruments can also be adapted to survey current teachers about their attitudes, knowledge of multicultural education, and skills related to teaching in diverse classrooms. The following are examples of each competency area.

Measuring teacher attitudes

Gorski's (2009[69]) typology of five approaches to multicultural teacher education can serve as an initial self-assessment of how teachers understand their role or view of teaching in diverse classrooms. Each approach can be converted into Likert-scale items to measure the degree to which teachers may report expertise. Table 4.2 summarises Gorski's approaches to multicultural teacher education.

Table 4.2. Measuring attitudes towards teaching multicultural education

In my teaching, I aim to...	Strongly Disagree	Disagree	Agree	Strongly Agree
1. …work effectively with diverse student populations by studying the cultures, values, lifestyles, and worldviews of individual identity groups and teaching them to adjust to the education system.	☐	☐	☐	☐
2. …develop awareness of and sensitivity towards diversity, particularly through an examination of my own biases.	☐	☐	☐	☐
3. …acquire the knowledge and practical skills necessary to implement multicultural curricular and pedagogical strategies that engage the diverse learning styles of all students.	☐	☐	☐	☐
4. …examine the systemic influences of power, oppression, dominance, inequity, and injustice on all aspects of education and student learning.	☐	☐	☐	☐
5. …challenge and change current social injustices and prepare students to do the same.	☐	☐	☐	☐

Source: Adapted from Gorski (2009[69]) typology of multicultural teacher education approaches.

One advantage of the above items is that respondents can ascribe to multiple approaches and attitudes toward teaching about diversity and equity that are not necessarily contradictory. For example, a teacher may feel strongly about learning the cultures, histories and views of different student groups (Item 1) and developing an awareness of individual biases (Item 2). Another advantage is that teachers who disagree with all items might be considered as misaligned in attitudes towards teaching diverse student populations and addressing social justice. Lastly, although each question captures one of the five approaches to multicultural education in Gorski's (2009[69]) typology, additional questions can be added to provide more concrete examples. For instance, Item 1 can be separated into one item about learning the backgrounds of different student groups, and another on teaching students to adapt to the education system. Another possible use of the items is for researchers and teacher educators to better understand teachers' conceptual understanding of and goals for teaching diverse classrooms. Items 1 and 3 focus on seeking curricular knowledge and an understanding of students from different cultural backgrounds. Items 2, 4, and 5 focus more on underlying issues of bias, equity, and justice that help to identify teachers' beliefs and educational philosophies.

Measuring teacher multicultural content knowledge

Gorski's (2016[25]) study of professional learning and the supports that multicultural teacher education faculty desire highlighted the role of different dimensions of diversity and multicultural content knowledge. For example, educators mentioned a lack of knowledge around how to think of disability as related to barriers created in society rather than medical conditions to support students with different learning needs. The list of multicultural content knowledge in Gorski (2016[25]) can be adapted into survey items that ask teachers about their familiarity or understanding of each dimension in Table 4.3.

Table 4.3. Measuring teaching content knowledge in multicultural education

In my teaching, I have knowledge in…	Strongly Disagree	Disagree	Agree	Strongly Agree
1. Religion and religious oppression	☐	☐	☐	☐
2. Sexual orientation and heterosexism	☐	☐	☐	☐
3. Race and racism	☐	☐	☐	☐
4. Language and linguicism	☐	☐	☐	☐
5. Disability and ableism	☐	☐	☐	☐
6. Class and economic social injustice	☐	☐	☐	☐
7. Gender and sexism	☐	☐	☐	☐
8. Indigeneity and ethnicity	☐	☐	☐	☐

Source: Adapted from (Gorski, 2016[25])

It is important to distinguish between having knowledge of particular identities or oppression and having specific skills and experiences beneficial for teaching students from marginalised backgrounds (see further below), although teachers who possess an understanding of each identity-specific dimension of oppression are more likely to teach marginalised students in culturally responsive ways. Another limitation is the self-reported survey items do not capture *degree* of understanding and specific content knowledge in each dimension. In other words, teachers may have a general awareness of each identity and select "agree" or "strongly agree", without possessing a critical understanding of each topic's historical context or how it manifests in society.

Thus, another approach is to ask directly about critical content knowledge. Table 4.4 presents potential items adapted from Dyches and Boyd's (2017[70]) research on social justice pedagogy and content knowledge. For example, Item 1 asks teachers about their knowledge of critical theories, such as feminist

theory, disability studies, and critical race theory. Similarly, Item 2 focuses on how and whether teachers understand the distinction between dominant narratives and counter narratives in the curriculum.

Table 4.4 Measuring teaching content knowledge

In my teaching, I understand…	Strongly Disagree	Disagree	Agree	Strongly Agree
1. …how to apply critical frameworks, such as feminist theory, disability studies, critical race theory.	☐	☐	☐	☐
2. …how to identify dominant narratives and include counter-narratives in the curriculum.	☐	☐	☐	☐
3. …how to analyse routine practices that seem neutral but can perpetuate inequality.	☐	☐	☐	☐
4. …how to model social justice knowledge into practice and empower students to be agents of change.	☐	☐	☐	☐

Source: Adapted from Dyches and Boyd (2017[70])

One caveat in any measurement of knowledge of any or all of the topics is this does not mean the teacher knows how to apply it in ways that help to make curriculum and instruction more just and supportive of students from marginalised backgrounds. In addition, one trade-off of asking about specific knowledge within each dimension and the extent to which teachers apply that knowledge in their teaching is that the survey becomes longer. This also does not account for the possibility that respondents may report understanding certain terms (i.e. critical race theory) but only superficially. Despite limitations such as this, and an absence of more formal multiple choice-like assessment of content, the below items may assist in measuring awareness of identity and marginalisation across multiple areas.

Measuring teacher pedagogy and practices

The final competency area for teaching in diverse classrooms focuses on pedagogies and practices to increase student engagement and learning. Among teachers who do receive training in multicultural education, part of the challenge is translating critical theory into classroom practice (Morrison, Robbins and Rose, 2008[71]). Table 4.5 provides examples of skills that researchers have documented in studies of culturally responsive pedagogies in the classroom (Meyer et al., 2010[68]; Savage et al., 2011[11]).

Table 4.5. Measuring pedagogy in multicultural education

In my teaching, I have expertise in…	Strongly Disagree	Disagree	Agree	Strongly Agree
1. Facilitating complex conversations about politically and emotionally charged equity and social justice issues	☐	☐	☐	☐
2. Identifying and sequencing readings and learning activities that cultivate deeper conversations	☐	☐	☐	☐
3. Engaging students who resist conversations about diversity and equity	☐	☐	☐	☐
4. Incorporating the cultural identities and daily lives of students into curriculum	☐	☐	☐	☐
5. Teaching students how to reflect on their own identities, biases, and prejudices	☐	☐	☐	☐
6. Preparing students to identify and assess systemic inequities	☐	☐	☐	☐
7. Developing relationships between school and the communities of students	☐	☐	☐	☐
8. Engaging students in social justice work through course materials and service in the community	☐	☐	☐	☐

Source: Adapted from Gorski (2016[25]) and Morrison, Robbins and Rose (2008[71])

The items capture Gorski's (2009[69]) typology of conservative, liberal and critical approaches to multicultural education:

- **Conservative approaches** tend to focus on teaching the "other" and assimilating the identities of students into the school system.
- **Liberal approaches** emphasise cultural understanding and multicultural competence.
- **Critical approaches** examine sources of inequality and ways to address social change.

Teacher pedagogy and practices for diverse classrooms range from facilitating difficult conversations about system inequalities, particularly among students who may resist such discussions, to developing activities that incorporate and build on the cultural backgrounds of students. In asking teachers to report about these practices, there are also certain assumptions that makes interpretation difficult. For example, Items 1, 2 and 3 emphasise practices that promote open conversations about social justice and inequality. However, discussion and debate formats may not be a common method of instruction in some countries.

The items also assume that greater insight into an issue, such as inequality, can be arrived at from frequent discussion. Whether these items capture critical multicultural education pedagogy of individual teachers or different models of instruction across countries is unclear. Similarly, Items 7 and 8 asks about teacher practices related to the community with the assumption that social change begins locally. The questions also assume schools have strong relations with local communities. Teachers who work in such schools may have expertise in engaging with the community and would respond differently to those questions than teachers in schools without a strong community connection. These items are still of interest in certain contexts but should be interpreted with the limitations in mind.

Particular challenges and decisions for an international survey

Developing an international survey of self-reported teacher attitudes, pedagogy and content knowledge for teaching diverse classrooms poses certain challenges (see Table 8.1 in Chapter 8 for the main takeaways from this chapter for TALIS and the TKS assessment module). As discussed below, the challenges are related to the topic itself, the local cultural context (national, regional or district), and possibly some combination of both.

Which multicultural teacher education approach to emphasise?

Decisions about education and schooling in every country are not politically neutral acts. The same can be said about decisions related to multicultural teacher education in schools and which aspects to measure among teachers. As an example, Table 4.6 presents all the diversity and multicultural-related questions from the most recent 2018 TALIS teacher questionnaire.

Table 4.6. TALIS 2018 diversity questions

Self-efficacy in multicultural classrooms: ***In teaching a culturally diverse class, to what extent can you do the following?***	MTE Approach
a) Cope with the challenges of a multicultural classroom	Conservative
b) Adapt my teaching to the cultural diversity of students	Liberal
c) Ensure that students with and without a migrant background work together	Liberal
d) Raise awareness of cultural differences amongst students	Liberal
e) Reduce ethnic stereotyping amongst students	Liberal
Diversity-related practices: ***In this school, are the following practices in relation to diversity implemented?***	
a) Supporting activities or organisations that encourage students' expression of diverse ethnic and cultural identities	Liberal
b) Organising multicultural events (e.g. cultural diversity day)	Conservative
c) Teaching students how to deal with ethnic and cultural discrimination.	Conservative
d) Adopting teaching and learning practices that integrate global issues throughout the curriculum	Liberal

Source: (OECD, 2018[2])

Using the Gorski (2009[69]) typology, the authors coded each item in terms of conservative, liberal and critical approach. To be clear, the items are helpful in measuring different dimensions of teacher pedagogy and practices in diverse classrooms, and also to provide meaningful cross-country information. However, of the ten items coded, most were liberal or conservative views of multicultural education, with none addressing the critical approach. That is, none referenced teaching practices that address social justice, equity or oppression.

Whether teachers adopt more critical practices is less important than whether the questions are included to measure the range of possible multicultural education views. Future surveys may need to consider whether to emphasise certain dimensions of multicultural education or provide a balance of questions. One advantage of including more questions about critical multicultural education is a better understanding of whether teachers are aware of its existence. The questions may also foster discussions across countries on how multicultural education relates to issues of equity and social justice.

Cultural sensitivity and local context

One challenge with any international self-assessment of teacher knowledge is that certain items may go beyond declarative-conceptual knowledge (König, 2015[72]) and are not free of cultural context. For example, although multicultural education focuses on diversity and varied dimensions of inequity and oppression, the emphasis in the United States tends to be on racial inequality. Teachers in South Korea and Chinese Taipei, in contrast, may view diversity in terms of migration trends, such as the large number of recent ethnic minority immigrants from other Asian countries. In New Zealand, teachers may consider diversity in relation to local Indigenous groups. Although each national example fits under the broader umbrella of diversity and equity, one concern is whether respondents may view multicultural education questions only in terms of race or ethnicity (or another dimension) despite the local diversity and intersections across dimensions of diversity. Providing a list of many cultural dimensions (e.g. race, ethnicity, language, gender) in the stem of the question or survey may help to mitigate confusion about what diversity represents.

A separate but related issue is the extent to which specific concepts in multicultural teacher education may transfer across different cultural contexts, even if translated into the local language. For example, the critical component of multicultural teacher education highlights specific theories related to cultural diversity, such as feminist theory and critical race theory, which may be less widely read in some countries. More importantly, what does it mean to ask about social justice efforts in teaching when the historical and political context has not aligned with those movements? A similar issue arises when asking teachers about special needs education, given that disability can be a culturally and socially-specific construct. For example, teachers in countries that adopt a more medical model of disability may focus on physical impairments in special education, rather than behavioural or cognitive challenges.

Although international surveys of teacher knowledge in multicultural education should be aware of these issues to improve reliability and reduce bias in the questions asked, the challenge is in how to interpret the results and make inferences about countries. Broad questions about prior training and current professional development needs in multicultureal education, such as those in Figure 4.2, would appear to avoid some of these issues. In contrast, inferences about attitudes and content knowledge, in particular, may need to be summarised with caveats and the local context in mind. Another approach is to group results by similar geographic region or economic context, rather than focus on individual countries. The goal is to summarise what teachers know, while acknowledging the limitations in the instruments and differences across countries.

Grade level appropriate questions

Up to this point, all examples of multicultural education and the potential survey items are assumed to be grade level neutral. Many scholars would argue that the task of measuring content knowledge and

pedagogies for teaching diverse classrooms is the same for primary and secondary education. Indeed, research shows that children are aware of and have conversations about discrimination, bias and inequality at an early age (Marcelo and Yates, 2019[73]). However, the frequency of these discussions may be more common in the secondary level as students become more mature. Their critical thinking skills around these topics become a more urgent goal, which may affect how teachers rate their ability to conduct such discussions. Secondary teachers may also have more training to facilitate such discussions if that is the expectation. Thus, any difference in how teachers respond to self-assessment questions about critical pedagogies may be biased towards teachers in the secondary levels.

Although this limitation of the survey items should be acknowledged, it would still be useful to know if primary school teachers reported, on average, low levels of using critical pedagogies. This information could be used to identify teachers for professional development. Another option is to modify the survey items to include grade-specific questions for teachers that takes into consideration developmental differences in students and classroom expectations. For example, instead of focusing on open conversations about social justice issues, survey questions at the primary level may ask whether teachers implement activities that engage students with each other around these topics.

Going beyond self-assessments

It is important to note that all previous examples focus on self-assessments of teacher attitudes and knowledge rather than teacher assessments required for licensure or certification. All also assume a quantitative approach to measuring teacher attitudes and knowledge in multicultural education. König (2015[72]) reviewed common quantitative methods to measure teachers' general pedagogical knowledge, including video vignettes (see also Chapter 5 for an overview of different assessment approaches). Video-vignette studies typically ask teachers to watch a short clip of a classroom situation as a stimulus followed by questions that measure their professional knowledge. One large concern with video-vignettes, particularly if involving questions about culture and diversity, is that a classroom filmed in one country may be interpreted very differently among teachers in another context (e.g. identifying and responding to slang).

Assessments tend to involve multiple choice response items, open-response items, or short-answer construct-response items (König, 2015[72]). Although these assessments have been used to test specific knowledge (i.e. what is intrinsic motivation), they can be adapted to assess multicultural education skills. One consideration for future assessments is whether to include more open-ended items about multicultural education knowledge. Due to time and cost considerations for teachers in completing the assessment, and also raters who would have to score or code each open-ended response, which would involve creating scoring standards, the self-assessment examples in this chapter all involved short Likert-scale questions. A combination of written vignettes about specific teaching scenarios, followed by questions with multiple choice or Likert-scale items, may be one approach to ask more in-depth questions about multicultural education skills, without overwhelming time and cost burdens.

Conclusion

The confluence of growing student diversity, widening inequality in academic and social outcomes, and concerning levels of teacher preparation across the world pose significant issues for schools in the 21st century. However, critical approaches to multicultural education hold promise for teachers and students. This chapter concludes with several implications for education policy and practice, and recommendations for future research (see Table 8.1 in Chapter 8 for the main takeaways from this chapter for TALIS and the TKS assessment module).

Implications for education policy and practice

1. **Measurement and professional development.** Better measurement of teacher attitudes, knowledge, and practices in multicultural education can better inform teacher education programmes and continuing teacher support. However, identifying and understanding the scope of a problem is different from addressing it. Not only are professional development opportunities for teachers often sporadic and difficult to schedule, research shows some teachers may resist training around diversity and equity (Pollock et al., 2010[3]). Professional development is often assumed to be high quality and effective for all teachers, yet short-term multicultural training experiences, for example, can be counterproductive. Efforts to better monitor the state of teacher preparation in multicultural education should be matched with similar efforts to improve and provide ongoing professional development. At the same time, the effectiveness of professional development opportunities and change in attitudes and skills over time can be assessed with better measurement.
2. **Unintended consequences.** Some approaches to multicultural education currently focus on critical pedagogies that support social justice. However, research also shows teachers adopting approaches less focused on social change (Gorski and Parekh, 2020[48]). Although such approaches may be viewed as appropriate for certain contexts and better than no attempt at addressing issues of diversity and inclusion, there can be unintended consequences. For example, students' academic achievement may improve in the short-term but without a focus on social justice in the classroom, systemic inequities are never addressed and may become even more entrenched. Similarly, teachers may incorrectly believe that they are preparing students to critically engage in issues of diversity and inequity when the instruction may only be at a superficial level or reinforces harmful thinking about marginalised groups (Pollock et al., 2010[3]). To avoid such consequences, schools may need to encourage and support teachers toward more critical approaches.
3. **Institutional and political support.** Supportive school environments play a key role in teacher satisfaction and retention (Grayson and Alvarez, 2008[74]). Whether teachers adopt or embrace certain curriculum also depends on perceived level of support from school leaders and colleagues. Research shows that is especially the case for multicultural education; limited support or resistance can result in less critical approaches. One implication for policy is that school leaders should receive similar training in multicultural education as teachers, as well as preparation in supporting teachers and establishing a school climate conducive to these endeavours. Without institutional support (e.g. mentorship, professional development), teachers are still able to implement critical multicultural education in their classrooms, but extenuating efforts may result in adverse repercussions, including greater stress and burnout, disillusionment, marginalisation from colleagues, and lower job satisfaction that ultimately leads teachers to leave the profession (Borman and Dowling, 2008[75]).
4. **Multicultural competence as 21st century skills.** Why some schools are less supportive of critical multicultural education is related to numerous historical and demographic factors. Scholars have more recently contended that the development of empathy and skills to navigate a culturally pluralistic society is important for all children. An emphasis on the role of multicultural education in preparing students for increased migration and globalisation may be effective in generating institutional support and persuading policymakers of its importance. Embracing such elements of multicultural education initially may also help schools and countries make an essential transition to more critical pedagogies. As multicultural education has its origins in supporting the learning needs of marginalised children and promoting social justice, it is important to bear in mind that multicultural education's focus on citizenship skills and social justice should not be mutually exclusive.

Implications for research

5. **More international and quantitative research.** Studies of multicultural education tend to be qualitative and conducted in a single country. Much less attention has focused on cross-country trends in multicultural education and teacher preparation that can provide meaningful information on how schools are educating children globally, e.g. PISA and TALIS. Developing and refining surveys of teacher knowledge similar to the questions proposed in this chapter should motivate more cross-country comparisons of multicultural education. The goal is not to evaluate or rank countries, but to understand the scope of the issue and identify the structural conditions and contexts where teachers successfully implement multicultural education.
6. **Success without institutional support.** Gorski and Parekh (2020[48]) found a negative relationship between teacher implementation of critical multicultural education pedagogies and perceived institutional support. One possibility is teachers feel the need to respond more critically when there is less support. However, the finding prompts several new questions. First, are there cases where teachers apply more critical forms of multicultural education without institutional and political support? If so, what are the characteristics, training, and attitudes of these teachers that enable them to do so? How do they navigate and persist in less supportive environments? More qualitative research may be needed to understand the decision-making of teachers around which forms of multicultural education they implement, if at all.
7. **Diversity versus inequality.** Broad survey questions about supporting diversity and raising awareness of cultural differences serve multiple purposes, including establishing a record of current teacher perceptions and attitudes. These questions are sometimes framed in terms of skills and learning. However, future studies and surveys should ensure that more critical questions about teacher dispositions and practices related to addressing equity and social justice are included. Not doing so may present an overly optimistic or superficial view of multicultural education and teacher preparation across countries. Excluding such questions also ignores the topic of inequality in schools and may reinforce systemic issues.
8. **Student achievement and outcomes.** Research on multicultural education overwhelmingly focuses on curriculum design and teacher preparation. Fewer studies examine the relationship between multicultural education (including teacher preparation in this area) and student outcomes; even fewer explore this relationship empirically. Future studies using international surveys should analyse the extent to which self-reported teacher preparation in multicultural education is associated with student academic and social outcomes. Of interest is whether the relationship between teacher preparation and student outcomes differs across country contexts, whether student groups benefit differently, and mechanisms for improved achievement among different groups.

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5 The contextualised measuring of general pedagogical knowledge and skills: Exploring the use of knowledge in practice

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What do teachers need for knowledge-based practice? This is a key research question of great relevance to policy and practice. The chapter highlights the role of teachers' practice-based knowledge and situation-specific skills for transforming general pedagogical knowledge into effective practice. It also provides an overview of the state-of-the-art on measuring such knowledge and skills through contextualised measurements, including the suitability of different approaches for an international large-scale teacher assessment.

Introduction

Teachers' general pedagogical knowledge is seen as an important aspect of teachers' professional competence [see Guerriero (2017[1]) for an overview]. This specialised knowledge, combined with subject-specific knowledge beliefs, motivation and self-regulation [Baumert and Kunter (2011[2]) based on Shulman (1986[3]; 1987[4])], enables teachers to effectively foster learning processes.

Many teachers, however, experience difficulties in the transition phase from teacher education to teaching. They struggle to apply acquired knowledge in the classroom (Doyle, 2006[5]; Wanzare, 2007[6]). Additionally, research results show that it cannot necessarily be assumed that the pedagogical knowledge captured at the end of teacher education correlates with effective practice in the classroom (Brühwiler et al., 2017[7]; Cauet et al., 2015[8]). The common struggle of novice teachers showcases the need for a more comprehensive perspective on teachers' professional knowledge, and a deeper understanding of teacher transition from theory to practice.

Newer models of professional competences include situation-specific skills and highlight their importance for the transformation of knowledge into effective practice (Blömeke, Gustafsson and Shavelson, 2015[9]; Depaepe, Verschaffel and Star, 2020[10]; Krauss et al., 2020[11]). The development of such skills and more practical knowledge seems to require guided teaching experiences. This insight has led to teacher education reforms worldwide [e.g. Ball and Forzani, (2009[12])]: Diverse practical elements have been introduced into the curricula of most teacher education programmes, complemented by induction activities for novice teachers in many countries. Further empirical information on the transition process of teachers and the impact of such reforms would be of great value in terms of policy and practice. This requires knowledge assessments that cover more of those practical knowledge and skills.

The development of such assessments that are reliable and valid is as important as it is challenging [see Depaepe, Verschaffel and Star (2020[10]) for an overview]. Situated- and performance-oriented assessments have been developed that go beyond the limited scope of traditional paper-and-pencil assessments. Many of the more recent assessments require teachers to apply knowledge in hypothetical classroom situations (Blömeke, Gustafsson and Shavelson, 2015[9]; Depaepe, Verschaffel and Star, 2020[10]; Shavelson, 2010[13]). This approach has often been referred to as a contextualised assessment of teacher knowledge.

The aim of this chapter is to give an overview of the state-of-the-art on contextualised measurement of general pedagogical knowledge and skills. It seeks also to highlight the potentials and challenges for such an approach in the context of large-scale international studies. This chapter will first discuss the knowledge and skills teachers need to transform general pedagogical knowledge into effective practice. Then, different approaches to measure these knowledge and skills with contextualised assessments will be compared, including their suitability for an international large-scale assessment of teachers. The chapter ends with some main conclusions for a large-scale contextualised assessment of teacher knowledge across countries.

The role of practice-based knowledge and situation-specific skills for effective teaching

Initial models describe teachers' knowledge as an important aspect of teachers' professional competence, which includes subject-independent knowledge (general pedagogical knowledge) and subject-specific knowledge (such as content knowledge and pedagogical content knowledge). Each of these knowledge component is further broken down into its composing elements, for example the content areas and topics of teacher knowledge.

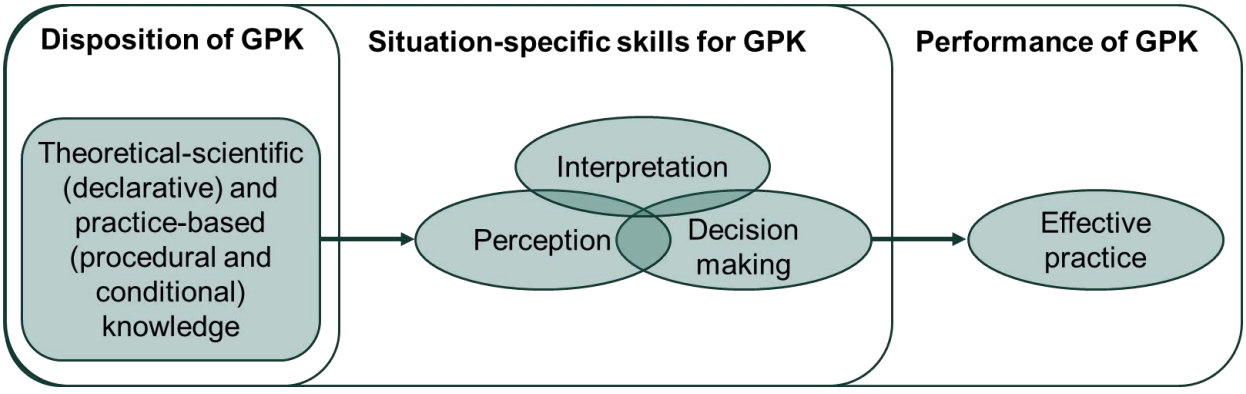
In his international review, König (2015[14]) identified three *content areas* that are common across existing knowledge frameworks: assessment, instruction and learning. These content areas, thus, need to be covered in an international assessment of teachers' general pedagogical knowledge, which is the case for the Teacher Knowledge Survey (TKS) (see Chaper 1 for a detailed description of these content areas). Some authors highlight the particular importance of two sub-dimensions within the broad content areas: (1) classroom management and (2) knowledge of the learning processes of students (Borko and Putnam, 1996[15]; Bromme, 2001[16]; Fennema and Loef Frank, 1992[17]).

Similar to other knowledge, general pedagogical knowledge can also be broken down into two different *knowledge types*: (1) theoretical-scientific (declarative) and (2) practice-based (procedural and conditional) knowledge [see Guerriero (2017[1])]. *Theoretical-scientific knowledge (declarative knowledge;* "knowing what") comprises the knowledge of pedagogical concepts, as well as contents and facts about learning and teaching from educational research (Anderson, 1996[18]).

Practice-based knowledge (action-related knowledge) includes procedural and conditional knowledge (Anderson, 1996[18]). *Procedural knowledge* ("knowing how") corresponds to knowledge relating to concrete teaching-related actions, such as the typical procedures involved in planning and implementing lessons (Artelt and Wirth, 2014[19]). It contains primarily unconscious cognitive operations (Seel, 2003[20]) and helps by using typical procedures to recognise, plan and realise teaching, both stepwise and systematically (König and Blömeke, 2009[21]). *Conditional knowledge* or pragmatic knowledge ("knowing when and why") comprises the knowledge of conditions under which pedagogical theories and concepts (*declarative knowledge*) apply in a given classroom situation, and which teaching methods (*procedural knowledge*) are appropriate and effective in achieving a specific teaching goal (Lenske et al., 2016[22]). This knowledge is therefore necessary when deciding which declarative and procedural knowledge are appropriate in which situation (Woolfolk Hoy and Schönplug, 2008[23]), i.e. which teaching method is appropriate in achieving teaching targets.

Research into teacher expertise established that both theoretical-scientific and practice-based knowledge contribute to expert teachers' performance in the classroom (Bromme, 2001[16]). Yet, teachers also need situation-specific skills to transform their knowledge into practice (Blömeke, Gustafsson and Shavelson, 2015[9]; Depaepe, Verschaffel and Star, 2020[10]; Krauss et al., 2020[11]). It is assumed, therefore, that knowledge is a prerequisite for high-quality teaching and learning outcomes, but that it is an indirect relationship mediated by situation-specific skills (Blömeke, Gustafsson and Shavelson, 2015[9]; Ulferts, 2019[24]). Blömeke et al. (2015[9]) have extended the initial models to cover the mediating role of situation-specific skills. Figure 5.1 displays an adapted version of this competence model.

Figure 5.1. Model on the transformation of theoretical-scientific and practice-based knowledge to effective practice



Source: Adapted from the competence model of (Blömeke, Gustafsson and Shavelson, 2015[9])

The model assumes three *types of skills* as crucial for transforming general pedagogical knowledge into effective practice: Teachers' perception of classroom situations, interpretation and decision making (Guerriero, 2017[1]; Blömeke, Gustafsson and Shavelson, 2015[9]). Teachers constantly need to monitor the classroom and identify situations and cues that, from a professional perspective, are decisive for effective instructional practice and student learning (*perception*). In this regard, teacher knowledge acts as a filter helping teachers to direct their attention to those relevant acts. Such a knowledge-directed perception is indispensable in classroom teaching where numerous teaching and learning acts occur; some of particularly importance, others not. Teachers then have to process the information based on their knowledge of principles of teaching and learning (*interpretation*), in order to make instructional decisions.

It is assumed that *decision making* in classrooms benefits from a great breadth and depth of pedagogical knowledge (e.g. knowledge about various instructional approaches and how they impact student learning and when to apply them). Research is generally in accordance with the models' assumption. Studies have proven that general pedagogical knowledge helps teachers to perceive and interpret classroom situations and decide on an appropriate course of action in the classroom (Charalambous, 2020[25]; König and Kramer, 2016[26]; Krauss et al., 2020[11]).

König and colleagues (2014[27]) showed, for example, that general pedagogical knowledge, measured with the *Teacher Education and Development Study in Mathematics* (TEDS-M) instrument [cf. König et al. (2011[28])] and comprising declarative and partly procedural general pedagogical knowledge, correlates substantially with teachers' situation-specific skills to interpret. The current models see teachers' theoretical-scientific and practice-based knowledge as a necessary, but not sufficient prerequisite for situation-specific skills (perception, interpretation, decision making) and for teachers' effective practice (Blömeke, Gustafsson and Shavelson, 2015[9]; Kaiser and König, 2019[29]; Krauss et al., 2020[11]). Professional perception, interpretation and decision making requires specialised knowledge but also specific training. Gold, Förster and Holodynski (2013[30]), for instance, showed that guided video analysis can be used to train teachers' perception abilities. Consequently, assessing teachers' situation-specific skills alongside their pedagogical knowledge is key for understanding how well they are equipped for high-quality teaching.

Contextualised assessments of practice-based knowledge and situation-specific skills

Only in recent decades has there been a shift from self-assessment to more objective measures of teachers' professional competence (Hill, Beisiegel and Jacob, 2013[31]). By now, several measurement instruments have been developed that measure theoretical-scientific and practice-based knowledge in a more contextualised way and include situation-specific skills (König et al., 2011[28]). They frequently use (text or video) vignettes that confront teachers with typical classroom situations (Gasteiger et al., 2020[32]), or challenging situations in which teachers fail to provide an adequate response (Brühwiler et al., 2017[7]; Brühwiler and Vogt, 2020[33]; Lenske et al., 2015[34]). Table 5.1 lists various recently developed contextualised assessments. The table does not represent an exhaustive list but rather a selection of instruments differing in assessment approach.

Content areas

It becomes obvious when comparing the existing instruments that they vary in content covered. Some instruments cover a broad range of topics from different content areas (Brühwiler et al., 2017[7]; Lenske et al., 2015[34]; Charalambous, 2020[25]), whereas other instruments focus on certain content dimensions and sub-dimensions, e.g. classroom management or assessment (Brühwiler and Vogt, 2020[33]; König and Kramer, 2016[26]; Wildgans-Lang et al., 2020[35]).

Table 5.1. Overview of contextualised assessments of general pedagogical knowledge and skills

Study/Instrument	Pedagogical-psychological teaching knowledge (PPTK)	Professional knowledge in natural science (ProWiN)	Classroom management expertise (CME)	Video test for adaptive teaching competency (ATC video test)	Teaching simulation	Simulated online environment
Reference	Brühwiler et al. (2017[7])	Lenske et al. (2015[34])	König and Kramer (2016[26]); König (2015[36])	Brühwiler and Vogt (2020[33])	Charalambous (2020[25])	Wildgans-Lang et al. (2020[35])
Construct measured	Pedagogical-psychological teaching knowledge	Pedagogical-psychological knowledge	Classroom management expertise	Teachers' adaptive performance competency	Performance in the simulation (action-related competence)	Teachers' diagnostic competence
Content area	Instruction (and learning)	Instruction and learning	Instruction	Instruction and learning	Instruction and learning	Assessment
Types of knowledge and skills	Situation-specific skills (interpretation and decision making)	Practice-based knowledge (procedural and conditional)	Situation-specific skills (perception and interpretation)	Situation-specific skills (perception, interpretation and decision making)	Situation-specific skills (perception, interpretation and decision making)	Theoretical-scientific and practice-based knowledge
Task format	Text vignettes	Text vignettes	Video vignettes	Video vignettes	Digital simulations	Digital simulations
Response format	Closed	Closed	Closed and open	Open (oral answers)	Open	Open
Evaluation and scoring method	Pairwise agreement with experts	Pairwise agreement with experts	Absolute agreement with experts	Scoring based on a coding system	Evaluation as correct/incorrect based on a coding system	Evaluation as correct/incorrect based on a coding system

Note: The table does not present an exhaustive list of instruments for a contextualised assessment of general pedagogical knowledge and skills, but it gives an overview of instruments differing in assessment approach.

Type of knowledge and skills

The various instruments are designed to measure different types of knowledge and skill, as explained earlier. In particular, the instruments used to measure classroom management expertise [CME] and adaptive teaching competency [ATC] video test focus on teachers' interpretation of a specific classroom situation. Other instruments (e.g. pedagogical-psychological teaching knowledge [PPTK], ATC video test) include teachers' decision making. The Professional knowledge in natural science (ProWiN) study covered practice-based knowledge (procedural and conditional knowledge) (Lenske et al., 2015[34]), whereas the simulated online environment by Wildgans-Lang et al. (2020[35]) includes teachers' theoretical-scientific and practice-based knowledge in its assessment.

Task format and administration mode

As shown in Table 5.1, the task format corresponds closely to the types of knowledge and skills captured. Whereas traditional uncontextualised tasks seem appropriate for measuring teachers' theoretical-scientific knowledge, contextualised approaches using vignettes (hereafter, *vignette approaches*) are essential for assessing teachers' practice-based knowledge and situation-specific skills. The contextualisation can either be realised with text- or video-vignettes (Brühwiler et al., 2017[7]; Gasteiger et al., 2020[32]; König and Kramer, 2016[26]; Krauss et al., 2020[11]; Lenske et al., 2015[34]). With regard to video-vignettes, two approaches can be distinguished: (1) participants are shown a short, completed video sequence, which they then have to evaluate [e.g. the video-vignette test to assess classroom management expertise (König, 2015[36])] and (2) participants are shown a longer video sequence, in which they are asked to stop the video themselves as soon as they notice a situation that was not handled adequately. Once they stop

the video, they should express their thoughts and suggest a more adequate alternative to the teacher's action [e.g. the video test to assess teachers' adaptive teaching competence; (Brühwiler and Vogt, 2020[33])]. Whereas the former approach mainly focuses on teachers' interpretation of the situation shown in the video, the latter allows insights into their decision making as the teachers have to suggest a more adequate alternative action.

Empirical studies regarding the validity of these instruments (e.g. can the quality of the teaching be predicted) confirm that both assessment approaches, text- and video-based vignettes, capture knowledge and skills relevant for instructional quality (Brühwiler et al., 2017[7]; Hollenstein, Affolter and Brühwiler, forthcoming[37]; König and Kramer, 2016[26]; Lenske et al., 2016[22]; Lenske, Wirth and Leutner, 2017[38]).

The most recent developments in measurement instruments are digital simulations, which also use typical classroom situations as their stimulus (Charalambous, 2020[25]; Wildgans-Lang et al., 2020[35]). For example, in a virtual mathematics lesson, participants indicate how the teacher should interact with the students concerning topics such as providing explanations, using representations, analysing student work or contributions, and responding to students' requests for help. This is used, for example, in the simulation of Charalambous (2020[25]) to assesses (pre-service) teachers' action-related competence. Wildgans-Lang et al. (2020[35]) developed an instrument with which (pre-service) primary school teachers should diagnose virtual students' competence levels, while the students solved mathematical problems. Digital simulations are promising tools in the assessment of characteristics, closely linked to classroom performance (Charalambous, 2020[25]; Wildgans-Lang et al., 2020[35]). Nevertheless, to date, few studies exist that evidence their relationship to instructional quality (Charalambous, 2020[25]).

Response format, evaluation and scoring method

A further distinction between the measuring instruments can be made in terms of response formats. In principle, the instruments can be categorised into closed or open answer formats. There are several options for the closed response formats and the choice among them determines, to a certain extent, the methods for evaluating and scoring the answers obtained from teachers. In the context of large-scale assessments, typically multiple choice items, Likert-scale items or short answer formats are used.

Multiple choice items force teachers to choose one out of several options provided. The underlying assumption is that answers are either correct or incorrect, i.e. in agreement or disagreement with scientific theories and evidence. Consequently, answers are scored binary (e.g. no point for incorrect answers and one point for every correct answer). Partial credit models allow for a more differentiated evaluation of teachers' responses: Responses may indicate some knowledge and are, thus, partially credited (e.g. teachers receive one point for a partially correct answer and two points for an entirely correct answer).

Multiple choice items might be appropriate for assessing theoretical-scientific knowledge, but for situation-specific skills *Likert scales* seem more appropriate. The perception and interpretation of classroom situations as well as decision making in teaching is not a question of either-or but of choosing among options that are more or less appropriate. Likert scales can take account of this by asking teachers to judge the degree of appropriateness, effectiveness or utility of different options for teaching: Brühwiler and colleagues, for instance, asked teachers to judge on 4-point Likert scales whether the various options proposed are more or less useful (Brühwiler et al., 2017[7]).

The scoring happens via comparison with an expert solution, either through absolute agreements (as done for the instrument by König (2015[36]) measuring Classroom management expertise) or relative agreements with experts [as done for the instrument measuring pedagogical-psychological knowledge by Lenske et al. (2015[34])]. Absolute agreements require teachers to rate the options exactly like experts, whereas relative agreements consider if teachers rank the options similarly as experts.

Expert ratings have already been successfully used in international, large-scale assessments. For example, in the 2009 round of PISA (Programme for International Student Assessment), pairwise

comparisons with expert ratings were used to measure students' reading strategies (OECD, 2010[39]) (for more detail see Box 5.1). Similarly, TALIS Starting Strong tested expert rankings and other forms of rankings to measure pre-school teachers' responses on several situational judgement items (Nielsen et al., 217[40]). Though both did not measure teacher knowledge (the latter measured staff practices and the former students' reading strategies), these examples show the feasibility of the approach for international surveys.

Box 5.1. Pairwise comparison with expert rating

Using a pairwise comparison with experts' answers is based on the assumption that practice-based knowledge or situation-specific skills become apparent, particularly when teachers are able to distinguish between adequate and inadequate teacher actions, and are able to rank teacher actions according to their adequacy (Lenske et al., 2016[22]). Besides PISA (OECD, 2010[39]), other text-vignette instruments use the pairwise comparison as an evaluation method (Schlagmüller and Schneider, 2007[41]; Lenske et al., 2015[34]; Brühwiler et al., 2017[7]; Rutsch et al., 2018[42]).

A pairwise comparison with expert rating means that the participants' and the experts' answers are related to one another. There are different ways of doing this. If the item relation of the test person (a > b) corresponds to the item relation of the expert solution (a > b), e.g. 2 points are awarded. Only 1 point is given if the test respondent considered the items to be equivalent (a = b). If the item relation of the test respondent (a < b) is opposite to the item relation of the expert answer (a > b), the test respondent receives 0 points (Brühwiler et al., 2017[7]; Lenske et al., 2016[22]; Rutsch et al., 2018[42]). In PISA 2009 (OECD, 2010[39]) a binary coding was applied. Participants received 1 point for a correct relation or 0 points for an incorrect relation, compared to the experts' solution.

Open response items ask teachers to produce short answers without providing any options. Answers can be given in writing (König, 2015[36]) or orally (Brühwiler and Vogt, 2020[33])]. Participants' answers are usually scored on several criteria by trained experts according to a structured coding scheme. The schemes describe the different criteria for rating the teacher answers and provides examples of correct answers. It also details the points awarded for each criterion that is met. Coding schemes can be developed deductively (e.g. from a theoretical framework) or inductively (from the empirical teacher responses, for example via content analysis). Coding schemes can vary in their prescriptiveness and, thus, the amount of inferences required by the raters. Low-inferent codes allow to code every response with the least possible amount of inferences by the raters.

Advantages and disadvantages of different approaches in the context of international large-scale surveys

As the previous section has highlighted, various options for designing teacher assessments exist. Each choice comes with certain advantages and disadvantages and they are not equally suitable for an international large-scale assessment (see Table 5.2 for an overview).

Choice 1: Narrow vs. broad content coverage

The breadth of content covered with the assessment impacts the generalisability of obtained results, as well as the efficiency of data collection and the psychometric quality of obtained data. Instruments covering a broad range of knowledge and skills assess the constructs more comprehensively than instruments with a more narrow focus (as these only provide information on specific content areas and information on other areas is missing).

In contrast, a narrow approach can render a more detailed coverage of topics in a specific area (e.g. detailed information on the knowledge and skills needed for effective classroom management). Further advantages of a narrower assessment are that sufficient reliability in terms of internal consistency can generally achieved with fewer items and less testing time.

It would be of great importance to select content that is relevant for teaching across countries such as classroom management and further knowledge about instruction, learning and assessment (see Chapter 2).

Table 5.2. Advantages and disadvantages of different design choice

Design Choice	Advantages	Disadvantages
	Choice 1	
Broad coverage of content	• a more comprehensive measurement of knowledge and skills	• requires more items items to obtain sufficient internal consistency for all areas covered • requires more time to complete
Narrow coverage of content	• allows for a more detailed coverage of a specific aspect • sufficient reliability in terms of internal consistency may be achieved with less items, limiting the response burden for teachers	• insights into teachers' knowledge and skills is limited to a certain aspect, leaving out others
	Choice 2	
Theoretical-scientific knowledge	• prerequisite for situation-specific skills and effective teaching • closely linked to the content of initial teacher education and suited for measuring its output	• insights into teachers' knowledge and skills is limited to a certain aspect, leaving out others
Practice-based knowledge	• prerequisite for situation-specific skills and effective teaching • important for evaluating the practical elements of teacher education	• indirectly linked to effective teaching practice
Situation-specific skills	• more direct relationship with effective teaching • important for understanding the transformation of knowledge into practice; and evaluating the practical elements of teacher education	• standardised measurement of situation-specific skills comes with additional challenges
	Choice 3	
Uncontextualised tasks	• widely used in international assessments • less developmental effort • suitable for assessing theoretical-scientific knowledge	• no reference to classroom situations • not suitable for assessing practice-based knowledge and situation-specific skills
Video vignettes	• cover the complexity and authenticity of classroom situations • suitable for assessing practice-based knowledge and situation-specific skills	• achieving standardisation and comparability across diverse cultures and educational contexts is challenging • requires technical equipmentt
Text vignettes	• provide a neutral description and, thus, easier applicable to various contexts than video vignettes • less cost and resource intensive than video vignettes • suitable for assessing practice-based knowledge and situation-specific skills	• cover less well the complexity and authenticity of classroom situations
Digital simulations	• close to actual experience of teachers in classrooms • various factors can be systematically varied • suitable for assessing practice-based knowledge and situation-specific skills	• very demanding to create an internationally comparable, simulated classroom environment • time consuming in the development stage • scarcity of empirical evidence for its relationship to teaching quality and student outcomes • limited experience of the scientific community, and, thus, is a risky choice

Design Choice	Advantages	Disadvantages
	Choice 4	
Multiple choice items scored as correct/incorrect or using partial credit models	• widely used in international assessments • take little time to answer and score • provide reliable and valid information • partial credit allows a more differentiated measurement	• do not allow respondents to express their own ideas • force teachers to choose one of the proposed alternatives, though none may reflect their preferred option • cannot capture more complex tasks of teachers in classrooms (e.g. decision making and professional judgement) • teacher decisions and actions may not be correct or incorrect, but may vary in effectiveness, depending on the situational context
Likert-scale items using agreement with experts for scoring	• have been shown to provide reliable and valid information in international large-scale assessments • reflects the typical choice of teachers among various more or less suitable options and require a moderate time to complete • can use the degree of alignment with expert opinion, rather than judging teachers' decision and action as correct or incorrect	• do not allow respondents to express their own ideas • requires additional efforts for developing a reliable and valid expert rating system such as the involvement of (international) expert
Open response format scored with a coding system	• respondents are free in their response • allows a highly individualised and differentiated assessment of knowledge and skills • takes account of the specificities of different cultures and educational systems • allows for a differentiated evaluation of teachers' answers and perspectives on complex classroom situations	• requires expressive and reflective skills and a high motivation of teachers • very time consuming to complete, and, thus, lead to high response burdens for teachers • coding is time consuming requires high expertise and training

Choice 2: Theoretical-scientific knowledge, practice-based knowledge or situation-specific skills

Teacher education is largely concerned with teaching theories, concepts and principals of teaching and learning. Thus, instruments focusing on theoretical-scientific knowledge of teachers are suitable tools for measuring the output of teacher education to a certain extent. Insights from these instrument into the transition process from theory to practice of teachers are limited. Understanding why some teachers (especially novice teachers) struggle to apply acquired knowledge in the classroom, requires instruments that cover practice-based knowledge and situation-specific skills of teachers. Yet, a standardised measurement of situation-specific skills in an international context is challenging. A particular attention to the administration mode and task formats are required as well as to the classroom situations selected for the vignettes.

Choice 3: Uncontextualised tasks, vignettes or simulations

Uncontextualised tasks (mostly multiple choice tasks) are widely and successfully used in many international assessments. Many reliable and valid instruments already exist and the development effort is lower than for more recent approaches. Such tasks are suitable for measuring theoretical-scientific knowledge. They need to be complemented with text- or video vignettes that confront teachers with authentic and typical classroom situations, in order to provide information on situation-specific skills and practice-based knowledge of teachers.

Existing vignette instruments have their origin in a particular cultural and educational context. Adapting the vignettes and items for other contexts may be quite challenging and will not simply be a matter of translation (Hambleton, Merenda and Spielberger, 2005[43]). Text vignettes seem to be a more feasible choice for an

international assessment than video vignettes, as they are probably easier to adapt and develop. Video vignettes, which show classroom situations with teachers and students in a specific national and cultural context, may not work in other contexts and cultures. A text vignette can provide a more neutral description of a classroom situation. Respondents can interpret the described situation within their specific cultural and educational context and translate the description into a mental image that fits their specific experience. Furthermore, text vignettes have lower technical requirements and are, thus, a more economic means of creating contextualised assessments than video vignettes.

However, the question arises as to whether text vignettes can adequately represent the complexity of a classroom situation. Generally, text vignettes provide only brief summaries of classroom situations and acts. Conversely, video vignettes can capture the complexity of classroom situations where multiple exchanges happen simultaneously and also non-verbally. They are, therefore, closer to the authentic situation and pose particular, real life challenges to teacher perception, interpretation and decision making (Kramer et al., 2020[44]; Stürmer, Konings and Seidel, 2013[45]).

Though promising, *digital simulations* are relatively new to the field. Given the scarcity of empirical evidence, developing an internationally validated, simulated classroom environment would be very demanding and time consuming. In addition, the lack of experience of using them in diverse contexts would be a risky choice for an international assessment. Furthermore, their additional benefit has not yet been empirically tested; in particular, there is a lack of empirical evidence of their relationship with teaching quality and student outcomes. Consequently, at this time, the implementation of digital simulations in large-scale assessments is not recommended.

Choice 4: Open or closed response format and choice of a scoring and evaluation method

Developing cross-cultural valid items and agreeing on responses across countries is a major challenge, regardless of the answer format used. Closed response items (such as multiple-choice or Likert scales) may, however, be the most efficient option: They take little time to answer and - once the scoring grid is developed - to score. The use of partial credit models to score answers allows both a speedy and more differentiated scoring. A major drawback is that they do not allow teachers to express their own ideas and force them to choose one of the proposed alternatives, even though none may reflect their preferred option. They are also less suited for measuring practice-based knowledge and situation-specific skills. In most classroom situations, there is not a right choice but a most adequate one (e.g. choosing between different teaching approaches varying in effectiveness and suitability for a specific situational context).

In view of the complex situations in classrooms, using Likert scales and comparing the responses to expert answers seems like an economic alternative. As already mentioned, the feasibility of such an approach for international assessments has been successfully demonstrated (OECD, 2010[39]; Nielsen et al., 217[40]). However, developing an expert rating system requires additional efforts and the involvement of (international) experts.

Open formats enable teachers to provide differentiated judgements, allowing for a more individualised assessment of teacher knowledge. As a result, the specificities of cultural and educational systems are accounted for. Yet, answering open response items takes time and requires motivation and more complex skills (expressive and reflective skills, as well as writing skills for written responses). Furthermore, it is very challenging and resource intensive to create an internationally valid and reliable coding system for the evaluation of answers. Open response items also require expertise and coding training for those categorising the items.

Conclusion

Based on the aforementioned advantages and disadvantages of different assessment approaches, considerable added value is expected from text-vignettes. They should describe typical and challenging classroom situations that most teachers are confronted with in their classrooms. Vignettes allow for a measurement of practice-based knowledge and situation-specific skills. The response burden for teachers, as well as the costs and resources, can be kept modest if Likert scales and comparisons with expert ratings are used. In the following, two examples of text vignettes for a contextualised assessment are described in more detail.

Example text vignettes and items for a large-scale assessment

Two example vignette items are shown in Table 5.3. They stem from an adapted version of the Swiss instrument measuring "pedagogical-psychological teaching knowledge" [PPTK; (Brühwiler et al., 2017[7]; Brühwiler et al., forthcoming[46])] and aim at capturing situation-specific skills. Both vignettes describe situations that most teachers around the globe face and represent both typical and challenging situations.

The first vignette describes a situation in which a teacher returns corrected papers to students after an exam. Solving the items requires knowledge about the attribution theory of achievement motivation (Weiner, 1985[47]). The second vignette is related to the context of classroom management and represents a typical situation in which a pupil is inattentive because he is bored. Each vignette is followed by two sets of Likert-scale items immediately after the vignette, which measure different situation-specific skills (Blömeke, Gustafsson and Shavelson, 2015[9]): The first set asks how the respondent would act in this situation and, therefore, require *professional decision making* of the responding teachers. The second set asks teachers for a *professional interpretation* of the described classroom situation.

Teacher responses were scored using the pairwise comparison. The experts' rating (also shown in Table 5.3.) was generated by consulting a total of 16 experts. Experts had either a strong teaching expertise *or* research expertise. The answer most frequently chosen by the experts was used as the expert rating. Discrepancies were discussed among a smaller group of experts, in order to reach consent (Brühwiler et al., 2017[7]; Brühwiler et al., forthcoming[46]). If consent could not be achieved, the item was excluded.

Brühwiler and colleagues (2017[7]) tested the assumption that situation-specific skills are closely related to effective practice, as explained earlier. The results show that PPTK predicts both instructional quality and the pupils' academic achievements. These findings underline the potential of contextualised assessments.

Table 5.3. Examples of text vignettes focusing on typical classroom situations

Vignette 1: Students wrote an exam in class. The teacher returns the corrected papers.

a) How would you act in this situation? Which action is likely, which is unlikely? *Please tick one box per line.*		very unlikely	unlikely	Likely	very likely
A	Karin receives a bad grade in her exam and the teacher says to her: "I know that you practiced a lot, but this is not one of your strengths."	☒	☐	☐	☐
B	Peter receives a very good grade in his exam. The teacher says to him, "It doesn't seem to have been difficult."	☒	☐	☐	☐
C	Michael receives a good grade in his exam with the comment: "You see, your diligence has really paid off."	☐	☐	☐	☒
D	To Anna she says, "Your talent is obvious once again." Anna receives a very good grade.	☐	☐	☒	☐

b) Analyse the reaction of the student Karin (first statement above). What effect could the teacher's feedback have on Karin? Which of the effects outlined below is likely, which is unlikely? *Please tick one box per line.*		very unlikely	unlikely	Likely	very likely
A	Karin goes home reassured because she now knows that the teacher is not disappointed in her.	☐	☒	☐	☐
B	Karin will try harder next time. She really wants to show the teacher that she is good at maths.	☒	☐	☐	☐
C	Karin will not feel like practicing a great deal for the next exam, as it has not been of any use so far.	☐	☐	☐	☒
D	The next time Karin achieves a good result, she will believe that she has finally been able to show her abilities.	☒	☐	☐	☐

Vignette 2: A teacher explains a difficult maths task in the classroom, which almost no student was able to solve. Patrick, a very good student in mathematics, paints the paper in front of him during the lesson without disturbing any of his classmates.

a) How would you act in this situation? Which action is likely, which is unlikely? *Please tick one box per line.*		very unlikely	unlikely	Likely	very likely
A	I ask a question to assess comprehension and then call Patrick.	☐	☒	☐	☐
B	I try to make eye contact with Patrick.	☐	☐	☐	☒
C	I ignore Patrick's behaviour.	☐	☐	☒	☐
D	I say to Patrick: "Please stop painting now."	☐	☒	☐	☐
E	While I continue the lesson, I stand close to Patrick's table.	☐	☐	☐	☒
F	I ask Patrick what is going on.	☐	☒	☐	☐
G	I send Patrick to the next room.	☒	☐	☐	☐
H	I give Patrick extra homework.	☒	☐	☐	☐
I	I give Patrick the opportunity to explain the task to his fellow students in his own words.	☐	☐	☐	☒

b) Analyse the situation. What could be the difficulty? Which statements are likely, which are unlikely? *Please tick one box per line.*		very unlikely	unlikely	Likely	very likely
A	Patrick is one of the few students who solved the maths problem correctly.	☐	☐	☐	☒
B	Patrick is trying to annoy the teacher with his behaviour.	☒	☐	☐	☐
C	Patrick paints the paper in front of him out of boredom.	☐	☐	☒	☐
D	The task is too difficult for Patrick.	☒	☐	☐	☐

Note: Vignettes were scored using a pairwise comparison with expert ratings. Crosses indicate the experts' answers; adapted version of the German-language instrument (Brühwiler et al., 2017[7]; Brühwiler et al., forthcoming[46]); Vignette 1 relates to attribution theory, vignette 2 relates to teaching disturbances (classroom management).

Further recommendations for a contextualised assessment of teacher knowledge and skills

The question of which type of knowledge and skills teachers need to transform general pedagogical knowledge into effective teaching practice is highly relevant. To date, however, it remains largely

unanswered. Further empirical information, which would allow for a deeper understanding of these transformation processes, would be of great value in terms of both policy and practice. As it seems that practice-based knowledge and situation-specific skills play a crucial role in this transformation process, it would be of great importance to include a sufficient number of contextualised items in an international survey on teacher knowledge.

Based on the considerations in this chapter, considerable added value could be expected by developing text vignettes which describe difficult classroom situations in which teachers' practice-based pedagogical knowledge and situation-specific skills are required to solve the challenging situation. These situations should be typical and relevant for most teachers across countries. The development of text vignettes instead of video vignettes is recommended not only for economic reasons, but also because text vignettes can provide a more neutral description of a classroom situation and are, therefore, easier to develop for various cultural and educational contexts.

The development of vignettes and items that are valid and reliable across all participating countries is crucial. They should be based on theory and practice. The OECD Global Teaching InSights (GT) study could be a fruitful starting point for identifying typical and challenging classroom situations relevant across countries (OECD, 2020[48]). Applying a rater-scoring system represents an efficient and appropriate scoring method that has successfully been used in other international studies (OECD, 2010[39]; Nielsen et al., 217[40]).

An extensive validation of the items and expert scoring system in a pilot study and in the field trail is recommended. An important aspect is measurement invariance testing (Milfont and Fischer, 2010[49]): It must be ensured that vignettes are comparable across countries. Additionally, it would be important to test the predictive or at least concurrent validity of the developed instrument (König, 2015[14]), i.e. whether the measured knowledge and skills are actually related to effective teaching practice. The TALIS includes various scales on teaching practices (e.g. classroom management and cognitive activation), which could be used for the validity testing.

To sum up, it is less a question of ''whether'' but ''how'' to assess general pedagogical knowledge and situation-specific skills in a large-scale assessment (see Table 8.1 in Chapter 8 for the main takeaways from this chapter for TALIS and the TKS assessment module). Empirical information would be of great value for policy and research, as it would allow for a greater scientific understanding of how knowledge is transformed in practice, and why some teachers struggle with this. The inclusion of more contextualised items, therefore, would strengthen the value of the TKS assessment module.

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6 Studying opportunities to learn general pedagogical knowledge along the teaching career

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This chapter is dedicated to the learning opportunities that enable knowledge-based practice of teachers. It also contributes ideas for measuring such learning opportunities along the teaching career, drawing on existing cross-country research. This includes concrete recommendations for how to extend the TALIS 2018 teacher questionnaire and the TKS assessment module for an in-depth study of teachers' opportunities to learn general pedagogical knowledge in future cycles. The chapter ends with implications for further research on the learning opportunities needed to ensure knowledge-based practice in schools.

Introduction

Despite the importance attributed to general pedagogical knowledge (GPK) for effective quality teaching, the degree to which teachers universally acquire such knowledge is still an open question (Tatto, 2018[1]; Ulferts, 2019[2]). Further, while teachers are exposed to a wide range of opportunities to learn during their initial teacher education (ITE), induction, and during their careers, once they become teachers of record, there is much to learn about which of these are the most effective and how they complement each other.

Finding answers to these questions is a very complex undertaking given the norms of the different institutions at play and teachers' own life experiences. It is well established that teachers learn about teaching through the 'apprenticeship of observation', that is, by watching their teachers for more than 10 000 hours during their schooling (Lortie, 1975[3]). The powerful influence of such an apprenticeship is hard to challenge in ITE. There is evidence, however, that ITE programmes located in universities (where teachers have ample opportunities to study the subjects they will teach, the pedagogy of their subject, and general pedagogy plus a practicum) can produce highly knowledgeable teachers (Tatto et al., 2012[4]; Tatto, 2018[1]). Also, programmes that are internally coherent and provide opportunities to learn (OTL) within an inquiry-based model (e.g. emphasis on problem-solving through action research to explore productive ways to teach subject matter to diverse pupils including planning, adaptations to curriculum design and implementation, assessment of student progress, and classroom organisation) are effective in challenging deeply held beliefs about teaching and learning (Tatto, 1996[5]; Tatto, 2018[1]).

The *practicum* component of ITE presents special challenges, particularly if the norms of ITE programmes and those of the schools where the practicum is to occur are at odds. The practicum, however, also offers important opportunities to learn to teach because it focuses on three essential aspects: the situated learning experience about pupils, classrooms and what it means to be a teacher; the learning that occurs as a result of planning, instruction, and assessment; and the extent to which teachers' actions best help pupils learn and enhance their capacity to continue learning. Research has shown the importance of well-structured practicum experiences for teaching knowledge. Of particular importance are opportunities to engage in action research under continuous mentoring or supervision from experienced and committed teachers (Peralta and Tatto, 2018[6]). Also, successful practicum experiences require strong working partnerships and supportive mentoring in both programmes and schools able to provide future teachers OTL that are mutually consistent and productive (Tatto et al., 2018[7]; Zeichner, 1996[8]).

While not universally implemented in schools, an induction period for early career teachers provides important OTL at this crucial stage in teachers' careers. Research shows that intensive mentoring focused on content and instruction, management, and student engagement seems to be a key component mediating OTL and teaching quality improvement among early career teachers (Stanulis and Floden, 2009[9]; Kane and Francis, 2013[10]; Hammerness and Matsko, 2012[11]).

Much emphasis has been placed on professional development (PD) for teachers, not only as a way to promote continuous learning and professional improvement but also as an important factor supporting the implementation of curricular reforms, including the introduction of new standards and increased accountability. Research shows that well-structured substantive PD opportunities can improve teaching practice with important positive consequences for pupil learning (Yoon et al., 2007[12]; Darling-Hammond, Hyler and Gardner, 2017[13]). Moreover, PD that emphasises leadership, autonomy, collaboration and substantial feedback on teaching practices seems to be a successful way to not only improve teaching practices but to build communities of practice within schools (Gore et al., 2017[14]).

The OECD, through the Teaching and Learning International Survey (TALIS) teacher questionnaire and the Teacher Knowledge Survey (TKS) assessment module, is planning to investigate the complex dynamic relationship between the continua of OTL and learning outcomes for teachers in ITE, induction and PD. This will help in beginning to understand how to contribute to build a robust knowledge base for the profession.

This chapter contributes new ideas, advances and specific feedback on the 2018 TALIS and TKS frameworks and teacher questionnaire, concerning the conceptualisation, definition and measurement of secondary teachers' OTL GPK.

The chapter has three sections. It first examines promising concepts and supporting strategies that may allow the development of a profile of OTL GPK for secondary teachers in ITE including courses and the practicum, induction and PD. This section also briefly introduces key studies that may contribute to a solid theoretical basis for TALIS and TKS assessment module. The next section provides suggestions for profiling teachers' opportunities to learn. The last section concludes with concrete recommendations for how to extend the TALIS 2018 teacher questionnaire and the TKS assessment module for an in-depth study of teachers' OTL general pedagogical knowledge in future cycles. It also reflects on the further research that is needed to support building the knowledge base of the teaching profession.

Concepts and strategies for exploring teachers' opportunities to learn

While OTL occurs in fluid ways through both formal and non-formal experiences for teachers, it is widely acknowledged that the three phases of development described above (ITE, induction, and PD) are likely to occur through teachers' careers. Drawing on international studies (see Box 6.1), the chapter will use these phases to organise the suggestions of important concepts, methodological advances, and indicators of OTL lead to essential knowledge for teachers with a particular emphasis on GPK.

Box 6.1. Existing cross-country studies on teachers' opportunities to learn general pedagogical knowledge

The Teacher Education and Development Study in Mathematics (TEDS-M) is the first and only study that has surveyed representative samples of teacher education programmes, their future teachers and their teacher educators in 17 countries. The study proposed to explore mathematics content knowledge, pedagogical content knowledge, general pedagogical knowledge, background, beliefs, and opportunities to learn among future primary and secondary teachers close to graduation (Tatto, 2013[15]).

The First Five Years of Mathematics Teaching study (FIRSTMATH) explored novice teachers' development of mathematical knowledge for teaching, and the influence that previous preparation, school context and opportunities to learn-on-the-job have on that knowledge. FIRSTMATH explored the connections between opportunities to learn in pre-service preparation and what is learned on the job as it concerns knowledge, skills and curricular content. Additionally, the study analysed the degree to which standards, accountability and other similar mechanisms operate to regulate the support that beginning teachers of mathematics at the primary and secondary levels receive (Tatto et al., 2020[16]).

While TEDS-M and FIRSTMATH focused on mathematics, an important concern in both studies was with general pedagogical knowledge and the diverse opportunities to learn teachers encounter in initial teacher education programmes, induction and professional development, and their connection to practice. For instance, two-thirds of the opportunities to learn questions in both studies directly focus on general pedagogical knowledge.

The Learning to Teach in England and the United States study (LTTE-US) is a small-scale observational study that explores the challenges that teachers encounter in their practicum and the extent to which policy and practice in teacher education programmes and schools mediate initial teaching practice among secondary teachers. This study explored general pedagogical knowledge across different subjects and settings (Tatto et al., 2018[7]).

The recommendations in this section draw primarily from experiences in two large-scale international comparative studies. These are the Teacher Education and Development Study in Mathematics (TEDS-M) (Tatto, 2013[15]; Tatto, 2018[1]) and the First Five Years of Teaching Mathematics (FIRSTMATH) (Tatto et al., 2020[16]). Additionally, a comparative observational study, called Learning to Teach in England and the United States (LTTE-US) (Tatto et al., 2018[7]), is drawn upon. Recommendations are also based on insights of effective PD (Darling-Hammond, Hyler and Gardner, 2017[13]) and PD that builds on professional communities of practice (Gore et al., 2017[14]). Insights from other relevant studies are included as well.

The TALIS 2018 teacher questionnaire (TQ) asked teachers several questions about OTL (Ainley and Carstens, 2018[17]). These included questions relating to ITE (TQ-06, TQ-15), PD and induction (TQ-19-23, TQ-25-28), feedback (TQ-29-Q31) as well as learning communities (TQ-32-33). Answers provided information to draw profiles of teaching practices, understand teachers' collaborative experiences (professional learning communities and communities of practice), and whether these practices and experiences resulted in innovation, equity and attention to diversity. TALIS 2018 pursued the following aim:

> *'TALIS 2018 will collect information that should enable the construction of initial teacher education (ITE) profiles and allow in-depth analyses of the effects of these profiles on outcomes such as GPK among lower secondary school teachers. The link between ITE and continuous professional development is of particular interest. Understanding the different ITE profiles that lead to teaching and their association with these outcomes is highly relevant….' (Ainley and Carstens, 2018, p. 41[17]).*

With this aim in mind, the following section outlines ways to extend the existing TALIS 2018 teacher questionnaire and the analytical potential indicators for ITE, for PD and induction to allow for more fine-grained profiling of teachers' OTL GPK in future cycles. An analysis of whether and how these indicators measure GPK OTL is important as they have the potential to explain key elements of high quality teaching and teacher professionalism as outlined in the TALIS framework.

Grounding the measurement of ITE opportunities to learn in teacher education practice

To be able to understand and describe OTL in ITE, it is important to ground the development of measures on programmes' theory of action. Because the TEDS-M study was the first international comparative study of ITE, it was considered essential to ground the indicators and measurement of OTL on the design of the teacher education curriculum in the participating countries (Tatto, 2013[15]). While participants provided much information via interviews and questionnaires, the research team decided to carry out an analysis of course syllabi drawing from a representative sample of programmes in each country (Tatto and Bankov, 2018[18]; Tatto, 2013[15]).

The product of the syllabi analysed included coding the topics covered in courses on subject content, pedagogy of the content, general pedagogy and practicum. The syllabus analysis was used to make explicit the diverse OTL provided to future teachers, to arrive at clear definitions that were agreeable across countries, and to finally develop the OTL items drawing on the topics and subtopics from the analysis. The syllabus analysis was not only a strategy to develop definitions and to build items and indicators, but to develop capacity among teacher educators to analyse and reflect on the larger teacher education curriculum. Table 6.1 contains the list of topics covered in GPK courses.

Table 6.1. General pedagogy topics and subtopics across ITE programmes in TEDS-M

Topics covered in ITE courses	
History of Education and Educational Systems • characteristics of development and international systems (not your country) • historical development of the national system	Principles of Instruction • instructional theory and instructional design • didactic/teaching methods and models • lesson planning
Educational Psychology • motivational theory • theories of psychological development, cognitive development, and intelligence • learning theory • teaching and learning with the framework of multiple intelligences	Classroom Management • theory of classroom management • management of classroom community and learning environment classroom rules and handling of improper behaviour
Philosophy of Education • philosophy of education and general philosophy • knowledge and appreciation of educational theory (including meaning of educational goals) • educational ethics and moral education • education and epistemology • education and humanism	Assessment and Measurement Theory • types and functions of assessment • purposes, reliability and validity of assessment • analysis and design of examinations
Sociology of Education • social status of teachers • purpose and function of education in society • organisation of current educational systems • organisation and culture of schooling and school • social conditions, social change, social development, social resources and school education • diversity (e.g. knowing how to teach students of different abilities/cultures including Indigenous people, cultural, language, gender and special needs) • educational policies, reform, and current educational issues • comparative education relations of education and other topics (including culture, economy, society, politics)	Counselling, Advising Students, and Pastoral Care • basic theories and models in counselling • professional ethics of counselling training for skills and ability of counselling
Introduction to Education or Theories of Schools • goals of schooling (institution of schooling) • purpose and function of education • role of teacher • curriculum theory and theory of curriculum development • teacher-student relations • school administration and leadership (including personnel management, school finance, etc.) • education and legal issues • teacher professional development	Instructional Media and Operation • theories of media design • developing skills and abilities for media design • use of ICT and other media to support instruction
Methods of Educational Research	
Topics covered in the Practicum	
• knowing how to teach students of different abilities • knowing how to teach students with different linguistic, cultural and economic backgrounds and special needs • demonstrating moral responsibility toward diverse pupils • using assessment and similar data in making decisions regarding students • knowing how to motivate students	• identifying/differentiating learning styles • knowing how to develop lesson plans • knowing various forms of classroom assessment • knowing how to structure content • knowing how to manage classroom discourse • demonstrating strategies to deal with behaviour problems (ex: aggression) • knowing how to communicate and/or engage parents • engaging in general cooperation among teachers (e.g. marshalling resources at school)

Source: The intended, implemented and achieved curriculum of mathematics teacher education (Tatto and Bankov, 2018[18])

Similarly, TALIS could conduct a syllabus analysis to construct OTL items attuned to the current curriculum in teacher education, induction and PD. While the items developed by TEDS-M have proven valid for the newer FIRSTMATH study (Tatto et al., 2020[16]), TALIS includes a much larger number of countries. Furthermore, the last ten years have seen increased immigration across the world among many other changes. This requires teachers to develop skills to address the learning needs of children from diverse cultures. Additionally, the current COVID-19 pandemic is likely to have altered the teacher education curriculum, particularly concerning important aspects such as the use of information and communication technology (ICT) in classrooms, as well as an increased emphasis on socio-emotional learning. While the OECD has released recent work on ITE and PD e.g. A Flying Start (OECD, 2019[19]), the ongoing Teachers' Professional Learning Study [TPL] (Boeskens, Nusche and Yurita, 2020[20]), this work is policy-focused and did not have the scope to carry out a topic analysis of the teacher education curriculum, the induction curriculum or the PD curriculum.

Acknowledging the progressive and practical nature of teachers' learning in ITE

There has been much research on the optimal combination of courses and practical experiences that future teachers need to become effective (Darling-Hammond et al., 2010[21]; Jensen et al., 2019[22]; Seidel and Shavelson, 2007[23]). There is general agreement that the kind of teachers required to promote a 21st-century education are professionals who can implement inquiry-based teaching and inquiry-based learning. In inquiry-based learning, teachers must know their subjects deeply so that they can guide their students through the fundamental concepts and nature of these subjects. Typical characteristics of inquiry-based teaching and learning are, for example, critical and collaborative classroom communities that emphasise active learning of students, and the capacity of students to investigate and research their own questions. Learning to engage in teaching in this manner challenges the traditional role of the teacher as someone whose practice is primarily lecturing. Inquiry-based teaching is not something that can be learned in short courses. A significant period of learning, observation and mentored practise is needed.

The most helpful suggestion regarding the learning progression of inquiry-based teaching including courses and practicum was offered by McIntyre back in the early 1990s, and occurs at three levels: technical, practical, and critical or emancipatory (1993[24]) (see Box 6.2).

Two main theoretical disciplines are seen as essential to support teachers' practical theorising. Learning to think logically and conceptually to question the meaningfulness of concepts and to uncover hidden assumptions and implicit value judgements in the task of teaching and learning. The second is the use of theory developed from empirical research as applied to the practice of teaching. In sum, McIntyre emphasises the importance of action research and other education-based research engaged by teachers and educators to inform knowledge for teaching, and for learning to teach.

Finally, McIntyre (1993[24]) argues that the integration of theory and practice in initial teacher education depends on having a 'core curriculum' negotiated around the tasks of teaching that are agreed to be the most important for both university and school educators.

In designing the TKS assessment module and refining TALIS to profile ITE OTL, it would be important to consider the three phases of teachers' formation (described in Box 6.2) and the OTL they provide teachers in these phases as recommended by McIntyre (1993[24]). More detail describing useful scales and sub-scales including what the items measure is outlined below.

Box 6.2. Learning progression of inquiry-based teaching

Rather than beginning with theoretical courses, the *technical* is first emphasised as is the progressive attainment of short-term goals. Future teachers must be able to know the basics of what the role requires according to standards of good practice such as 'achieving and maintaining classroom order and purposeful activity, gaining pupils attention and interest, ensuring that pupils know what they are expected to do, that they understand the content of the lessons, etc.' (McIntyre, 1993, p. 45[24]). Planning is an important aspect of these basic skills and it is understood as mediated by teachers' understanding of their pupils, their context, and teachers' skills and commitments. When planning, teachers must resort to a wide repertoire of concepts and ideas emerging from their discipline and must engage in the challenging task of what McIntyre calls practical theorising (or anticipating how students will receive the lesson, how well it would go and how much would be learnt). Once this phase is completed, teachers can move on to the practical and emancipatory phases.

The key task in the *practical phase* is for teachers to be able to self-evaluate their practice and its consequence (most importantly its effect on students' learning). This phase requires the development or adoption of standards or criteria that will be used to collect evidence to self-evaluate and to correct courses of action—an important question for teachers in this phase is what are the results of the practical theorising that occurred before, during and after the lesson, how does the nature of the subject, students' styles of learning, and the school curriculum interact with the teaching and learning dynamic.

The third phase which McIntyre called the *critical or emancipatory phase* is at the core of inquiry-based teaching. In this phase, teachers begin to understand the contradictions inherent in institutional and social structures which may conflict with serving the best interests of students and with teachers' professional commitments. McIntryre asserts that these conflicts will invariably arise during the programme courses, but more intensely once teachers are in their practicum. The key task in this stage is to develop strategies to analyse, reflect and even contest norms and mandates that may be at odds with the essential task of teaching and learning.

Source: (McIntyre, 1993[24])

Fostering learning communities of autonomous professionals

Teachers' professional development OTL typically have been short-term experiences created to engage teachers in curriculum reform or assessment exercises. These have been disconnected from and inconsistent with the task of teaching and learning (Darling-Hammond, Hyler and Gardner, 2017[13]). The work of Kennedy is particularly relevant for expanding on teachers' OTL in TALIS (2004[25]; 2016[26]). Based on her qualitative work on teaching, Kennedy argues against the increasing focus on lists of core practices to characterise teaching and inform teacher education (Grossman, Hammerness and McDonald, 2009[27]) and proposes five 'universal goals' of teaching that need to be addressed in teacher education and professional development.

Kennedy's (2016[26]) five goals of teaching provide a road map for thinking about ways to re-imagine OTL GPK and extending McIntyre's (1993[24]) conceptions. Teachers need to know:

1. to portray curriculum content in a way that enables young minds to comprehend it
2. to enlist student participation
3. to expose students' thinking *at* the moment
4. to contain student behaviour
5. to do all of this in a way that is consistent with teachers' professional commitments in constructing a conducive teaching and learning environment.

An extensive review of the PD research literature (Kennedy, 2016b[28]) documents how PD programmes in the United States differ in the extent to which they address the five goals of teaching. The review also demonstrated how they varied in degree of autonomy and independent professional judgement they offer to teachers ranging from OTL *prescriptions* (programmes explicitly describe or demonstrate what they believe is the best way for teachers to address a particular teaching problem), *strategies* (prescriptions but accompanied with rationales leading to understanding), *insights* (programmes that push teachers to reflect on practice, to change the way they interpret classroom situations and to make their own decisions about how to respond) and *coherent bodies of knowledge*, that is programmes that provide teachers with concepts and principles, giving teachers 'maximum discretion regarding whether or how teachers [use] that knowledge' (p. 956[28]). Inquiry-based teaching would seem to require the latter and this knowledge is typically acquired in the university. When referring to PD, however, Kennedy notes that early career and experienced teachers are more likely to benefit from strategies and insights as they have presumably absorbed bodies of knowledge in their pre-service preparation.

Another effective approach to PD relies on the development of professional learning communities in schools. An example is the so-called 'Quality Teaching Rounds' as implemented in parts of Australia (Gore et al., 2017[14]) (see Box 6.3 for a short description).

Box 6.3. Quality Teaching Rounds centred on three dimensions of pedagogy to achieve instructional goals

The Quality Teaching Rounds use a lesson study approach (Lewis, Perry and Murata, 2006[29]) backed up by standards of teaching quality specifically those issued by New South Wales. This PD approach 'involves four or more teachers within a school working in professional learning communities'. A round is composed of three sequential sessions that occur in a single day (pp. 99-101[14]):

- *Reading discussion*: Designed to support the group in developing a shared theoretical basis for professional conversations and build a sense of professional community (lasting typically 1 hour).
- *Observation*: One member of the professional learning community teaches a lesson that is observed by all other members of the community (a full lesson length, typically 30-80 min).
- *Coding and discussion*: Individual coding of the observed lesson, including coding by the observed teacher, is followed by discussion whereby all community members contribute (lasting typically one to 2 hours). Coding and discussion are centred on constructs of the Quality Teaching Framework (NSW Department of Education and Training, 2003[30]).

According to the authors, the Quality Teaching Framework focuses teachers' attention on three dimensions of pedagogy centred on instructional goals for students:

1. pedagogy that promotes high levels of intellectual quality (deep knowledge and understanding, problematic knowledge, higher-order thinking, metalanguage, substantive communication)
2. pedagogy that establishes a high-quality learning environment (explicit quality criteria, engagement, high expectations, social support, students' self-regulation, student direction)
3. pedagogy that generates significance by connecting students with the intellectual demands of their work (background knowledge, cultural knowledge, knowledge integration, inclusivity, connectedness and narrative).

Source: (Gore et al., 2017[14])

The Quality Teaching Rounds is an approach to teacher professional development designed to enable conversations around teaching practice that, in the words of Kennedy, may generate strategies and even insights that lead to improvement (2016b[28]). The substance of the discussion evolves around pedagogical practice (using the Quality Teaching Framework), the processes that lead to fruitful discussions (by building a safe space for critical analysis of teaching practice) and continuing improvement of practice (Gore et al., 2017[14]).

Empirical profiling of teachers' opportunities to learn about general pedagogy

Example items for profiling opportunities to learn in initial teacher education

This section contains a description of the TEDS-M OTL indicators (scales) and the items that formed these indicators, as well as the question, prompts[1] (Tatto, 2013[15]). These together successfully provide a profile of ITE and the practicum along the lines suggested in the previous section.

Typically, courses in teacher education programmes in universities offer future teachers OTL on the so-called *foundations*. In TEDS-M, two scales served to measure the extent to which programmes cover such topics. The question prompt read: 'Consider the following topics in education and pedagogy. Please indicate whether you have studied each topic as part of your current teacher preparation program'. The following scales were administered using a binary response format ('studied'/'non-studied'):

a) The *social science* scale included items measuring topics such as 'history of education and educational systems, philosophy of education and sociology of education'.

b) The *applied theory* scale included items measuring 'educational psychology, methods of educational research, assessment and measurement, and knowledge of teaching'.

Another area of interest had to do with the development of *lesson plans, instruction and use of assessments*. These are considered essential GPK skills and are also areas in which future teachers and early career teachers struggle (Abrams, Varier and Jackson, 2016[31]; Datnow and Hubbard, 2016[32]). In TEDS-M, several scales served to measure the extent to which programmes provide OTL in such topics. Future teachers were asked to answer the following prompt: 'In your current teacher preparation program, how frequently did you engage in activities that gave you the opportunity to learn how to do the following?' Responses to the following scales were provided on 4-point Likert scales ranging from ''never'' to ''often'':

c) *Instructional planning*, which included items such as 'accommodate a wide range of abilities in each lesson, create learning experiences that make the central concepts of subject matter meaningful to pupils and create projects that motivate all pupils to participate'.

d) *Instructional practice,* composed of such items as 'learn how to explore multiple solutions and strategies with pupils, learn how to show why rules and procedures work and make distinctions between procedural and conceptual knowledge when teaching concepts to pupils'.

e) *Assessment uses*, which included items such as 'give useful and timely feedback to pupils about their learning, help pupils learn how to assess their own learning and use assessment to give effective feedback to parents or guardians'.

f) *Assessment practice* used items such as 'analyse pupil assessment data to learn how to assess more effectively, assess higher-level goals (e.g. problem-solving, critical thinking) and build on pupils' existing knowledge and thinking skills'.

A key emphasis on teacher education has to do with how well programmes prepare teachers to attend to the learning and emotional needs of *diverse students*. One additional scale was created to measure these aspects:

g) *Teaching for diversity*, which included items such as 'develop specific strategies and curriculum for teaching pupils with learning disabilities, develop specific strategies and curriculum for teaching gifted pupils and develop specific strategies and curriculum for teaching pupils from diverse cultural backgrounds'.

Additionally, it would be important for TALIS to go beyond OTL GPK and to inquire whether teachers from different subjects were given the OTL the 'signature pedagogy on their subject' (see Box 6.4 for respective items for future maths teachers used in TEDS-M).

Box 6.4. Measuring teachers' opportunities to learn the signature pedagogy of their subject

In TEDS-M three scales were developed asking teachers to indicate how frequently they did any of the following in the subject and subject pedagogy methods courses (here mathematics) that they had taken or were currently taking in their teacher preparation program:

h) The *class participation* scale included items such as 'ask questions during class time, participate in a whole-class discussion and teach a class session using methods demonstrated by the instructor'.

i) The *class readings* scale was composed of items such as 'read about research on the subject (in this case mathematics), read about research on teaching and learning mathematics or analyse examples of teaching mathematics (e.g. film, video or transcript of the lesson)'.

j) The *solving problems* scale used items such as 'solve problems in applied mathematics, solve a given mathematics problem using multiple strategies and use computers or calculators to solve mathematics problems'.

While the last two items ('i' and 'j') concern mathematics, the message here is in the identification of a 'signature pedagogy' for the subject in question. In mathematics, the signature pedagogy is the conceptual understanding, mathematical reasoning, solution, and proof of mathematical problems. In science, the signature pedagogy could be using experiments to test hypothesis and build theory. Items can be created similarly for the other subjects taught by teachers participating in TALIS.

Example items for profiling opportunities to learn in the practicum

The quality of the practicum is an essential component of learning to teach. Its success depends on the degree to which future teachers have the opportunity to make (or find) connections between what they have learned in their courses and the practical tasks of teaching (e.g. to facilitate practical theorising). An important factor is the close collaboration of the supervising teacher or mentor with the university instructors, and the quality of the feedback the supervising teacher or mentor provides to future teachers. Three scales measured these important aspects of practice-based learning of future teachers (Tatto, 2013[15]):

a) *Connecting classroom learning to practice* asked future teachers 'During the school experience part of your program, how often were you required to do each of the following? Answers were provided on 4-point Likert scales (ranging from ''never'' to ''often''). Future teachers rated, for instance, how often they were 'asked to demonstrate that they could apply the teaching methods they were learning in their courses', and 'how often they had the opportunity to test out findings from educational research about difficulties pupils have in learning in their courses'.

b) Two scales asked specifically about experiences with their supervising or mentor teacher: 'To what extent do you agree or disagree with the following statements about the teaching practicum you had in your teacher preparation program?' Respondents provided answers on 4-point Likert scales (ranging from 'disagree' to 'agree') to the following scales and items:

   1. *Supervising teacher reinforcement of university goals for the practicum* asked, for instance, whether future teachers had a 'clear understanding of what their school-based supervising teachers or mentors expected of them as a teacher to pass the practicum,' whether they 'learned the same criteria or standards for good teaching in their courses and their practicum,' and whether their 'school-based supervising teachers or mentors used criteria or standards provided by their university or college when reviewing their lessons with them'.
   2. *Supervising teacher feedback quality* asked, for example, whether the 'feedback future teachers received from their supervising teacher or mentor helped them to improve their understanding of pupils', their 'teaching methods' and their 'understanding of the curriculum'.

These examples of OTL ITE scales have gone through much revision and scrutiny to develop a high quality instrument within a defensible theoretical framework to profile ITE course and practicum experiences across a diverse set of countries in the TEDS-M study. They could be used as a starting point for refining existing indicators on mentoring, teacher feedback and development and practical (field) experiences for the next TALIS cycle (Ainley and Carstens, 2018[17]).

Example items for profiling opportunities to learn in teacher induction

Several of the scales described in the previous sections, and particularly the teaching practicum items, can also be asked of the induction period. OTL in induction, however, needs to be tailored to each individual's experience and carefully illustrated in the recent observational study comparing the experiences of interns and early career teachers in England and the United States (Tatto et al., 2018[7]). As this in-depth study revealed, unique opportunities for early development are present when enacting practise emerging from contradictions between what teachers expect to happen as a result of planning and what occurs in the classroom, or as school norms begin to challenge teachers' autonomy to address the needs of their students.

Opportunities for change and to improve practice occur if these contradictions are met by effective mediational tools offered by the ITE institution or the school. These may include theoretical frameworks, short or long terms planning formats or the specific feedback or advice of a university-based or school-based instructor or mentor. Key in this dynamic, are the *individual's mediational tools* such as prior experience, knowledge and sense-making of the subject and processes of reflection underlying a sense of agency to inform future practice. Learning to teach across ITE, the induction period and PD is highly dependent on the individuals' disposition to recognise the opportunities for development and the opportunities for change that are both provided to them or that occur as a result of everyday practice.

While the LTTE-US study (Tatto et al., 2018[7]) did not develop scales it is possible to imagine the construction of items that could lead to scales to measure what are the most conducive opportunities for development for early career teachers, and what mediational tools at the institutional and individual levels are more supportive in producing a change in teaching practices. Equally important is to measure the individuals' disposition to recognise these opportunities for development and change and thus, teachers' beliefs play a key role across the continuum of teacher learning and especially in the crucial induction period because as it is known, many early career teachers leave the profession within the first five years. The emergence of contradictions can in part be explained by the lack of alignment between the individual intentions and beliefs and the higher education institution (HEI) and school culture and norms (Tatto et al., 2018, pp. 49-50[7]).

The TEDS-M study did develop a scale to measure such a sense of alignment (Tatto, 2013[15]). Teachers were asked to 'consider all of the courses in the programme including subject matter courses, subject pedagogy courses as well as general education and pedagogy courses. They were then asked to indicate the extent to which they agree or disagree with a series of statements on 4-point Likert scales.

The *programme coherence* scale included statements such as:

- Each stage of the programme seemed to be planned to meet the main needs teachers had at that stage of their preparation.
- Later courses in the programme built on what was taught in earlier courses in the program.
- The programme was organised in a way that covered what they needed to learn to become an effective teacher.
- The courses seemed to follow a logical sequence of development in terms of content and topics, each of their courses was designed to prepare them to meet a common set of explicit standard expectations for beginning teachers.
- There were clear links between most of the courses in the teacher education programme and school practices.

The FIRSTMATH study complements the induction profile that TEDS-M began to explore. FIRSTMATH inquired about OTL and beliefs in teachers' early career period.

Learning how to reflect on practise and using these reflections to improve it are essential skills needed for successful teaching, as revealed in the LTTE-US study. Two FIRSTMATH scales measured whether early career teachers had OTL this ability. The prompt asked teachers 'Please indicate whether you have ever had the opportunity to learn how to do each activity and whether you currently have the opportunity to do each activity in your classroom?' (Tatto et al., 2020[16]). The scales used binary response formats ('learned' vs. 'not learned' and 'yes I do this' vs. 'No, I do not do this'). The following two scales were administered:

a) The *teaching for reflection on practice* scale includes items asking whether future teachers had the 'OTL to use teaching standards and codes of conduct to reflect on their teaching', 'develop strategies to reflect upon the effectiveness of their teaching' and 'develop strategies to reflect upon their professional knowledge'.

b) The *improving practice* scale is composed of items such as 'develop and test new teaching practices', 'learn how to use findings from research to improve knowledge and practice' and 'identify opportunities for changing existing schooling practices'.

- An additional scale asked early carer teachers about their access to mediational tools and resources, a key element to successful development found in the LTTE-US study (Tatto et al., 2018[7]):

c) The *mediational tools/resources* scale asked teachers to indicate how important if at all, is each resource in their learning to teach. Items were, for instance, 'resources from their teacher preparation program', their 'professor(s) in their teacher preparation programme' and their 'mentor teacher in their current school' as well as their 'own resources'.

These OTL scales, measuring the different and complex dimensions of OTL in the induction period, have gone through a thorough validation and revision process in both the TEDS-M and FIRSTMATH studies, leading to the development of a high quality instrument to profile OTL in the induction period in teachers' early years on the job. These example items present valuable options for expanding on teachers' OTL in induction in future cycles of TALIS.

Example items for profiling opportunities to learn in professional development

While practically many of the scales listed for profiling OTL in initial teacher education and induction can be used to measure OTL in PD, there are unique characteristics of PD that would require specialised questions. Two examples are taken from the FIRSTMATH study (Tatto et al., 2020[16]):

1. The *OTL professional development* scale asked teachers to indicate how much emphasis if any, their professional development activities placed on each topic during the last 12 months. Items that teachers rated (ranging from none to great on a 4-point Likert scale) were, for example, 'improving students' critical thinking or problem-solving skills', 'teaching children from disadvantaged backgrounds' or 'gifted children', 'classroom management' and 'how to communicate and work with parents'.
2. *School context conducive to PD* scale measured how often, if ever, teachers had different types of interaction with other teachers. Teachers rated how often the following types of interactions happened (ranging from daily to never on a 4-point Likert scale): 'discussions about planning for lessons or teaching a particular concept', 'working on preparing instructional material' or 'visits to other teachers' classroom to observe their teaching'.

The Kennedy (2016b[28]) and Gore (2017[14]) studies, as well as FIRSTMATH (Tatto et al., 2020[16]), provide valuable insights for measuring different dimensions of OTL in PD. TALIS 2018 attempts to cover these aspects by asking teachers if a list of 'core practices' was covered in their PD or whether they received evaluative feedback from administrators or evaluators. Instead, it would be important to measure whether PD is more conducive to helping teachers learn strategies and develop insights and gain increased knowledge. It is vital to understand how to develop the capacity among teachers and schools to create safe spaces where teachers can learn to examine and be critical about their practice in a way that is conducive to professional learning and the development of learning communities.

Conclusion

Overall, the TALIS 2018 teacher questionnaire asked useful questions and provided valuable information for participating countries on how to improve the preparation and professional development of teachers. The 2018 TALIS questionnaire had a heavy emphasis on professional development thus a more uniform balance across the four areas of ITE, practicum, induction and PD would be recommendable for future cycles.

Further items sensitive enough to measure the diverse profiles of OTL in ITE, practicum, induction, and PD across countries would help guide policies directed at improving teacher education and learning. This is important because it is doubtful that PD alone can help teachers learn in a short period what teachers did not learn during ITE or in 'fast-track' programmes. TEDS-M and FIRSTMATH and the insights from the several studies included in this chapter could be used as a starting point for expanding TALIS to further the scientific and policy-relevant knowledge about teachers across countries. Table 6.2 below provides other ideas on how to expand and refine the TALIS 2018 questionnaire for the TKS assessment module to allow for more nuanced profiling of teachers' OTL as they progress on their professional careers (see Table 8.1 in Chapter 8 for the main takeaways from this chapter for TALIS and the TKS assessment module).

Table 6.2. Suggestions for expanding and refining the TALIS 2018 questionnaire on teachers' Opportunities To Learn (OTL) in their professional career for future cycles

TALIS 2018 Teacher questionnaire (TQ)	Comment	Recommendations
Initial Teacher Education (ITE) OTL		
TQ-06. Were the following elements included in your formal education or training and to what extent did you feel prepared for each element in your teaching? *Items: 'General pedagogy' and other elements*.	Several of the items are formulated in a rather broad and vague style, including the ones of most interest for the TKS assessment module: 'general pedagogy,' 'classroom practice,' 'monitoring students' development and learning,' and 'facilitating transitions'.	To have a more nuanced profiling of ITE OTL for the TKS assessment module the items need to include a more detailed description of what is understood by each term. Additionally, elements of a syllabus analysis similar to the one done in TEDS-M could guide the development of additional items for the module. Special attention should be given to the importance for these OTL to be authentically grounded in ITE practices.
TQ-15. Were the following subject categories included in your formal education or training, and do you teach them during the current school year to any ISCED-2 Level or 15-year-old students in this school? *Items: 'Mathematics' and other subjects*.	The question allows a report of whether teachers have had the OTL the content of the subjects, while it does not provide information if the methods of instruction in each subject area (pedagogical content knowledge) were covered.	The response option 'Included in my formal education or training' could be modified to ask if teachers had the OTL subject-specific-teaching methods as well: 'Content included in my formal education or training' and 'Methods included in my formal education or training'.
Induction OTL		
TQ-20. When you began work at this school, were the following provisions part of your induction? *Items: 'Online courses/seminars' and other provisions.*	Key aspects are missing which are very relevant, especially during teachers' early career. Items for the question could be added to provide further information on mentoring, feedback and observation and collaboration to what was already covered in TALIS.	The following two items could be added: 'Mentoring from an experienced teacher' and 'Peer observation, discussion and feedback'. Further items can be derived from the FIRSTMATH items described above.
TQ-21. Are you currently involved in any mentoring activities as part of a formal arrangement at this school? *Items: 'I currently have an assigned mentor to support me.' and 'I am currently an assigned mentor for one or more teachers*.'	Though having an assigned mentor, teachers are not always interacting with them. This may be one of the reasons why teachers quit teaching in the first five years of teaching. Moreover, it is commonly assumed that teachers already know how to mentor but research shows that mentoring is a learned skill. It would, thus, be important to know whether teachers have received courses on mentoring.	The following items could be added: 'I have daily discussions about my teaching with my school mentor', and 'I have had OTL how to mentor early career teachers or teachers new to the school.' Additionally, a question should be added that asks teachers to quantify and qualify the mentoring received and provided. These and further items on teacher induction can be developed drawing on experiences from the FIRSTMATH and LTTE-US studies described above.
Professional Development (PD) OTL		
TQ-23. Were any of the topics listed below included in your professional development activities during the last 12 months? *Items: 'Student assessment practices' and other topics.* **TQ-27.** For each of the areas listed below, please indicate the extent to which you currently need professional development. *Items: 'Student assessment practices' and other areas.*	It would be possible to ask teachers both questions in one question to reduce the survey burden. The topics and areas listed for both questions could also be more aligned.	Merge both questions and response options in the following way: 'In your professional development activities did you have the opportunity to learn the following topics during the last 12 months and indicate the extent to which you currently need professional development. Two binary response options (Yes/No) could be provided to answer the two elements of the question separately: 'I had the opportunity to learn this topic' and 'I currently need professional development in the area'.

TALIS 2018 Teacher questionnaire (TQ)	Comment	Recommendations
TQ-26. Thinking of the professional development activity that had the greatest positive impact on your teaching during the last 12 months, did it have any of the following characteristics? *Items: 'It built on my prior knowledge' and other characteristics.*	The question could be refined to capture the level of autonomy and professional judgement that the PD activities allowed teachers.	Revise this question to capture the PD characteristics outlined by Kennedy (2016b[28]): prescription, strategies, insight, bodies of knowledge. Further valuable item suggestions can be derived from the FIRSTMATH study described above.
TQ-28. How strongly do you agree or disagree that the following present barriers to your participation in professional development? *Items: 'Professional development is too expensive' and other potential barriers*.	The question does not consider that a lack of benefits derived from PD participation may cause teachers to disengage.	The following items could be added to capture a lack of benefits derived from PD participation: 'Low learning gains for time invested' and 'Professional development does not help build a professional learning community in the school'. .
TQ-29. In this school, who uses the following types of information to provide feedback to you? *Items: 'Observation of my classroom teaching' and other types of information*.	This question asks whom gives feedback on specific activities. Thus, the question allows information on the type of feedback but not on its content.	Questions could be added to ask if teachers received feedback on planning, instruction, assessment and teaching for diversity. These are areas where teachers most struggle. For instance the following item relating to diversity could be added: 'Feedback on the latest strategies to address the learning needs of students with special needs and from multicultural backgrounds.' Further ideas can be derived from the FIRSTMATH study described above.
TQ-31. Thinking about the feedback you have received during the last 12 months, did it lead to a positive change in any of the following aspects of your teaching? *Items: 'Classroom management' and other aspects of teaching*.	The questions could be framed more specifically and expanded to include items that ask about planning or the curriculum (since PD is the main tool used by governments to implement curricular reforms).	The question could be changed from 'positive change' to 'an improvement in teaching practice and pupil learning.' The following items could be added: 'Planning for critical thinking and conceptual understanding' and 'A deeper knowledge of the curriculum'.
TQ-33. On average, how often do you do the following in this school? *Items: 'Teach jointly as a team in the same class' and other collaborative activities*.	This is a good proxy for conducive collaborative and dynamic OTL for teachers in schools, which could be expanded further. The frequency of occurrence can indicate the level of schools' professional learning communities and the formation/support for the notion of distributed leadership. Important aspects are missing such as curriculum.	The following two items could be added: 'Read each other's lesson plans and provide suggestions for improvement' and 'Work with other teachers to understand and implement curricular changes'. Further ideas can be derived from the FIRSTMATH study described above.
General Comment		
TQ-06, TQ-15 and **TQ-23**. General comment	The questions ask teachers if a list of topics 'were included in their formal education.' Inclusion, however, does not mean that teachers learned or engaged at all or in a meaningful way with these elements.	These questions should be rephrased as: 'In your <formal education or training>, <professional development activities> did you have the opportunity to learn the following topics…'

Further recommendations for research on teachers' professional learning

Arriving at common definitions and measures of opportunities to learn

The conceptualisation of GPK needs to be aligned with the conceptualisation of OTL GPK. Excellent teachers need a substantial dose of academic studies (academic studies in disciplines such as psychology and sociology), as well as on the subjects they will teach (such as literature, mathematics, science and others aligned with the school curriculum). Additionally, they need foundational studies as applied to teaching (e.g. philosophy of education and ethics) and they need to learn theory as it applies to practice. The TEDS-M syllabus analysis helps to understand the configuration of OTL across 17 countries (Tatto, 2013[15]). More work is needed to figure out how different OTL contribute to different aspects of teaching. It is also important to distinguish between the knowledge needs of future, early career and more

established teachers. Future teachers may benefit from OTL that emerge from 'bodies of knowledge', strategies and insights, while early career teachers and more established teachers may benefit from OTL that offer them strategies and insights and even from prescriptions as well as learning from a professional community of practice (further explained in Box 6.3).

Longitudinal research that links teacher education, teacher knowledge and skills, teaching and learning

After defining the contours of the OTL domains to be conceptually linked to the different stages in the developmental process of becoming a teacher, a programme of longitudinal research is needed. Rigorous longitudinal research must seek to link evidence from the GPK assessment measuring teachers' knowledge at different stages of their careers, and these with GPK OTL. A longitudinal programme of research will allow the field to build a better research evidence base for the profession.

Addressing teaching and learning to teach holistically

An important concern for teachers is how to portray and enact the curriculum to students. Planning, instruction and evaluation occur around the particular school subjects' pupils need to learn (Tatto et al., 2018[7]). TEDS-M demonstrated that the most knowledgeable future math teachers were from programmes that provided balanced OTL content knowledge, pedagogical content knowledge and GPK together.

The current pandemic is placing increasing pressure on ITE programmes and PD to emphasise GPK in such aspects as socio-emotional learning and the use of online technologies, among others. This should not be done at the expense of preparing highly knowledgeable teachers in their subjects, able to help all students make sense of the curriculum, and able to structure successful and conducive learning environments. The measurement of GPK should be complemented in the future by a measure that integrates the OTL content and pedagogy as expressed in the concept of *pedagogical content knowledge*. This would allow, for instance, to better understand how teachers' planning is linked to the essential content and content pedagogy that teachers must possess to teach effectively.

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Note

[1] Results from the confirmatory factor analysis are available in the TEDS-M Technical Report (Tatto, 2013[15]).

7 Increasing test efficiency in an international assessment of teachers' general pedagogical knowledge through multidimensional adaptive testing

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This chapter discusses the potential of multidimensional adaptive testing (MAT) for increasing the measurement efficiency of large-scale assessments. It outlines the building blocks of MAT and describes the configuration of a MAT design for the Teacher Knowledge Survey assessment module, including recommendations for its pilot study, field trial, and main study. A Monte Carlo simulation study is used to illustrate the potential of such a design for the module. The chapter concludes with six concrete recommendations for using MAT to transform the module's knowledge assessment into a very modern, innovative and, at the same time, highly efficient measurement instrument.

Introduction and problem definition

The Teacher Knowledge Survey (TKS) was originally developed by the Centre for Educational Research and Innovation (CERI) in 2015 as a stand-alone survey. As detailed in Chapter 1, the revised assessment framework aims to assess general pedagogical knowledge on three key dimensions and six sub-dimensions:

1. **Instruction**: teaching methods and lesson planning, and classroom management
2. **Learning**: motivational-affective dispositions, and learning and development
3. **Assessment:** evaluation and diagnostic procedures, and data use and research literacy.

More than 200 items were developed to assess this multidimensional structure. Fifty-two of these items were used in the TKS pilot study, which was conducted from April to June 2016 in five countries (Sonmark et al., 2017[1]). These 52 items are dichotomously scored simple multiple choice (MC), i.e. a question with four response options – one correct and three incorrect, and complex multiple choice items (CMC), i.e. a question with four or more response options, each response option has to be answered with "right" or "wrong", "suitable" or "unsuitable". Thirty-three of the items were considered to have appropriate psychometric quality for future use, with each sub-dimension covered by at least three items.

The responses gathered were scaled using item response theory (IRT) (van der Linden, 2016[2]), e.g. with the unidimensional one-parameter logistic model (1PL). The 1PL IRT model describes test items in terms of only one-parameter, item difficulty, b, and provides an estimate of the latent ability level θ needed for solving the item. Each of the three dimensions was scaled separately. Reliability analyses of the complete pooled sample of lower secondary teachers (N = 943) resulted in values for Cronbach's Alpha of 0.55 (instruction), 0.63 (learning), and 0.52 (assessment). These values for the internal consistency of the scales are below the precision thresholds typically deemed appropriate for test score reporting.

Sonmark and colleagues (2017[1]) discussed that the precision of the test results could be increased by using the two-parameter logistic model (2PL), instead of the 1PL. The 2PL describes the probability that an individual with latent ability level θ endorses an item with two item characteristic parameters: item difficulty, b, and item discrimination a (how well an item is able to discriminate between persons differing in ability levels). The authors also noted that it would be useful to obtain more information on the sources of missing data, for example, by tracking the time spent on viewing pages and giving responses. Missing data is problematic, as it reduces statistical power, can reduce the representativeness of the samples, and can cause bias in the estimation of parameters. Improper handling of missing values may lead to inaccurate inference about the data. Finding out the sources of missing data and using appropriate missing data estimation methods is, therefore, of great importance to safeguard the validity of test score interpretations. Another refinement is the revision and extension of the existing item pool, for example, to include polytomous scored items and more situation-based items, in order to assess the more practical aspects of teacher knowledge (see Chapters 1 and 4).

Building on CERI's TKS, the TKS assessment module will form an optional module for the next cycle of the Teaching and Learning International Survey (TALIS) in 2024. The goals for the TKS assessment module are high: While reducing the testing time from 60 (pilot study) to 30 minutes, the reliability, which did not meet common reporting standards in the CERI TKS pilot study, has to be increased substantially. In fact, the proportion of systematic variance in the test scores needs to be roughly doubled. The Cronbach's Alphas, which ranged from 0.52 (systematic variance = $0.52^2 = 0.27$) to 0.63 (systematic variance = $0.63^2 = 0.40$), should be increased to a value of at least 0.75 (systematic variance = $0.75^2 = 0.56$). When such a portion of systematic variance (due to the responses to the cognitive items) is combined with responses to background questionnaire items (and other background variables) in a latent regression approach, a precision adequate for result reporting will be achieved. In order to achieve or

approach these ambitious goals, the possibilities of psychometrics and test administration using digital technology (offline and online) must be used in the best possible way; more specifically, by:

1. Using an IRT model that provides higher statistical information (allowing for a more precise measurement of teacher knowledge) while allowing for stable parameter estimates (e.g. 2PL instead of 1PL).
2. Making use of the correlation between the TKS dimensions to increase measurement precision by adopting a multidimensional IRT framework (e.g. multidimensional 2PL [M2PL]).
3. Presenting items with optimised information for each tested teacher by using multidimensional computerised adaptive testing.
4. Making the best out of the available testing time by selecting items that provide maximum statistical information per time unit.
5. Reducing the proportion of time needed to read and process item stimuli to the complete testing time by incorporating units with within-item adaptivity.

While the first two points can be achieved with the current design of the TKS assessment module, the last three points require a multidimensional adaptive testing (MAT) design. The first section of this chapter introduces briefly multidimensional IRT models and describes the key elements of multidimensional adaptive testing (MAT). It explains how MAT can help to cover a broad range of topics within a limited testing time and discusses further advantages and disadvantages of the approach. This section also outlines the six building blocks of adaptive testing that need to be accounted for when planning a MAT design. The next section discusses recommendable usages of MAT for the TKS assessment module. Suggestions are then substantiated with a Monte Carlo simulation study, which was conducted for this expert chapter. After that, the requirements for implementing such a design in terms of software and analytical skills are outlined. The chapter closes by summarising the main conclusions for the TKS assessment module.

What is multidimensional adaptive testing?

How can MAT help to cover a broad range of topics within a limited testing time?

Computerised adaptive testing (CAT) is a special approach to the assessment of latent traits (e.g. teacher knowledge), in which the selection of the test items that are presented next to the test taker is based on the test taker's responses to previously administered items (Frey, 2020[3]). The aim of this selection procedure is to tailor the item presentation to the trait level of the test taker (e.g. teachers' level of general pedagogical knowledge) in order to administer only those items that provide as much diagnostic information as possible about the individual characteristics to be measured.

The main advantage of CAT compared to non-adaptive testing, in a statistical sense, is the possibility of a considerable increase in measurement efficiency (Segall, 2005[4]). This efficiency gain can be used to increase measurement precision if the number of items is held constant for all test takers or it can be used to reduce the test length. Compared to traditional non-adaptive tests, the number of items can typically be reduced by approximately half when CAT is used while comparable measurement precision can be achieved [e.g. Segall (2005[4])]. In addition, CAT provides the possibility to overcome the problem that conventional tests typically measure test takers with average performance much more precisely than low- and high-performers. This is achieved by aligning the standard errors of the ability estimates across the ability range [e.g. Frey and Ehmke (2007[5])].

Adaptive tests can also be used to make the test-taking experience of the participants more positive. For the Programme for International Student Assessment (PISA), for example, a study showed that

low-performing students were confronted with a test situation in which they could not solve many of the presented items. This was accompanied by significantly lower levels of test-taking motivation, combined with significantly higher levels of boredom/daydreaming compared to average- and high-performing students (confronted with items with a more appropriate difficulty level). By adaptively adjusting the difficulty level of the items that are presented to the individual test takers, these systematic effects can be avoided (Asseburg and Frey, 2013[6]).

Although unidimensional CAT has proven to be advantageous in many simulation studies and empirical applications, the performance-related constructs (literacies, competencies, abilities, knowledge etc.) conceptualised in international large-scale assessments (ILSAs) are usually quite complex and can seldom be described by a single latent trait. Typically, the theoretical frameworks underlying these constructs include several interrelated components. To reflect this theoretical complexity directly in the measurement procedure, MAT [e.g. Frey and Seitz (2009[7])] can be used. In contrast to unidimensional CAT, with MAT, multiple dimensions can be measured simultaneously and, therefore, a much better fit between the theoretical underpinnings of complex constructs and test content can be achieved within a reasonable testing time. As measurement models, multidimensional item-response-theory (MIRT) [e.g. Reckase (2016[8]); see Box 7.1] models are used in MAT. These models make it possible to include assumptions about the theoretical structure of the construct of interest in the test instrument. Consequently, the resulting test scores can be interpreted clearly with regard to the theoretical framework and differentiated information on multiple dimensions can be reported.

Box 7.1. Multidimensional item-response-theory models

A general MIRT model is the multidimensional three-parameter logistic (M3PL) model, which specifies the probability that an examinee *j* = 1, …, *N* will answer an item *i* correctly $(U_{ij} = 1)$ as a function of the ability vector $\boldsymbol{\theta}_j = (\theta_1, \theta_2, \ldots, \theta_p)$ for *p* measured dimensions and for item parameters $\mathbf{a}_i'$, b_i, and c_i:

$$P\left(U_{ij} = 1 | \boldsymbol{\theta}_j, \mathbf{a}_i', b_i, c_i\right) = c_i + (1 - c_i)\frac{\exp\left(\mathbf{a}_i'(\boldsymbol{\theta}_j - b_i\mathbf{1})\right)}{1+\exp\left(\mathbf{a}_i'(\boldsymbol{\theta}_j - b_i\mathbf{1})\right)}. \quad (1)$$

The loading of item *i* on the different dimensions is represented by the 1 x *p* item discrimination vector $\mathbf{a}_i'$. Depending on whether the items reflect one (between-item multidimensionality) or multiple (within-item multidimensionality) dimensions, one or multiple elements of $\mathbf{a}_i'$ are different from zero. The difficulty of item i is given by the parameter b_i. The pseudo-guessing parameter c_i can be regarded as a lower asymptote that is introduced to model item-specific random guessing.

The multidimensional two-parameter logistic (M2PL) model and the one-parameter logistic (M1PL) model can be derived from the M3PL model shown in Equation 1. The M2PL model is derived from the assumption that, for all test items, c_i is equal to zero. In addition to this, the M1PL model is derived by constraining one or more elements (reflecting between- or within-item multidimensionality) of the vector $\mathbf{a}_i'$ to a non-zero constant and the remaining elements to zero for each item. Besides these standard MIRT models, more complex multidimensional models such as the non-compensatory MIRT model (Hsu and Wang, 2019[9]), the higher-order model (Wang and Kingston, 2019[10]), the multidimensional testlet model (Frey, Seitz and Brandt, 2016[11]), and the scaling individuals and classifying misconceptions model (Bao et al., 2021[12]) can be used for MAT.

The high measurement efficiency of MAT results on the one hand from the same advantages as those of unidimensional CAT mentioned above. On the other hand, additional efficiency gains are achieved by drawing on prior information about the multidimensional distribution of the measured dimensions. This results in an improvement in measurement efficiency, compared to that achieved by using separate unidimensional adaptive tests for each latent dimension [e.g. (Li and Schafer, 2005[13]; Paap, Born and

Braeken, 2019[14]; Segall, 1996[15])]. The measurement efficiency is especially high if latent dimensions are highly correlated [e.g. (Frey, Bernhardt and Born, 2017[16]; Makransky and Glas, 2013[17]; Segall, 1996[15]; Wang and Chen, 2004[18])].

In MAT, both maximum likelihood and Bayesian procedures can be used for the item selection. From these item selection procedures, the Bayesian approach introduced by Segall (1996[15]) has received the most attention in the literature so far. It has also proven to be one of the best performing and very robust methods in terms of accuracy and precision of ability estimates, compared to other item selection methods used across a broad range of MAT configurations (Mulder and van der Linden, 2009[19]; Veldkamp and van der Linden, 2002[20]; Wang and Chang, 2011[21]; Wang, Chang and Boughton, 2011[22]). The Bayesian approach takes into account the fact that individual responses to items constructed to measure one dimension provide information not only about that particular dimension but also about correlated dimensions. In this approach, item selection is optimised by using the variance-covariance matrix $\boldsymbol{\Phi}$ of the measured latent traits as prior information about the interrelation of the construct's dimensions (e.g. stemming from a field trial). During the test, the candidate item is selected from the item pool that provides the highest increase in measurement precision regarding all dimensions of interest, based on the D-optimality criterion (see Box 7.2 for details).

Box 7.2. D-Optimality

During the test, the item i^* is selected from the item pool that maximises the determinant of the *p* x *p* matrix $\mathbf{W}_{t+i^*}$.

$$|\boldsymbol{W}_{t+i^*}| = \left|\boldsymbol{I}\left(\boldsymbol{\theta}, \widehat{\boldsymbol{\theta}}_j\right) + \boldsymbol{I}(\boldsymbol{\theta}, u_{i^*}) + \boldsymbol{\Phi}^{-1}\right|. \quad (2)$$

$\mathbf{W}_{t+i^*}$ is derived by summing up the information matrix of the previously t administered items $\mathbf{I}\left(\boldsymbol{\theta}, \widehat{\boldsymbol{\theta}}_j\right)$, the information matrix of a response u_{i^*} to the candidate item i^* $\mathbf{I}(\boldsymbol{\theta}, u_{i^*})$, and the inverse of the variance-covariance matrix of the prior distribution of the measured dimensions $\boldsymbol{\Phi}^{-1}$. To estimate $\widehat{\boldsymbol{\theta}}_j$ during the course of the test, Segall proposes using the multidimensional maximum a posteriori estimator in combination with the same prior information given by $\boldsymbol{\Phi}$. The candidate item that causes the greatest reduction in the volume of the credibility ellipsoid (multidimensional Bayesian equivalent of a confidence interval) of the current estimated latent ability vector $\widehat{\boldsymbol{\theta}}_j = (\widehat{\theta}_1, \widehat{\theta}_2, \ldots, \widehat{\theta}_p)$ of person *j* regarding the *p* latent dimensions is selected next for administration.

What factors need to be accounted for in planning a MAT design?

As for all adaptive tests, the six building blocks of CAT (Frey, forthcoming[23]) need to be specified: (1) item pool, (2) start of the test, (3) person parameter estimation, (4) item selection, (5) constraint management, and (6) end of the test. All these aspects should be specified based on data from the field trial and pre-operational simulation studies.

Develop a *calibrated multidimensional item pool*

The functionality and quality of a multidimensional adaptive test is highly dependent on the quality of the multidimensional item pool (Building block 1). A clear definition of the content areas to be examined in terms of an assessment framework is a prerequisite for successful item construction and test development. The item pool should be constructed and/or selected (e.g. from existing sets of items) in such a way that it enables an optimal coverage across assumed dimensions and sub-dimensions. In addition, the item pool should allow a broad range of trait levels (e.g. skills) to be targeted for each of the dimensions measured

by the test. An adaptive test can adapt optimally if, for every ability level that can occur in the course of the test, there are at least as many items as the test is long.

In order for MAT to work at its maximum performance, the adaptive algorithm needs to update the ability estimation after each item response. In this process, the responses are typically scored automatically. However, that does not mean that human-coded items (e.g. questions with an open response format) cannot be used in MAT. These items can be selected based on the provisional ability vector and the response given can be stored. This response does not provide any additional information for the selection of the next item but can be easily scored by a human coder after the test and used for the final analyses of the response data.

An important decision that needs to be made in the test development phase, and which should also inform item construction, is which MIRT model to use. As in the unidimensional, non-adaptive case, it is important to consider how many item parameters to include in the model (e.g. M1PL or M2PL) and how to treat the item responses (dichotomous/polytomous). As mentioned earlier, when taking multidimensionality into account, a decision has to be made about whether the model allows for between- or within-item multidimensionality.

A good fit with the assessment framework is not the only thing to consider when choosing a suitable MIRT model; it should also be kept in mind that the higher the complexity of the MIRT model, the higher the number of item parameters that need to be estimated and, therefore, the larger the sample size needed for a stable estimation of these parameters. This estimation, also referred to as calibration, is an essential step in MAT development because the resulting item parameter estimates are used as fixed parameters in the operational phase of the adaptive test. For the frequently used 2PL model, for example, a minimum of 500 responses per item is recommended (De Ayala, 2009[24]). As the M2PL can use the correlation between the modelled dimensions in the estimation, this minimum requirement should also be realistic for the M2PL, at least if the number of dimensions is not too high (concrete suggestions for the TKS assessment module are presented below).

Furthermore, an important aspect that has to be considered in planning a MAT design is item position effects (IPEs). IPEs are variations in item parameter estimates that are related to the position in which they are presented in a test. A typical pattern in conventional testing is that the difficulties of the same items tend to increase towards the end of the test.

IPEs can easily be estimated based on traditional ILSA data, which use a balanced booklet design in which the position of items in the booklets is systematically varied. A booklet is the test form which includes the set of items given to the test taker. A lot of empirical evidence underlines that IPEs must be expected in ILSAs, with a typical decreasing proportion of correct answers and, thus, an increase in item difficulties towards the end of a test [e.g. (Albano, 2013[25]; Debeer et al., 2014[26]; Nagy et al., 2019[27]; Wu et al., 2019[28])]. IPEs are even more problematic for adaptive testing than for sequential testing. This is because in adaptive testing, different persons respond to different items in different positions, while the same item parameters are used for all positions for item selection and ability estimation. Ignoring existing IPEs can result in systematic bias in ability estimation and can therefore jeopardise the interpretations of the test results; it is thus a threat to validity [see Frey and Fink (forthcoming[29]) for an in-depth discussion of this problem].

In general, there are two options for dealing with IPEs in adaptive testing: statistical design and statistical modelling. The prerequisite for both options is that all items are presented in all possible positions during the calibration of an adaptive test. It is desirable that items and positions are stochastically independent from each other. One way to realise this is a randomised item selection. However, the desired uniform distribution of the items across positions can only be achieved asymptotically with a very large number of test takers. A second option to achieve the stochastic independence of items and positions is to use a position-balanced booklet design [e.g. Frey, Hartig and Rupp (2009[30])]. Such a booklet design consists of several booklets, with each booklet containing a subset of the item pool. Across all booklets, each item

(or each group of items) is presented in each position with equal frequency. By scaling items based on the responses stemming from such a position-balanced booklet design, the resulting difficulties are composed of the individual item difficulty plus the average IPE across positions. During an adaptive test, this leads to biased ability estimates unless the test length of the operational adaptive test equals the test length of the calibration test.

On the basis of these considerations, Frey, Bernhardt and Born (2017[16]) showed how statistical modelling of IPEs could be used to control for unwanted IPEs. They introduced a multistep procedure, which allows the incorporation of parameterised IPEs into the adaptive test if there is empirical evidence for their existence. This flexibility, however, comes with higher sample size requirements for a stable estimation of the IPE parameters and is therefore not optimally suited to ILSAs. An approach that is easier to implement is that introduced by Frey and Fink (forthcoming[29]). Frey and Fink's approach is based on statistical design principles and showed very good performance, including controlling for IPEs, within a Monte Carlo simulation under typical ILSA settings.

Determine specifications for final computerised adaptive testing

Next to a calibrated item pool, the remaining building blocks of an adaptive test need to be specified before its operational use. These building blocks are the start of the test (i.e. which items to select at the beginning of the test), person parameter estimation, item selection, constraint management, and end of the test. This should not be done based on arbitrary decisions; instead, Monte Carlo simulation studies should be conducted. Monte Carlo simulations are essential to compare and evaluate different methods and specifications for the building blocks for a given assessment situation (e.g. available testing time, content to be covered, number of dimensions, etc.) given an already calibrated item pool. Especially different configurations of the item selection algorithm should be simulated at this point.

Besides reaching statistical optimality, the item selection has to take different non-statistical constraints into account. These are, for example, the proportion of items per sub-domain, as well as the item and stimulus type (e.g. picture, video, text), the grouping of several items to units (testlets) that should be kept intact, and much more. The currently most powerful constraint management method for MAT is the shadow-test approach [(Veldkamp and van der Linden, 2002[20]); see Box 7.3 for details]. It enables the simultaneous consideration of a high number of such constraints and provides very good results regarding constraint violations.

Box 7.3. Shadow testing approach

The shadow-test approach (van der Linden and Reese, 1998[31]; Veldkamp and van der Linden, 2002[20]) is based on the idea of selecting items from a hypothetical test (=shadow-test), which is compiled automatically before the selection of each item, instead of selecting from the complete item pool. The algorithm can be described as follows:

1. Initialise the ability estimation.
2. Assemble shadow-test that accounts for all constraints (e.g. test length, content coverage, proportion of items per item type, etc.), contains all already administered items, and is optimal at the current provisional ability estimate.
3. Administer an eligible item from the shadow test.
4. Update ability estimation.
5. Update constraints to consider the non-statistical attributes of the items already administered.

6. Return all unused items to the item pool.
7. Repeat Steps 1–6 until the termination criterion of the adaptive test is met.

As each shadow test at each step is assembled to meet all non-statistical constraints imposed, the resulting set of presented items also meets all constraints. In addition, the shadow-tests are assembled to be optimal regarding the provisional ability estimation at each step. The shadow-test has to be assembled in real time before the administration of each item. This process is handled by automated test assembling methods (van der Linden, 2005[32]) that use a mathematical programming technique called mixed-integer programming. A detailed description of the shadow-test procedure for MAT can be found in (Veldkamp and van der Linden, 2002[20]).

In addition, item exposure constraints should be implemented in the adaptive test. Adaptive item selection that is solely based on statistical optimality will lead to items with high item discrimination parameters being selected very often. Thereby, they have an increased probability to be communicated among potential test takers and to thus become known, which is typically not wanted for items in ILSAs. To avoid this, different exposure control methods integrate a type of randomisation into the item selection [e.g. Huebner et al., (2016[33]); see Box 7.4 for an example of an exposure control method]. In addition to the constraints mentioned above, constraints regarding item response times [e.g. utilising the simplified version of the maximum information per time unit by Cheng, Diao and Behrens, (2017[34])] can be included in the test in order to maximise diagnostic information within a fixed testing time.

Box 7.4. Exposure control with the Sympson-Hetter method

With the Sympson-Hetter method (Sympson and Hetter, 1985[35]), an item is administered to an individual test taker only if it passes a probability experiment. Otherwise, it is removed from the item pool. Therefore, the user specifies a target proportion per item as a parameter for the item selection algorithm. For example, if test developers do not want an item to be administered to more than 50% of the test takers, they specify a probability of 0.5 for each item in the item pool. Each time the algorithm selects an item from the item pool, a random number between 0 and 1 is generated and compared to the specified probability. If the number is between 0 and 0.5, the item is administered. If not, the item is removed from the remaining pool for this particular test taker.

As exposure rates differ substantially between items, there is no need to specify the same probability for each item. Items with a difficulty near 0 or with high discrimination parameters are likely to be presented very often and therefore might deserve a lower probability (e.g. 0.3) than items with extreme item difficulties that are administered only to the top 5% of the test takers. Such items should not be constrained (which equals setting the probability to 1). In order to determine item-specific exposure probabilities with the Sympson-Hetter method, simulation studies are typically carried out.

What could multidimensional adaptive testing designs for the Teacher Knowledge Survey assessment module look like?

Item development

Depending on the resources available for item construction and calibration, an item pool size of 5 to 10 times the test length per dimension is recommended. This means, for example, when administering 10 items per dimension, the complete item pool of well-functioning calibrated items should contain between 150 and 300 items. The more items, the better the test can adapt to the individual trait level. However, the

advantages in terms of the measurement precision that can be achieved by increasing the size of the item pool follow a saturation curve. This means that, at the beginning, increasing the item pool size has a large effect, but this effect becomes smaller the more items are added. Even with item pools that are two to three times as large as the test length, considerable gains in measurement precision can be achieved compared to non-adaptive sequential testing [e.g. Spoden, Frey and Bernhardt (2018[36])].

Two possibilities for the development of the item pool seem especially feasible for the TKS assessment module: (1) An item pool consisting of single items only and (2) an item pool consisting of single items plus sets of items connected to a shared innovative stimulus, for example video or text vignettes of typical classroom situations (see Chapter 4 for a discussion of assessments using vignettes), or interactive stimuli, with adaptive item selection within units. From a statistical point of view, a multidimensional adaptive test with single items (possibility 1) has optimal flexibility to adapt. However, given the relatively short testing time available for the TKS assessment module (30 minutes), the items need to have relatively short stimuli in order for the testing time to be used efficiently. This might be problematic because measuring some aspects of teacher knowledge [e.g. knowledge-based decision making in the classroom and teachers' classroom management expertise; (Stürmer and Seidel, 2015[37]; König, 2015[38])] is likely to require more complex stimulus material. Innovative single items with video or text vignettes as stimuli, for example, could be a remedy here but would be too time consuming and may jeopardise reaching an appropriate level of measurement precision. Therefore, possibility (2) represents an innovative alternative, which also meets the wish to include more complex situation-based items, for example, a few video or text vignettes of typical classroom situations across countries and economies. For these, a larger number of items (e.g. 25) covering a broad difficulty range and different sub-dimensions of the assessment framework could be developed. These items can be regarded as a unit-specific item pool. During the adaptive test, the stimulus of such an innovative unit is presented and items (e.g. eight) are selected from the unit-specific item pool according to an item selection criterion. Each test taker is presented with one innovative unit and the rest of the testing time is filled with adaptively selected single items. If several innovative units are constructed that cover the assessment framework well, a good content coverage will be achieved across test takers. For all items that are constructed anew, the typical item development procedures, including cognitive labs, should be carried out.

Specification of the multidimensional adaptive testing design

As the psychometric model, the three-dimensional 2PL model (or the generalised partial credit model, GPCM, in the case of polytomous items) with between-item multidimensionality could be used to measure the three broad dimensions of general pedagogical knowledge (instruction, learning and assessment) specified in the TKS assessment framework. This model provides considerably higher statistical information than the three-dimensional 1PL but minimises the potential problem of item parameter estimates varying between countries/economies or assessments that is more likely to occur when more complex models are used. Item selection based on D-optimality and using maximum a posteriori (MAP) estimation of the provisional ability during the adaptive test is recommended. In order to maximise the statistical information obtained in the given testing time, item selection criteria that take the response times of the individual test takers into account could also be considered. A viable representative of such an item selection criterion, whose performance, however, has not yet been examined in the context of MAT in ILSAs, is the simplified maximum information per time unit criterion suggested by Cheng et al. (2017[34]).

In order to reflect the assessment framework within each adaptive testing session, the content constraints that have to be taken into account are the three dimensions of the TKS (instruction, learning and assessment), each of which is composed of two additional sub-dimensions. The main dimensions should each be measured by an equal number of items. To reach a content coverage that conforms with the assessment framework, within each dimension, the sub-dimensions should also be equally represented. In addition, the three transversal aspects (knowledge about using technology, fostering 21st century skills and managing diversity in classrooms) should be equally represented across dimensions. These content

constraints could be considered simultaneously and automatically by using the shadow-test approach (see Box 7.3). Exposure control methods, such as the Sympson-Hetter method (see Box 7.4), should be used to avoid over- and underexposure of some items.

The starting items could be chosen randomly from a set of items with difficulties near zero, or if applicable, teacher responses to background questionnaires could be used to determine the starting point of the test (e.g. if teachers indicate that they are novice teachers, they would get an easier starting block of items than their experienced colleagues). Termination criteria should be a test length of 30 items or a testing time of 30 minutes; whatever is reached first. Both test length and testing time should be kept constant between the field trial and the main study in order to be able to control for IPEs. In order to fine-tune the adaptive algorithm, pre-operational Monte Carlo simulations are recommended prior to the main study, based on the empirical results from the field trial.

After all responses had been gathered, the final scaling should be conducted. For this scaling, the M2PL is recommended in conjunction with a latent regression approach and drawing of plausible values (PVs), as done in PISA (OECD, forthcoming[39]). The PVs form the basis for the calculation of the reported results. The next three sections cover recommendations for the pilot study, the field trial and the main study of the TKS assessment module.

Pilot Study

As stated above, it would be useful to expand the item pool of the TKS assessment module, which currently consists of over 200 items. Especially units with innovative situation-based stimuli (e.g. video vignettes) with several (25 or more) connected items covering a broad difficulty range would make the TKS assessment module a very future-oriented and modern assessment. These items can be developed using standard item development procedures as they are typically used for OECD large-scale assessments. It is mandatory to pilot these innovative units. In addition, it would be useful to also include the existing TKS items in the pilot study. The IRT scaling of the gathered responses should be conducted with the M2PL. On the basis of the scaling results, deficient items can be identified and improved, if possible, or excluded from the item pool. The resulting variance-covariance matrix (before conditioning with a background model) and the provisional item parameter estimates will then be used in the field trial. The aim would be to have an item pool of about 150 good, calibrated items that covers all components of the assessment framework.

Field Trial

As the number of available items is too large for them all to be presented to one test taker, a balanced incomplete block design (BIBD) could be used to assemble different test versions. BIBDs are the type of design that was used, for example, for the paper-based assessments of PISA up to 2012. For the case of the TKS assessment module, the design can be similar to the design used by Spoden, Frey and Bernhardt (2018[36]) in the construction process of a three-dimensional computerised adaptive test. This design has two levels: At the first level, a Youden square design [e.g. Giesbrecht and Gumpertz, (2004[40])] is used for each dimension (here: instruction, learning and assessment). So, for each dimension, it is ensured that across all test versions (1) the test length is kept constant, (2) all items are presented with equal frequency, (3) each pair of items is presented with equal frequency, and (4) each item is presented in every possible position with equal frequency to control for IPEs. This first level design is nested in the second level.

At the second level, three blocks, one for each dimension, are specified. Therefore, for the case of the TKS, each test version would comprise one block of items for instruction, one block of items for learning, and one block of items for assessment. This balanced block design balances potential order effects at the second level. Thereby, it is ensured that (5) each test contains one block for each dimension and (6) each possible ordering of the three blocks is used with equal frequency across test versions. The composition

of the individual test versions can easily be done by computer. Note that a design of comparable quality can only be approximated by manually generated, labour-intensive multistage testing designs.

Defining sample size requirements is typically not trivial because they depend on a multitude of conditions. In order to make this chapter as concrete as possible, a conservative proposal with regard to the sample size is formulated below. However, it will certainly also be possible to achieve good results with other - possibly smaller - sample sizes. For a stable estimation of the M2PL model, there should be 500 or more responses per item, per country/economy. For an item pool with 150 items and a test length of 30 items, this would require a calibration sample size of at least *N* = 2,500 test takers. By using online calibration designs, such as the balanced continuous calibration strategy [CCS; (Fink et al., 2018[41]; Frey and Fink, forthcoming[29]), see below], this sample size requirement can be reduced, but it should not fall below 100 responses per item, per country/economy. In the example with an item pool of 150 items, this would lead to a sample size requirement of at least *N* = 500 teachers in the field trial per country/economy. By using such a calibration strategy, the field trial can be used to get an initial set of item parameter estimates. Clearly deficient items can be identified via item fit and differential item functioning (DIF) analyses across countries/economies and can then be excluded from the main study. The item parameters and the latent variance-covariance matrix estimated from the field trial can be used for multidimensional adaptive item selection and provisional ability estimation during the adaptive test administration in the main study.

Main Study

The same test system, test length, and testing time as in the field trial should be used in the main study. The use of the CCS is recommended, with proportions of items per dimension and per sub-dimension controlled for by shadow testing. The CCS includes concurrent scaling using the responses to all non-drifted items (items with substantial differences in item parameter estimates across assessments) from previous assessments (here: field trial) while controlling for IPEs, and it leads to a fast and continuous improvement of the item parameter estimates. The CCS therefore provides a good compromise between a stable estimation of item parameters and an optimisation of measurement precision. The resulting data can be used for the typical psychometric analyses such as those of item fit, country/economy DIF, and others. Using the final item parameter estimates, the results can be estimated and reporting that is based on PVs obtained by scaling with a latent regression approach is possible. Using the CCS makes it easy to add items to future assessments if needed and to improve item parameter estimates on the fly while controlling for IPEs.

Simulation of efficiency and precision gains for the Teacher Knowledge Survey assessment module

In order to obtain an impression of the efficiency gains that can be expected from using the suggested MAT design, a simulation study was conducted. For this purpose, a simplified version of the suggested MAT design was compared to two non-adaptive test designs: one based on a unidimensional IRT model (*urand*) and the other one on a multidimensional IRT model (*mrand*). The simulation study assumed an overall item pool of 150 items (50 items per dimension) under the M2PL model. Item difficulties were generated by extending the difficulty parameters obtained from the pilot study, as reported in Sonmark et al. (2017[1]), by drawing randomly from a standard normal distribution, $b \sim N(0,1)$. Discrimination parameters were randomly drawn from a lognormal distribution, with $a \sim logN(0,.25)$. Each item loaded on exactly one dimension (between-item multidimensionality). For the field trial, the study simulated *N* = 500 test takers (simulees). The ability parameters of the simulees were randomly drawn from a multivariate normal distribution using a conservative estimate of the mutual correlation between the TKS dimensions of 0.70:

$\boldsymbol{\theta} \sim \mathrm{MVN}(\boldsymbol{\mu}, \boldsymbol{\Phi})$, with $\boldsymbol{\mu} = (0,0,0)$ and $\boldsymbol{\Phi} = \begin{bmatrix} 1 & 0.70 & 0.70 \\ 0.70 & 1 & 0.70 \\ 0.70 & 0.70 & 1 \end{bmatrix}$.

The responses were generated for a linked calibration design, with the items assigned to 10 subsets of 15 items (five for each dimension). Each form consisted of two of these subsets, with one common subset between Forms 1 and 2, Forms 2 and 3, and so on. Forms were administered in a balanced way, in order to obtain 100 responses per item during calibration. Item parameters were estimated using marginal maximum likelihood (MML; Bock and Aitkin, 1981[42]). These item parameter estimates were used for adaptive item selection in the MAT condition.

After calibration, the adaptive and the two non-adaptive tests were simulated. Responses were simulated for a main study sample of *N* = 2,000 simulees. True abilities were randomly drawn from a multivariate normal distribution:

$\boldsymbol{\theta} \sim \mathrm{MVN}(\boldsymbol{\mu}, \boldsymbol{\Phi})$, with $\boldsymbol{\mu} = (0,0,0)$ and $\boldsymbol{\Phi} = \begin{bmatrix} 1 & 0.70 & 0.70 \\ 0.70 & 1 & 0.70 \\ 0.70 & 0.70 & 1 \end{bmatrix}$.

The test length for each condition was set to 30 items, with 10 items per dimension. For non-adaptive testing, items were randomly drawn from the item pool. For MAT, the D-optimality criterion was used for item selection. Information regarding the correlation between the three dimensions was incorporated into the adaptive item selection and ability estimation (for the MAT and mrand conditions) by using the variance-covariance-matrix $\boldsymbol{\Phi}$ estimated from the calibration data. MAP (Mislevy, 1986[42]) was used for ability estimation. In order to obtain more uniform item exposure rates across the complete item pool, the Sympson-Hetter exposure control method was integrated into the adaptive item selection. Afterwards, response matrices gathered from the simulated field trial and the main study in each condition were combined and the final item parameters were estimated using MML estimation. On the basis of these item parameters, final ability parameters were estimated using MAP estimation. For each condition, r = 20 replications were compared regarding the resulting test information (overall and per dimension), averaged across simulees given their true ability levels. In addition, reliability, calculated as the squared correlation between true and estimated ability (Kim, 2012[43]), was calculated for each dimension. The simulation was carried out in R (R Core Team, 2020) using the package mirtCAT (Chalmers, 2016[44]) to simulate the tests and the package mirt (Chalmers, 2012[45])for item and person parameter estimation. Table 7.1 shows the results of the simulation.

Table 7.1. Test information and reliability per simulation condition averaged across replications

Test information			Reliability		
Instruction	Learning	Assessment	Instruction	Learning	Assessment
urand					
3.931	4.014	3.804	0.653	0.639	0.660
(0.017)	(0.015)	(0.014)	(0.008)	(0.008)	(0.008)
mrand					
3.931	4.014	3.804	0.721	0.706	0.720
(0.017)	(0.015)	(0.014)	(0.010)	(0.009)	(0.008)
MAT					
4.667	4.764	4.463	0.753	0.747	0.763
(0.416)	(0.372)	(0.423)	(0.020)	(0.022)	(0.015)

Note: urand = random item selection and unidimensional IRT model; mrand = random item selection and multidimensional IRT model; MAT = multidimensional adaptive testing; standard errors are given in parentheses.

As the urand and the mrand condition used the same response matrix, the resulting test information with regard to the true ability was the same in these conditions. It can be seen that MAT provided a substantial increase in test information. The effect of using MIRT modelling instead of unidimensional IRT modelling is reflected in the increase in reliability between the urand and the mrand conditions. The additional effect of multidimensional adaptive item selection and the associated higher test information is illustrated by the increase in reliability from the mrand to the MAT condition. The results demonstrate that, even with a relatively small item pool of five times the test length, a short test length, and the integration of multiple constraints into the adaptive item selection, MAT increases the measurement precision up to a range that is well suited for precise result reporting, while this is not the case for non-adaptive testing. Nevertheless, it has to be noted that the simulation study did not include missing responses, which have to be expected when applying the TKS assessment module to real teachers. Therefore, it can be assumed that the test information and the reliability will be somewhat lower for empirical data, while the relative differences between the conditions are likely to be the same.

What is required in terms of software and analytical skills for implementing such designs?

All methods and algorithms needed to implement a highly efficient MAT design are already implemented in packages in the statistical programming language R (R Core Team, 2020[46]). It would thus be straightforward to build an adaptive TKS assessment module based on R. If an existing testing platform should be used for item delivery, an interface between this platform and R would need to be programmed. As R is free and open-source, it enables the integration of self-programmed algorithms as well as the usage and adaptation of already existing algorithms, according to the needs of test developers. For example, the mirt package (Chalmers, 2012[45]) can be used to conduct MIRT analyses including scaling, fit analysis, DIF analysis, latent regression analysis using plausible values (PVs), and others. In addition, the mirtCAT package (Chalmers, 2016[44]) can be used for adaptive item selection. The mirtCAT package includes a large variety of item selection methods as well as the possibility to customise the adaptive algorithm in accordance with the test-specific requirements. Furthermore, modern constraint management and exposure control methods, such as the shadow-test approach and the Sympson-Hetter method, can be applied using the package. Besides these two packages, some sub-routines of the KAT-HS-App (Fink et al., forthcoming[47]), which is also programmed in R, can be integrated into the test system to impose the CCS as described in (Frey and Fink, forthcoming[29]).

Implementing the suggested combination of methods requires psychometric expertise in IRT modelling and CAT development. The former comprises technical skills that are not that different from the skills that are usually required for traditional, non-adaptive ILSAs (e.g. IRT scaling and linking, fit analysis, item analysis, DIF analysis). The latter requires, alongside technical skills in IRT, comprehensive knowledge about calibration designs, adaptive algorithms (including item selection criteria, constraint management, ability estimation), skills in R-programming, and experience in conducting Monte Carlo simulations. However, because all suggested methods are already implemented in frequently used R packages, no specialised programming expertise is needed.

Conclusion

The aim of this chapter was to discuss possibilities to increase the measurement efficiency of the TKS assessment module for future cycles of TALIS by using state-of-the-art psychometric approaches and computer-based test administration in a goal-oriented way. In order to substantially increase the reliability while reducing the testing time of the TKS pilot study by 50%, six points are suggested to achieve this

ambitious goal. The first two points can be achieved with the current test design, whereas the other four require a change to a MAT design (which, thus, might only be implemented in later cycles of the module):

1. The 2PL model should be used instead of the 1PL model. The 2PL provides considerably higher statistical information than the 1PL while still allowing for a stable estimation of item parameters.
2. The M2PL model, as the multidimensional extension of the 2PL, should be used to further increase the measurement precision by using information about the correlation between the three dimensions covered by the TKS assessment module. The results of the initial simulation study presented in this chapter show that, even with a conservative estimate of a mutual correlation of 0.70 between the TKS dimensions and even when using random item selection, a substantial gain in reliability can be achieved when using the M2PL instead of the 2PL model.
3. MAT should be used in order to administer only highly informative items to each individual test taker. The results of the initial simulation showed that using MAT with as few as 10 items per dimension results in a precision level that is appropriate for reporting, even with a correlation between dimensions of only 0.70. It is expected that the latent correlation between the three dimensions of the TKS will be even higher. This would lead to a further increase in measurement efficiency, which can be used, for example, to place more constraints on the test content or to compensate for not-simulated factors such as missing responses.
4. Teachers' responses to background questionnaires should be used to determine the starting point of the test. More precisely, this means that novice teachers would get a different starting block of items than experienced teachers.
5. It would be worthwhile to consider an item selection procedure that takes individual response times into account in order to maximise information per time unit. Such a procedure was not covered in the simulation presented here but is likely to result in further small improvements in terms of measurement efficiency.
6. The incorporation of innovative units with scenario-based stimuli and within-item adaptivity is recommended. This will not only make the assessment modern and future-oriented but will also lead to a very efficient usage of the longer processing time needed for more complex, situation-based items.

All methods needed have already been developed and published and can be applied with free statistical software. As shown, it would already be possible to use TALIS 2024 as a starting point for the adaptive TKS assessment module and to continue it with future cycles, even if some participating countries and economies change (see Table 8.1 in Chapter 8 for the main takeaways from this chapter for TALIS and the TKS assessment module). Contractors whose staff have solid psychometric training will be able to perform the analyses needed to implement and operate the suggested MAT design. Even though the implementation of the six proposed points requires some additional effort, this chapter and the results from the simulation study should encourage test developers to use computers in the best possible way, in order to create an innovative and psychometrically optimised assessment.

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8 Moving forward: Advancing the research and policy agendas on teacher knowledge

Studying teaching as a knowledge profession, especially in an international survey, is as important as it is challenging. This publication summarised the research on key topics relating to teacher knowledge and provided many suggestions for making such a challenging endeavour a success. This closing chapter first outlines main takeaways from these discussions, embedding them into a broader discussion around researching teacher knowledge in education systems around the globe. In the end, the success of any research endeavour is also determined by the contributions made to improving policy and practice. The chapter, therefore, also discusses how research on teacher knowledge can be used for informing teacher policy and strengthening professional exchange and knowledge-based practice in schools. Tackling these issues requires enormous efforts from everyone: researchers, policy makers and practitioners. Given the importance of a strong knowledge base of teachers for the thriving of students and societies, the effort is worth it.

Introduction

Teaching provides the foundation for future professional careers and, thus, is in fact the mother of all professions. This publication explored teaching as a knowledge profession, with a focus on teachers' general pedagogical knowledge. It collated convincing arguments for considering teaching a full profession with teacher knowledge as a main pillar. Whereas content knowledge (e.g. knowledge about mathematics, science) is partly shared with other professions, pedagogical knowledge (e.g. knowledge of how to teach and how students learn) is unique to the teaching profession. General pedagogical knowledge, which is independent of the subject taught, provides teachers with a common language and understanding for reflecting jointly on improving teaching and learning across subjects. Hence, strengthening general pedagogical knowledge among the teaching profession has a great potential for enhancing the learning experience of students across different subjects as well as the collaboration in and among schools.

A better understanding of teacher knowledge, in particular general pedagogical knowledge, and effective means of promoting it is of value for both education systems aiming at improving teacher quality and learning outcomes, and for practitioners striving continuously to improve their teaching and the support they receive for their work. An international study of teacher knowledge can play a key role in sparking greater attention to the topic and making education systems, schools and teachers part of a global education community determined to strengthen knowledge-based and evidence-informed practices in schools. To do so, an international study of teacher knowledge must represent the state-of-art of scientific knowledge and use cutting-edge methodologies. Certainly, such a study needs to address the major challenges education systems face with regard to teacher knowledge and its results need to be informative and useful for policy makers, practitioners and researchers alike.

These are the ambitions for the new optional Teacher Knowledge Survey (TKS) assessment module in the 2024 cycle of the OECD Teaching and Learning International Survey (TALIS). The module will explore teacher knowledge across education systems, drawing on the extensive work conducted in the Centre for Education Research in Innovation (CERI), where the module was originally developed as a stand-alone survey (see Chapters 1 and 2). The module has now been integrated into TALIS and will be further developed to fulfil the great ambition for the 2024 cycle.

This publication aimed to contribute to this challenging endeavour and to the broader discussion on teacher knowledge and professionalism. Its chapters summarised what is known from research about major challenges relating to teacher knowledge across countries and economies, such as managing diversity and technology in teaching. They also shared ideas for studying these issues across education systems using innovative testing designs.

This closing chapter reflects first on the experts' insights and ideas and outlines the main takeaways. It then summarises the implications of using research on teacher knowledge for improving both policy and practice as well as implications for future research. The chapter ends with a concluding note.

Main takeaways for an international study of teacher knowledge

This publication brought together experts' insights on the state-of-art of scientific knowledge about teacher knowledge. It also presented viable approaches to studying teacher knowledge across education systems and strengthening the relevance of this research for guiding teacher policies. Each chapter addressed a particular key topic relating to the study of teacher knowledge:

- **Chapter 1** set the scene for an in-depth exploration of teaching as a knowledge profession and presented arguments for considering teaching a profession with teachers' pedagogical knowledge as its main pillar and for studying teacher knowledge across countries.

- **Chapter 2** provided an overview of the new TALIS Teacher Knowledge Survey (TKS) assessment module and described its design, aims as well as its conceptual underpinning and instruments.
- **Chapter 3** focused on the knowledge and skills teachers need to master a major challenge in today's classrooms: the effective use of technology to facilitate student learning.
- **Chapter 4** was dedicated to the pressing issue of preparing and supporting the teaching workforce for high quality teaching in increasingly diverse classrooms.
- **Chapter 5** centred on the knowledge and skills teachers need for making adequate use of their knowledge in the context of specific classroom situations.
- **Chapter 6** discussed the importance of offering teachers practical opportunities to learn about pedagogy to foster knowledge-based and evidence-informed practice in schools.
- **Chapter 7** is dedicated to innovative testing designs for exploring teacher knowledge across education systems (i.e. multidimensional adaptive testing designs).

Each chapter also made suggestions for the challenging endeavour for the 2024 TALIS cycle: exploring teacher knowledge across education systems through a new module. The aim for the TALIS Teacher Knowledge Survey (TKS) assessment module is the design of a survey that provides meaningful information on key areas of teacher knowledge, while limiting the response time and burden for participating teachers. The work on the Teacher Knowledge Survey (TKS) and its integration into the Teaching and Learning International Survey (TALIS) was guided by the CERI and TALIS Governing Boards, which were also invited to a meeting to discuss the topics covered in this publication. An expert group in collaboration with participating countries and economies, the TALIS Governing Board (TGB) and important stakeholders will be involved in the further development of the module. The suggestions made by experts in this publication are meant to provide a stimulus for future joint discussions and collaborative efforts. Table 8.1 provides a brief summary of the main takeaways from the chapters for the development of the TKS assessment module.

Table 8.1. Takeaways from the expert chapters for the Teacher Knowledge Survey (TKS) assessment module

Chapter number and focus	Main takeaways
Chapter 1: Teachers as knowledge professionals	• Chapter 1 provided convincing arguments for considering teaching a profession with teachers' pedagogical knowledge as its main pillar. • Education systems have enacted policies and reforms to ensure a solid knowledge base and a continuous update of knowledge and skills among the teaching workforce. An international study of teacher knowledge such as the TKS assessment module provides guidance for policy and practice and helps foster learning and dialogue among policy makers, practitioners and researchers. • Thus far, TALIS has relied on indirect measures of teacher knowledge through self-reports. Yet, research suggests that assessed and self-reported knowledge are distinct teacher characteristics. The TKS assessment module will, therefore, use an objective assessment of teacher knowledge, building on prior international and national work in that area, most notably the substantive prior work conducted in CERI. • General pedagogical knowledge is crucial for mastering emerging challenges in today's classroom such as digital teaching as well as learning and the increasing diversity. Teachers need to be not only owners of deep professional knowledge but also able to apply knowledge adequately in different pedagogical contexts and situations. Thus, an international knowledge assessment needs to cover pedagogical knowledge in the area of technology and diversity and measure practice-based knowledge, professional judgement and knowledge-based skills in addition to theoretical-scientific knowledge.
Chapter 2: Studying teaching as a knowledge profession across education systems	• Drawing on the CERI Teacher Knowledge Survey (TKS), the new TALIS TKS assessment module will study teaching as a knowledge profession across education systems. It will collect international comparative data on the strengths and weaknesses of teachers' knowledge base, in particular teachers' general pedagogical knowledge. • The assessment covers teachers' general pedagogical knowledge in the areas of instruction, learning and assessment. Kowledge for fostering 21st century skills, teaching diverse classrooms and using digital technology for teaching are considered transversal knowledge areas across these three main areas. Chapter 2 provided an overview of the existing objective teacher assessments of technology- and diversity-related pedagogical knowledge, which can be used to strengthen these areas in the TKS assessment.

Chapter number and focus	Main takeaways
	• The assessment will include contextualised items and text vignettes that confront teachers with written descriptions of typical classroom situations and different options for teaching. In line with the CERI TKS approach, the module will use indicators measured via questionnaires to provide the context for the assessment results.
Chapter 3: The use of technology in teaching	• Technological knowledge is not sufficient to ensure an effective use of technology in teaching. Teachers need specialised pedagogical knowledge. Accordingly, the CERI TKS included this knowledge in its framework and assessment. Teachers' preparedness and their use of technology was also considered with single items in the TALIS 2018 questionnaire. • Teachers can use technology to support their *instruction* and their *assessment* practices. Technology can also help foster 21st century skills and facilitate individual and group *learning*. Consequently, technology is considered a transversal area across the three main knowledge areas of instruction, assessment and learning in the module's assessment framework. The TKS assessment already includes technology-related items but the item bank should be carefully reviewed to ensure a sufficient coverage of items across all areas. • The Technological Pedagogical and Content Knowledge (TPACK) framework described in Chapter 3 provides a nuanced description of the technology-related knowledge of teachers. The framework has also produced several useful self-report instruments. Some items can be used to strengthen the technology topic in the next round of TALIS and the new TKS assessment module. • Chapter 3 points out that exploring teachers' self-rated Technological Pedagogical Knowledge and practice enables a deeper understanding of the relevance of this knowledge for an effective use of technologies as educational tools. Studying the purpose and frequency of teachers' technology usage as well as the overall conditions for technology use at schools could further improve the interpretation of assessment results. Several items are proposed for the measurement of such context information, which is in line with the approach of TALIS and the TKS assessment module.
Chapter 4: Teaching in diverse classrooms	• Tailoring teaching to diverse backgrounds and needs of students is a major challenge growing in importance. Consequently, TALIS puts an emphasis on the diversity topic and explored self-efficacy in multicultural classrooms and diversity-related practices. The TKS assessment module complements TALIS with an assessment of teachers' knowledge about teaching in diverse classrooms. Chapter 4 provides an impulse for a more nuanced consideration of this topic in the next cycle by including the critical component of inclusive and multicultural education, mainly with a focus on self-report measures. • A review of TALIS 2018 items shows that *conservative* and *liberal* approaches to multicultural education are well represented, whereas *critical approaches* are missing. The chapter includes first ideas for new items and scales that would allow exploring critical approaches and diversity-related competences for teaching more holistically (e.g. self-report items on content and pedagogical knowledge, attitude, multicultural pedagogy and practice).
Chapter 5: Drawing on knowledge in the context of specific classroom situations	• Measuring practice-based knowledge and situation-specific skills is key for understanding why many teachers, especially novice teachers, struggle to apply knowledge acquired in teacher education in the classroom. Chapter 5 provides a model illustrating their role for transforming knowledge into effective practice. • Chapter 5 also highlights the advantages of using text vignettes with Likert scales to assess these knowledge and skills while using of an expert rating system for scoring. This reflects the directions taken for the TKS assessment (further increasing the amount of vignette-based items, including Likert scales as a response format and discussing an expert rating system for scoring).
Chapter 6: Opportunities to learn about general pedagogy	• Chapter 6 outlines strategies and concepts for exploring teachers' opportunities to learn about general pedagogy, drawing on experiences from national and international studies on general pedagogical knowledge. It outlines promising approaches, and suggests items for profiling teachers' learning opportunities across education systems in initial teacher education, induction and professional development. • TALIS has a well-established item battery measuring subject-specific and subject-independent learning opportunities along the teaching career. The original TKS questionnaire developed in CERI complements the TALIS questionnaire, providing a more nuanced picture on subject-independent learning opportunities. With every cycle, TALIS revises a certain share of items from the teacher questionnaire and includes new items. The items presented here, especially those from cross-country studies, can be used as a starting point for the revision.
Chapter 7: Multidimensional adaptive testing	• Chapter 7 explains the importance of using multidimensional item-response-theory for the scaling of data from international assessments such as the TKS assessment module. A two-parameter logistic (M2PL) model is suggested for the module, which provides allows for a more precise measurement of teacher knowledge while allowing for stable parameter estimates. This is already envisioned for 2024. • The benefits of an adaptive testing design is highlighted, including improved test efficiency and precision as well as reduced test burden and increased motivation of respondents. These benefits apply in general for using such a design for international assessments. • The chapter also makes concrete suggestions for the TKS assessment module (including pilot study, field trial and main study) and shows efficiency and precision gains for the module in a simulation study. Though an adaptive design is currently not envisioned for 2024, Chapter 7 points out the direction for the future of the TKS and international assessments in general.

Using cross-country insights on teacher knowledge for education policy and practice

Though each of the chapters includes specific suggestions for exploring teacher knowledge across education systems, these suggestions are embedded into a broader discussion on major challenges relating to teacher knowledge across education systems and, thus, have implications for research, policy and practice that are more general in nature. In the following, implications for strengthening teacher knowledge and improving knowledge-based and evidence-informed practices in schools emerging from the topics discussed and further scientific literature will be discussed.

Using knowledge assessments to drive policies and initiatives

Within education systems, policy reforms and local initiatives should be informed by sound evidence, indicating strengths as well as weaknesses and actual need for improvement. These needs should be met with programmes and initiatives of proven effectiveness and the progress made in implementing reforms and scaling up promising initiatives must be evaluated regularly. Results from surveys such as TALIS have been widely used to identify needs and evaluate progress through trend analysis (OECD, 2019[1]; OECD, 2020[2]). Yet, these analysis were based on teachers' self-reports (e.g. self-reports of teachers' feeling of preparedness, their participation and need for professional development). The discrepancies observed for self-rated vs. assessed knowledge discussed in Chapter 1 underline the importance of additionally using an objective assessment of the strength and weaknesses of teacher knowledge for informing policies and practice. Naturally, results need interpreting in light of national priorities and contexts.

As discussed in Chapter 1, TALIS and other international studies have proven to be powerful tools for inspiring learning and dialogue among education systems. Similarly, an international study focused on teacher knowledge may help foster learning and dialogue about effective policies and practices for strengthening the knowledge base of the teaching profession and knowledge-based practices in schools. However, such a study is only a first step, additional studies are necessary for guiding policy and practice, as discussed further below.

Building a global professional community that jointly reflects on pedagogy and co-constructs knowledge

Apart from fostering learning about effective policies among education systems, results from an international study on teacher knowledge can be used as an impulse for a joint reflection on pedagogical knowledge and improving teaching and pedagogies among the teachers around the globe. They can also promote peer learning about effective means of knowledge exchange and constructions in and across schools. Being part of a community that shares knowledge and experiences at a global scale allows teachers to find authentic examples of practices drawn from a rich range of contexts that can inspire their own practice. Such a platform can thus enrich national and regional pedagogical debates and help explore new approaches to pedagogical situations.

To promote peer learning among teachers on a global level, the OECD developed a global video library of teaching practices. The library showcases and disseminates videos of effective teaching practices around the world, using results from the OECD Global Teaching InSights (GTI) study (OECD, 2020[3]). The digital platform allows creating and sharing expertise about teaching, including video-enhanced examples of teaching practices that the GTI study finds to be most associated with student outcomes. Drawing on that experience, a digital platform could collect and distribute scientific knowledge and state-of the art research on teaching and learning. Best practice examples could demonstrate how teachers engage in reflecting on their practice and embedding research into their everyday teaching and how knowledge in schools is successfully shared and co-constructed in schools. Through such a platform, teachers can not only share

pedagogical success stories, research and personal experiences, they can also provide mutual support and feedback.

Promoting knowledge exchange and co-construction in schools

Schools should work out further means to promote knowledge exchange and co-construction in and among schools. Regular meetings can be held, where research and innovative pedagogical approaches are discussed and teachers work jointly on potential solutions for challenges they face in their daily work (Ulferts, 2019[4]; OECD, 2019[5]). School networks enable teachers to be continuously in contact with a large community of practice and other resources that are essential support for innovating and improving pedagogies (Paniagua and Istance, 2018[6]; Révai, 2020[7]).

TALIS 2018 results indicate that lower secondary teachers are generally open towards change and willing to develop new ideas and solutions for teaching and learning and provide each other practical support for innovating teaching (OECD, 2020[8]; OECD, 2019[1]). Nonetheless, professional exchange stays commonly limited to discussing the learning of students, exchanging teaching materials and attending team conferences. Deeper forms of collaboration are rare (e.g. joint teaching, collaborative professional learning). Initiatives such as team teaching, research groups or peer learning through observations and feedback are, however, important for establishing a culture where teachers regular share their knowledge and grow together. Such initiatives build on a strong school leadership that goes beyond management and administration. This requires pedagogical leadership in schools, which includes the facilitation of a constant knowledge exchange and co-construction among teachers and schools through various means.

Preparing teachers with a good start and ensuring a career-long updating of knowledge

Education systems need to support teachers in acquiring and updating their pedagogical knowledge. Teachers also need support in developing and refining their ability to apply knowledge in various pedagogical situations and contexts. The content areas of general pedagogy and approaches identified as promising in this publication can serve as first reference points for a reflection on the learning opportunities offered in education systems. As detailed in Chapter 1, it is important that systems:

- ensure a sufficient coverage of topics across all important areas of general pedagogy in initial teacher education (ITE) and continuous professional learning (CPL) (see Chapter 2 for an overview on important knowledge areas)
- incorporate new findings and insights into effective teaching and learning evolving from research (OECD, 2019[5]; Boeskens, Nusche and Yurita, 2020[9]; Tatto and Menter, 2019[10]; Tatto et al., 2018[11]; OECD, 2019[1])]
- increase teachers' opportunities to experiment and probe knowledge in practice during initial teacher education (e.g. during teaching practicum, modelling of pedagogical approach, video- and computer-based learning)
- provide expert guidance and mentoring when novice teachers enter school to help them learn about the context-adequate use of knowledge (OECD, 2019[5]; OECD, 2020[2])
- differentiate and tailor learning opportunities to the needs and varying knowledge and skills levels of participating teachers (Collinson et al., 2009[12])
- offer digital courses, platforms and other digital resources of high quality as flexible and cost-efficient opportunities for learning about general pedagogy, which are available even during potential closures of schools and institutions offering ITE and CPL (Donitsa-Schmidt and Topaz, 2018[13]; Shin et al., 2009[14])
- enhance (pre-service) teachers' reflective practice, systematic inquiry and their continuous engagement with research (e.g. promote knowledge and skills for identifying and interpreting

relevant research and data and adapting it to their own classroom contexts) (OECD, 2019[5]; Tatto and Menter, 2019[10]; Boeskens, Nusche and Yurita, 2020[9])

- establish partnerships between research institutions and schools, translate and package knowledge in ways that are user-centred as well as promote "knowledge brokering" in schools (Wollscheid and Opheim, 2016[15]; Malin and Brown, 2019[16]; OECD, 2019[5]).
- ensure the professionalism of all those involved in educating teachers (e.g. higher education staff, supervisors of practice in schools linked to initial teacher education institutions and trained and experienced teachers supervising practice in other schools, professional development staff of private providers) (European Commission, 2013[17])
- safeguard the pedagogical preparedness of teachers entering into the profession through "alternative" routes (e.g. second career fast-track training, Teach for All). This means, for example, the provision of high quality trained mentors as well as a strong practicum and continuous contact with schools that partner with the programme (Drake et al., 2018[18]; OECD, 2019[5]).

Certainly, a successful restructuring of teacher support requires a needs analysis, including a profiling of the strength and weaknesses of the knowledge base of the teaching profession prior to implementation as well as an evaluation of the effectiveness of measures post implementation.

Basing career entry and progression on competences and knowledge

The structures and processes in place need to ensure a solid pedagogical knowledge base among teachers entering the profession as well as a system of career progression that ensures a continuous updating of in-service teachers' knowledge in the various areas relevant for 21st century teaching.

Existing licensing procedures must be up to date with the recent research on high quality teaching as well as the knowledge it requires and reflect the latest methodological standards (Ulferts, 2019[4]; OECD, 2013[19]). Qualification frameworks and standards need to emphasise that a strong pedagogical knowledge base is a key requirement for career entry and progression (Guerriero, 2017[20]; Révai, 2018[21]).

Optimally, education systems reward efforts of teachers to strengthen their knowledge, for example through salary advancements, promotions and non-financial rewards. Systems and schools can promote not only individual knowledge progression but also reward and promote the engagement of teachers in facilitating knowledge exchange and improving pedagogies. Schools could create, for instance, positions for "knowledge broker teacher" that are responsible for facilitating knowledge exchanges and updating the knowledge of colleagues (Jusinski, 2021[22]).

Updating teacher knowledge for the 21st century

Teachers are also more than ever expected to foster 21st century skills (e.g. critical thinking and collaboration) and to meet diverse needs and backgrounds in classrooms and to embrace diversity as an enriching element of school education (König et al., 2017[23]; Wasonga, 2005[24]; Valanidou and Jones, 2012[25]; Schleicher, 2014[26]). Diversity in the classroom and schools can be used to enable young people to see the world from different perspectives, engage with different ways of thinking and appreciate different cultures (OECD, 2020[27]). In doing so, teachers prepare their students for a globalised world and citizenship in diverse and open societies.

These educational missions require specialised knowledge and skills. TALIS results, however, indicate that the share of teachers who feel "well" or "very well" prepared for such 21st century teaching tasks (i.e. teaching cross-curricular skills, teaching in a mixed ability and multicultural setting) is the lowest while the need for professional development is the highest for these tasks. Thus, stronger investments into learning opportunities are needed that help teachers update their knowledge to 21st century teaching.

…including digital and hybrid teaching

Stronger investments into teachers' learning opportunities for digital and hybrid teaching are also needed. Results from the Programme for International Student Assessment (PISA) 2018 showed a consistent negative association between the intensity of students' technology use in classrooms and the digital reading skills of 15-year olds (OECD, 2021[28]). This means that the use of digital technology does not automatically translate into better learning outcomes. Of course, there are many potential reasons for this (OECD, 2021[29]), inter alia a use of technology lacking pedagogical purpose and depth.

Teachers have an important role in guiding and shaping students' use of such tools and optimising the educational benefits of their digital experiences. This requires specialised knowledge from teachers. As explained in Chapter 3, Technological Knowledge (TK; knowledge of how to work with and apply technologies) is not sufficient. Teachers need Technological Pedagogical Knowledge (TPK; knowledge for using technology effectively for teaching and learning. International evidence on this is missing but TALIS 2018 results showed, for example, that the majority of lower secondary teachers do not feel well prepared for the use ICT for teaching and the reported need for professional development in that area was among the highest (OECD, 2019[1]).

Technologies are constantly evolving, providing new educational opportunities through learning analytics as well as social robots and smart technologies powered by AI (artificial intelligence) (OECD, 2021[29]). Thus, systems need to adjust constantly offered learning opportunities to allow teachers to update their technology-related knowledge. For instance, to make efficient use of Teaching and Learning Analytics (TLA) teachers now need data literacy and data inquiry skills (Ndukwe and Daniel, 2020[30]). Apart from that, a broader technology planning in schools needs to guide teachers and schools in the integration of technology in teaching and learning (Vanderlinde and Braak, 2013[31]). Such planning needs to ensure, for example, the selection of digital tools that meets the intended pedagogical purposes and provide support activities and menus that help teachers differing in knowledge and skills to use them adequately.

Acknowledging teachers as experts of learning and teaching

Education systems today have high expectations of their teachers in terms of pedagogical knowledge and expertise. This publication has provided many good arguments for this. Such high expectations need to be rewarded with an adequate status, autonomy, salary and societal value to keep teaching an attractive job as many systems are challenged with teacher shortage and high attrition (OECD, 2019[1]; OECD, 2020[2]). Teachers also need a stronger acknowledgement as experts of teaching and learning.

Expert teachers should be involved in debates and consulted in decisions made about education policies, technology and research. A study by Joram and colleagues (2020[32]) found that a reason for teachers not to engage in research was that they felt as though they were mainly passive recipients of research, and that they – as experts of teaching and learning in practical contexts - themselves had little influence on the kind of questions addressed by research and proposed solutions. There was also a sense among teachers that research is drawn upon to make decisions (e.g. changes in curricula or initiatives) by administrators who do not involve teachers in this process.

In the area of technology, partnerships between schools and education technology (EdTech) companies are important building blocks for a successful digital transformation of education (Burns and Gottschalk, 2020[33]). This also means that EdTech companies should not only conduct usability studies, teachers also need to be involved in the design of education tools and software, to ensure tools serve pedagogical purposes and are adapted to teachers' and learners with different needs and levels of knowledge and skills (OECD, 2021[29]).

Pushing forward the research agenda and broadening the understanding of teacher knowledge

To push further the research agenda on teacher knowledge, the following sections outline the broader implications for research emerging from discussed issues. The sections signal important gaps in the knowledge about teacher knowledge that future research needs to fill. Some of the gaps identified will be addressed by the next cycle of TALIS and the TKS assessment module; others require further international and national research, using a variety of designs and methods.

Researching teacher knowledge and skill required for digital and hybrid education

Technological knowledge is not sufficient to ensure an effective use of technology in teaching. Teachers need specialised pedagogical knowledge. This publication supported a view on teachers' general pedagogical knowledge with knowledge about the effective use of technology as an integral element (see Chapters 2 and 3). This contrasts with most research on this topic, which has often drawn on the Technological Pedagogical Content Knowledge (TPCK) framework described in Chapter 3 (Mishra and Koehler, 2006[34]). This research emerged – though with reference to Shulman (1986[35]) – as a line of research somewhat separate from the work on teachers' pedagogical knowledge (Ulferts, 2019[4]; Harris et al., 2017[36]). More recent work has investigated the relationship between general pedagogical knowledge and Technological Pedagogical Knowledge but still treated them as separate knowledge entities (Baier and Kunter, 2020[37]; Drummond and Sweeney, 2017[38]; Maderick et al., 2016[39]).

Within this publication, technology-related pedagogical knowledge is seen as a transversal domain of general pedagogical knowledge, since technologies can serve a wide range of pedagogical purposes, spanning tasks in all broad knowledge areas (i.e. assessment, instruction and learning). Technology can also be used to enhance inclusion and equity and to foster 21st century skills (OECD, 2021[29]). This and the discussions in chapter 2 and 3 provide some good arguments for treating technology-related knowledge as an integral part of teachers' general pedagogical knowledge instead of separate entities.

Apart from such conceptual refinements, more work is needed to understand the knowledge and skills teachers need for modern technology. While most research in this area still focuses on more traditional, digital tools, modern tools such as social robots, Teaching and Learning Analytics (TLA) and other smart technologies powered by AI technologies are entering classrooms and schools (Ndukwe and Daniel, 2020[30]; OECD, 2021[29]). In addition, researchers should investigate the knowledge and skills that help teachers successfully combine offline and online teaching and learning, thus create holistic hybrid and blended learning experiences. Generally more research is also required on the type of learning opportunities that bring the most value for teachers' Technological Pedagogical Knowledge and skills and the kind of support (e.g. help menus, defaults) that optimise the use of digital tools for education purposes of teachers of varying backgrounds and knowledge.

Investigating diversity-related pedagogical knowledge of teachers

Despite substantive variations in policies and practices to tackle diversities in schools among education systems, there is an overall trend towards a more inclusive, equitable education. Systems also increasingly aim at embracing diversity and unique experiences and backgrounds of students as an enriching element of school education. Thus far, however, it is unclear if teachers have sufficient knowledge and skills to fulfil these educational missions. Though in TALIS lower secondary teachers across OECD countries reported high needs for professional development for managing diversity in classrooms (e.g. teaching special needs students and teaching in multicultural or multilingual settings) (OECD, 2019[1]), there is no evidence showing that reported needs reflects an actual lack of diversity-related pedagogical knowledge among the teaching workforce. An international assessment of teachers' diversity-related knowledge promises, therefore, to fill important research gaps unanswered by the current TALIS measures.

Chapter 4 of this publication includes suggestions for measuring teachers' knowledge, beliefs and practices for managing diversity in classrooms using self-ratings in questionnaires. Given the low correlations between self-rated and assessed knowledge (Baier and Kunter, 2020[37]; Drummond and Sweeney, 2017[38]; Maderick et al., 2016[39]; König, Kaiser and Felbrich, 2012[40]), it seems necessary to assess diversity-related pedagogical knowledge additionally.

However, actual assessments of teachers' diversity-related pedagogical knowledge are still rare. Existing assessments also often focus on diversity-related pedagogical knowledge in certain areas or cover knowledge about specific student characteristics such as attention-deficit/hyperactivity disorder (ADHD) and external behaviour problems (see Chapter 2 for a discussion). However, managing diversity requires pedagogical knowledge across all knowledge areas (instruction, learning processes, as well as assessment). An important aspect insufficiently covered by existing instruments is teachers' knowledge about using technologies for improving inclusion and equity. Technologies provide unique opportunities for inclusive education (e.g. highly individualised learning and accurate learning analytics) but also come with risks (e.g. bias and discrimination reinforced through certain algorisms) (OECD, 2021[29]). In addition, more research is needed on teachers' knowledge for embracing diversity, including the development of assessments to measure the knowledge and skills that teachers need to use diversity in the classroom to enrich the education experiences of students.

Studying how teachers apply their knowledge in classroom contexts

Chapters 1 and 5 highlighted that teachers need to be not only owners of deep professional knowledge but also able to apply their knowledge in context. A major barrier for knowledge-based practice in schools is, however, the "theory-practice gap" (OECD, 2019[5]; Paniagua and Sánchez-Martí, 2018[41]): Teachers struggle to integrate the knowledge, theories and research learnt in training into the reality of classrooms. This is especially visible for novice teachers transitioning from teacher education to schools [the so-called "practice shock"; (OECD, 2020[2]; Paniagua and Sánchez-Martí, 2018[41])]. However, even more experienced teachers struggle to act in accordance with their own beliefs and attitudes. Results from TALIS 2018, for instance, show that 80.3% of lower secondary teachers feel confident about using a variety of assessment strategies but the majority of teachers across OECD countries report relying on a few strategies in their practice (mainly using own assessments as well as observing students and providing immediate feedback) (OECD, 2019[1]).

There are various possible explanations for this, among them a lack of knowledge, in particular actionable knowledge (i.e. practice-based knowledge and the skills needed to apply knowledge in the context of specific classroom situations). The TKS assessment module will explore to which extent teachers from different education systems are able to apply their knowledge, addressing an important research gap. The module will use a contextualised assessment that uses text vignettes that confront teachers with a written description of typical classroom situations and different options for teaching (see Chapters 2 and 5). Further development into innovative approaches such as simulations is needed to make them viable for large-scale international studies in the future.

Investigating the evolution of teacher knowledge and the effectiveness of learning opportunities

Typical ways to alleviate the "theory-practice gap" include providing more opportunities to experiment and probe knowledge in practice during initial teacher education (e.g. teaching practicum, modelling of pedagogical approach, video-based learning) as well as practical guidance and mentoring when novice teachers enter school (OECD, 2019[5]; OECD, 2020[2]). International reviews and TALIS 2018 showed how the structure, content and quality of initial teacher education, induction and professional learning differ within and across countries and economies (OECD, 2019[5]; Boeskens, Nusche and Yurita, 2020[9]; Tatto and Menter, 2019[10]). As discussed in Chapter 6 and in the pilot TKS report (Sonmark et al., 2017[42]),

a more fine-grained international data with a stronger focus on the opportunities to learn general pedagogical knowledge is needed to better understand how this special knowledge can be developed and shaped over a teacher's professional career. This includes a more fine-grained measurement of the pedagogical content covered but also the type and quality of practical experiences and guidance offered to teachers, especially in the initial career phase. This is crucial for researching how type, duration and quality of initial teacher education (ITE) and continuous professional learning (CPL) relate to the acquisition and consolidation of a strong knowledge base among teachers.

As experts of teaching and learning teachers also need to shape increasingly their own professional learning and actively engage in an autonomous career-long updating of their knowledge. Thus, research should focus more on the non-formal and informal learning activities teachers involve in. TALIS explores professional exchange and collaboration as key pillars of teacher professionalism and includes certain informal activities (e.g. networking, reading professional literature) (OECD, 2019[1]; OECD, 2020[2]). This promising starting point for an exploration of non-formal and informal learning opportunities of teachers needs expanding in the future. Additionally, further research, using a variety of designs and methods, is needed for a more complete understanding of teaching as a knowledge profession. It would be worthwhile, for example, to have more in-depth insights into the role expertise plays in professional networks and collaborations and to explore how knowledge is exchanged and co-constructed in schools as well as in virtual environments (Révai, 2020[7]).

Additionally, the evolution of teacher knowledge requires further attention. A comparison of pedagogical knowledge among different teacher populations can also provide some insights into the evolution of teacher knowledge (e.g. comparing the knowledge of pre-service, novice and experienced teachers). Such a comparison has been made in the TKS pilot study. Longitudinal data would be of particular value for understanding how general pedagogical knowledge evolves over time. This has been done previously for German teachers in a follow-up study of TEDS-M (König et al., 2014[43]).

Exploring the role of teacher knowledge for teaching quality and student outcomes

A systematic review and meta-analysis showed that teachers' general pedagogical knowledge is linked to teaching quality as well as student outcomes (Ulferts, 2019[4]). The study found overall positive associations of teacher knowledge to more "traditional" indicators of teaching quality (e.g. cognitive activation, emotional support) and student outcomes, particularly in maths and science (e.g. achievement, self-regulation and interest). Yet, more research is required that explores the role of teachers' general pedagogical knowledge for implementing innovative pedagogies as well as digital and inclusive lessons. Research should also focus on a broader range of subject areas and more studies should look at the importance of teacher knowledge for fostering so-called "21st century learning outcomes" (e.g. critical thinking, metacognition). The review also points to a lack of empirical evidence on how teachers' general pedagogical knowledge interacts with other parts of the teacher's knowledge base (content knowledge, pedagogical content knowledge) and further competences such as beliefs, motivation and attitudes.

Drawing on established and new self-report measures in TALIS, the TKS assessment module will be able to address some of these gaps, for instance, how general pedagogical knowledge relates to the well-being, beliefs, motivation and attitudes as well as teaching practices of teachers across different national contexts. If the measures of self-reported feeling of preparedness and need for professional development are kept in the next cycle, it would also be interesting to compare the self-ratings to assessed knowledge to get a sense for how aware teachers are of the strengths and weaknesses of their knowledge base.

Although the TKS assessment module will fill important gaps in the knowledge base about teaching as a knowledge profession, further research should address remaining gaps. Studies that link teacher knowledge to observations and student ratings of teaching practices and artefacts (e.g. lesson plans) as well as student outcomes, for example, can counterbalance the common criticism of teacher self-reports of teaching practices used in TALIS. Some of this has been done in national add-on studies of the

international study Teacher Education and Development Study in Mathematics (TEDS-M) (Ulferts, 2019[4]). Some studies used longitudinal or experimental designs, allowing an investigation of the directions of relationships.

An international comparative study that links teacher knowledge to observed or student-rated instructional practice and student outcomes would be a completely new and promising undertaking. This allows studying the variations of associations across education systems, schools and student populations in the future (e.g. students varying in socio-economic and migration background, education systems varying in teacher policies). Such an undertaking can draw on existing experiences from international studies that linked data gathered from teachers to observations of teaching practices and student outcomes, such as the Global Teaching InSights (GTI) study (OECD, 2020[3]) and the TALIS-PISA link (OECD, 2021[44]).

Researching teacher educators as gatekeepers of teachers' pedagogical knowledge

Of particular value is research on those educating teachers, as planned for the original TKS stand-alone study in CERI (Sonmark et al., 2017[42]). Yet, researching the knowledge and professional competences of teacher educators requires additional efforts. First, they have received far less intention of the international research community, and, thus, there is less existing work to draw from (e.g. conceptual work, instruments and study designs). Second, the organisation of teacher education and support varies substantially between education systems, especially for the phases beyond initial teacher education. As teacher educators comprise all those who actively facilitate the (formal) learning of (pre-service) teachers, it includes a wide range of actors and providers (e.g. higher education staff, supervisors of practice in schools linked to initial teacher education institutions and trained and experienced teachers supervising practice in other schools, professional development staff of private providers) (European Commission, 2013[17]). Thirdly, studying competences, including general pedagogical knowledge, means measuring competences on two levels: first-order and second-order knowledge, skills and attitudes (European Commission, 2013[17]):

- *First-order competences* refer, for instance, to the knowledge base about schooling and teaching that teacher educators teach to the teachers in training.
- *Second-order competences* refer to the knowledge base of how teachers learn and grow in competence. The focus is on teachers as adult learners and the pedagogy associated with teaching teachers as well as the organisational knowledge about the workplaces of teachers.

Studies on teacher educators, especially large-scale international surveys, are scarce. TEDS-M (Tatto et al., 2018[11]), the pilot TKS (Sonmark et al., 2017[42]) and the International Forum for Teacher Educator Development (InFo-TED) survey (Czerniawski, Guberman and MacPhail, 2016[45]) exemplified how the background, needs and competences of teacher educators from higher education can be measured across countries and economies. The CERI TKS pilot additionally studied the general pedagogical knowledge of higher education teacher educators across countries, using the same assessment as for teachers. Future research should include the second-order knowledge base of teacher educators as well as other teacher educator populations, who have increased in importance over the last decades.

Increasing motivation and reducing barriers to participation in research

Lower secondary teachers (including full-time and part-time teachers) spend on average 38.8 hours per week on all the tasks related to their job across OECD countries (OECD, 2019[1]). Hence, the numbers of available hours for additional tasks, such as participating in research, are limited and stress levels are high. Almost half of all lower secondary teachers (48.7%) across the OECD reported that they experience stress in their work "a lot" or "quite a bit" (OECD, 2020[2]). At the same time, teachers are being asked to participate in a growing number of studies. Consequently, survey fatigue is a common phenomenon among teachers and a huge challenge for researchers: Among the potential consequences are problems to recruit a

sufficient number of teachers and thus to suffice sample size requirements, biased results and low power due to non-response and high drop out rates.

Key for maximising participation and response rates is a transparent communication that highlights that:

- Through participation teachers contribute to research, that informs policies and decision making.
- Results will be used to give teachers voice, in particular, on how to design teacher education programmes and schools that empower knowledge sharing and construction, and to optimise the support and working conditions of teachers, rather than to blame them.
- Participation is anonymous and the reporting will use aggregated (e.g. regional or country-level) results with no possibility to identify individual results.

Apart from a transparent communication, effective incentives need to be offered. More research is needed to determine which incentives are effective without leading to bias as done for the PISA assessments and the United States National Assessment of Educational Progress (NAEP) (OECD, 2019[46]). It is likely that the effectiveness varies across regions, countries and economies and probably also between different teacher populations. An open question is, for example, if instant feedback about the strength and weaknesses of the knowledge base at the end of the assessment completion has a positive effect on completion rates. A similar question relates to the type of information that should be provided with the results from an individual assessment (e.g. about the limitations of obtained results and useful online resources and courses on the topics identified as weaker areas).

Additionally, potential barriers to survey participation need to be minimised by reducing, for instance, survey length, increasing the flexibility of participation and avoiding boredom or the feeling of being overwhelmed among participating teachers. As explained in Chapter 1, the aim for the TKS assessment module is the design of a survey that provides meaningful information on key areas of teacher knowledge, while limiting the response time and burden for participating teachers. The online format will further allow for a flexible participation, e.g. allowing teachers to choose the time and take breaks. Similarly, drop out analysis and non-response analysis are planned to estimate potential bias.

Technological and methodological advances such as the multidimensional adaptive testing (MCAT) design in Chapter 7 help further optimise the efficiency of testing (i.e. covering a variety of knowledge topics in a limited amount of time) and the accuracy of obtained results. Such designs can also facilitate participants' motivation through selecting optimal difficulty levels and thus neither risk bore teachers with too easy items, nor overwhelm and discourage them with questions that are too difficult for them. Though not being considered for this cycle, the discussion of such cutting-edge technology may pave way for a modernised assessment in a future round of the of the TKS assessment module. More generally, the discussed design and methodologies can also inspire other studies to innovate their assessment approach.

Concluding remark

Teaching is, in fact, the mother of all professions. It is the starting point for successful professionals, engaged citizens and influential leaders. Yet, the status of teaching as a profession has long been under scrutiny. Critics have commonly argued that teaching lacks a common body of knowledge that informs practice. This publication has collated many good arguments rebutting such criticism.

Teaching is indeed a complex task that can only be mastered by skilful and highly knowledgeable teachers. Creating effective learning environments and promoting a healthy, prosperous development of students requires a strong and highly specialised body of knowledge. It also requires teachers to update constantly their knowledge and skills as societies and technologies evolve, and new insights into effective teaching and learning emerge from research as well as practice. The COVID-19 pandemic has shown yet again how vital a strong and updated knowledge base is for tackling the enormous challenges of teaching,

especially in times of uncertainty that ask for autonomous decisions and flexible, adaptive solutions to unforeseen new challenges.

Together with its companion publication *Pedagogical Knowledge and the Changing Nature of the Teaching Profession* (Guerriero, 2017[20]), this publication makes a strong case for acknowledging teaching as a knowledge profession. Though a significant body of research exists, the overview presented in this publication has also revealed a great need to better understand the professional knowledge required for teaching and a great need in many education systems for effective means to strengthen the knowledge base among the teaching profession.

An international study on teacher knowledge, especially on general pedagogical knowledge, has a particular potential for providing new insights into the nature of teacher knowledge and its role and evolution in various education contexts. It can provide a powerful tool for facilitating peer learning and joint reflections among education systems, schools and practitioners around the world on how to improve the knowledge base of teachers and the learning experiences of students. With the optional Teacher Knowledge Survey (TKS) assessment module the next cycle of the OECD Teaching and Learning International Survey (TALIS) puts teacher knowledge, more particularly teachers' general pedagogical knowledge, in the centre of its evidence-based reflections on teacher professionalism across countries and economies.

Exploring teaching as a knowledge profession across education systems is, however, as challenging as it is important. To be successful, such a study has to provide internationally comparable evidence on the knowledge and learning opportunities needed for creating effective learning environments and fostering the well-being and socio-emotional development of all students. Sufficient attention should be paid to the most pressing challenges in today's classrooms, such as diversity and technology and a use of knowledge that considers the pedagogical context. We also owe it to the participating teachers to invest in designs and cutting-edge methodologies that deliver precise, efficient measures, reduce the response burden and make participation a motivating experience.

The TKS assessment module can build on the substantial work previously conducted in CERI, outlined in Chapters 1 and 2. This publication provided additional ideas to make this challenging endeavour a success. It has also outlined areas for further research that go beyond the scope of this module and for using research on teacher knowledge to improve teacher policy and practice. In the end, the success of any research endeavour is also determined by the contribution made to informed decision making and learning, in this case in terms of its impact on strengthening knowledge-based practice in schools. Tackling this issue requires enormous efforts from everyone: research, policy and practice. Given the importance of a strong knowledge base of teachers for the well-being and thriving of students and societies, the effort is worth it.

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Annex A. List of abbreviations

Abbreviation	Description
1-3PL model	One to three-parameter logistic test model
ADHD	Attention-deficit/hyperactivity disorder
AI	Artificial intelligence
BIBD	Balanced incomplete block design
CAT	Computerised adaptive testing
CCS	Continuous calibration strategy
CERI	Centre for Education Research in Innovation
CPL	Continuous Professional Learning
DIF	Differential item functioning
EdTech	Education technology
FIRSTMATH	First Five Years of Teaching Mathematics study
GPCM	Generalised partial credit model
GPK	General pedagogical knowledge
GTI	Global Teaching InSights
ICT	Information and communication technology
IEA	International Association for the Evaluation of Educational Achievement
InFo-TED	International Forum for Teacher Educator Development
IPE	Item position effects
IRT	Item-response-theory
ILSA	International large-scale assessment
ITEL	Innovative Teaching for Effective Learning
ITE	Initial teacher education
LTTE-US	Learning to Teach in England and the United States study
MAP	Maximum a posteriori
MAT	Multidimensional adaptive testing
MIRT	Multidimensional item-response-theory
MML	Marginal maximum likelihood
mrand	random item selection
NAEP	National Assessment of Educational Progress
OTL	Opportunity to learn
PCK	Pedagogical Content Knowledge model
PD	Professional development
PISA	Programme for International Student Assessment
PV	Plausible value
SDI	Service Delivery Indicators
SES	Socio-economic status
TALIS	Teaching and Learning International Survey
TEDS-M	Teacher Education and Development Study in Mathematics
TCK	Technological Content Knowledge
TGB	TALIS Governing Board
TK	Technological Knowledge
TKS	Teacher Knowledge Survey

Abbreviation	Description
TPACK	Technological Pedagogical and Content Knowledge
TPK	Technological Pedagogical Knowledge
TQ	Teacher questionnaire
TLA	Teaching and Learning Analytics
urand	random item selection

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Educational Research and Innovation

Teaching as a Knowledge Profession

STUDYING PEDAGOGICAL KNOWLEDGE ACROSS EDUCATION SYSTEMS

What knowledge do teachers need for 21st century teaching? Today, teachers have an important role in guiding and shaping students' use of digital tools and optimising the educational benefits of their digital experiences. They are also agents of inclusive, equitable education and ambassadors of embracing diversity as an enriching element of our societies.

To fulfil these roles teachers need to be experts of teaching and learning, and base their practice on a specialised and updated body of knowledge. However, there is a great need for a better understanding of the knowledge and skills that teaching in the 21st century requires. This is the ambition for the next cycle of the OECD Teaching and Learning International Survey (TALIS) and its new Teacher Knowledge Survey (TKS) assessment module.

Studying teaching as a knowledge profession across education systems is as challenging as it is important. This publication aims to contribute to this challenging endeavour by summarising the state-of-art on teacher knowledge and its measurement across systems. It discusses cutting-edge methodologies and designs and outlines implications for research as well as policies and practices for strengthening knowledge-based and evidence-informed practices in schools.

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