Linda Hobbs · Günter Törner *Editors*

Examining the Phenomenon of "Teaching Out-of-field"

International Perspectives on Teaching as a Non-specialist

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ISBN 978-981-13-3365-1 ISBN 978-981-13-3366-8 (eBook)
https://doi.org/10.1007/978-981-13-3366-8

Library of Congress Control Number: 2018962392

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Foreword

What does it mean to teach out-of-field? For me, the meanings are personal and multifaceted. My first experience as an out-of-field teacher was in a technical college, teaching food science to apprentice chefs, bakers, and pastrycooks and drawing only on my professional experience as a food technologist, having worked for several years for a large dairy manufacturing company. Later, after going back to university to complete a teaching qualification in secondary school mathematics and chemistry, I was nevertheless offered positions teaching physics, geology, and German in an educational jurisdiction that was "hard to staff." I didn't accept any of these positions because I felt I had no authentic claim to expertise as a teacher in disciplines that I had only studied at school or in my science degree.

After gaining some in-field experience teaching the subjects for which I was qualified, I eventually became a teacher educator responsible for the professional preparation of future secondary school mathematics teachers. I was the gatekeeper for this postgraduate program, checking applicants' academic records to make sure they met the requirements for having studied sufficient university mathematics to qualify for entry. But I soon realized that my small group of mathematics teaching specialists—around 25 graduating per year—were vastly outnumbered by teacher graduates in other disciplines and that these non-mathematics teachers would surely be assigned to teach mathematics classes in secondary schools.

What to do?

Over several years, I developed two strategies to support non-specialist teachers of mathematics. The first was an elective subject, which I called *Introduction to Teaching Junior Secondary School Mathematics*, that could be taken by non-mathematics teacher education students who anticipated (feared?) being assigned to teach mathematics out-of-field. The second was a Graduate Certificate in Mathematics Education, a part-time program for teachers qualified in other subjects, or qualified primary school teachers, who wished to develop their mathematical knowledge for teaching. The latter program attracted 10–15 participants each year but was discontinued when the University rationalized its postgraduate coursework degrees.

Now, after moving from Australia to Ireland, I find myself in the position of Course Director for the Professional Diploma in Mathematics for Teaching (PDMT), a national program for out-of-field teachers of mathematics coordinated by the University of Limerick. Unlike the Graduate Certificate in Mathematics Education at my previous university, tuition fees for the PDMT are fully funded by the government and more than 1000 teachers have graduated from the program. For many of these teachers, completing the PDMT has led to permanent employment instead of the short-term contracts usually offered to teachers whose subject qualifications do not match their teaching assignment. The contrast with my experience in Australia leads me to wonder about how out-of-field teaching is constructed, understood, and addressed in different countries.

It would be easy to construct out-of-field teaching as the consequence of misalignments, for example, a misalignment between teacher supply and demand or between teaching qualifications and teaching assignment. But it has become clearer to me, through reflecting on my own experience in two countries and also through growing familiarity with the research literature in this area, that out-of-field teaching is more complex than these simple dichotomies suggest.

Instead, I think about the consequences of taking different standpoints along a number of dimensions that collectively influence the experience of out-of-field teaching. For example, how are initial teacher education program standards implicated in the construction of fully qualified and out-of-field teachers, in terms of prescribing the type and amount of content to be studied? How does the language of crisis in the public portrayal of out-of-field teaching contribute to a view that these teachers are deficient, and the cause of falling educational standards? To what extent should we regard out-of-field teaching as a problem to be fixed or a permanent feature of the education landscape? The way in which countries respond to these questions is deeply embedded in cultural and historical contexts.

Notwithstanding the cultural dimensions of out-of-field teaching, it might be reasonable to assert that the ideal teaching workforce in any country would be fully qualified, fully employed, and equitably deployed to serve the needs of all learners. Whether or not this ideal can be achieved, it is surely incumbent on policy makers, school leaders, teacher educators, and researchers to engage constructively with the phenomenon of out-of-field teaching in order to enhance understanding of teachers' needs and lived experiences, for the ultimate benefit of learners.

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Contents

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Introduction

This book identifies and surveys the major themes around teachers who teach subjects or year levels for which they have no specialization. Internationally, this practice has many names, most notably out-of-field teaching, but also teaching across specializations, non-specialist teaching, or teaching out-of-area, for example. This practice often requires teachers to teach specializations they do not have a background in, while also teaching within their specializations (in-field), although not always. This movement across in-field and out-of-field specializations carries with it challenges, implications for teacher and student learning, and sometimes opportunities that might not normally be experienced if teaching only within specialization. Internationally, this practice is being recognized as a phenomenon of import, with research showing impacts on the nature of teacher knowledge, identity and practice, impacts on student outcomes, and negative experiences associated with teacher stress and attrition, unsympathetic school cultures and leadership practices, and policy settings that sideline the issue.

This book arises out of collaborations between members of an international group of researchers and practitioners called the Teaching Across Specializations (TAS) Collective, who held their inaugural international symposium in 2014 in Portugal, and yearly since. While the TAS Collective is principally comprised of mathematics and science educators and researchers, the issue of teaching out-of-field is examined more broadly than these two subjects in this edited book. Further, specialization is often associated with secondary or high schools where teachers are generally specialized according to their disciplinary training; however, out-of-field teaching has also been associated with year level specializations, levels of teacher qualifications, and more generally, any instance where teacher qualifications do not match the teaching assignment (including in primary schools and adult education). Ultimately, the notion of out-of-field teaching raises tensions between qualifications and teacher experience (at what point do qualifications no longer matter?), and contemporary and traditional constructions of the teacher (are teachers facilitators or educators?). This book explores the many issues that are raised for teachers, and by implication other key stakeholders that influence or are influenced by out-of-field teaching.

The chapters combine the research perspectives and practical knowledge of the TAS Collective in a way that examines the experiences, practices, and contexts of out-of-field teachers from the perspectives of different countries. In particular, the book will consider the phenomenon of out-of-field teaching within national policy contexts and local school leadership and staffing practices. Where possible, chapters include contributions from at least two countries to allow for cross-national comparison of ideas through case studies, descriptions of practice and research data from multiple countries. Through this international juxtaposition, there is a greater chance of understanding:

- that which is unique and common about the experiences, practices, and contexts of out-of-field teachers;
- how policy settings and education systems determine tolerance, attitudes towards, and response to this practice; and
- how to conceptualize out-of-field teaching and its effect, and respond as researchers, practitioners, and policy makers.

The book incorporates researchers and practitioners from Australia, Germany, Ireland, England, Indonesia, South Africa, and the United States. The countries selected for comparison more or less represent the countries for which teaching out-of-field been recognized, researched, and responded to that have come to the notice of the editors. It is possible that in the process of preparing the book that we might become aware of additional research, authors, and countries whose insights from research may be missed from the book. Teaching out-of-field is becoming increasingly highlighted in research, policy, and practice, so in the time that it has taken to write this book, new research programs have emerged, new government policies giving reference to it, and new practices emerging in schools and through professional development programs.

But when comparing research outcomes across countries, it is important to be aware that systemic factors—such as initial teacher education, schools within which they teach, and the policy settings that influence availability of support and funding—can differ between regions, states, and countries. Therefore, the extent, causes, and effects of teaching out-of-field can be common or vary internationally; further, the effect of context becomes paramount in local and global (administration) conceptualization of, and responses to, teaching out-of-field. International collaboration is vital for: understanding what counts as teaching out-of-field and how it arises transnationally; enabling greater insight into our local conditions influencing this practice; and raising possibilities for research and action to improve knowledge and practice of systems, leaders, and teachers. International collaboration has potential to highlight critical culturally specific factors that might not otherwise have been identified as significant. It also has the potential for understanding how a cultural system influences what is deemed acceptable although not desirable, that is, the conditions under which teaching out-of-field is identified as a problem or simply part of the reality of teaching. A comparative lens shifts the focus from the incidence and experiences of teaching out-of-field teachers per country, to considering culturally specific factors that influence incidence, perceptions, and responses associated with teaching out-of-field. Such cultural analysis is often missing from investigations of teaching out-of-field within a single culture.

The chapters have been organized into three parts. The overall intention is to first define out-of-field teaching and make the case for understanding it through research and analysis in Part I, explore the complexity of it in terms of the teacher, the subject as field, teacher knowledge and quality, and the learner in Part II, then explore ways of addressing the issues and dilemmas associated with the out-of-field phenomenon in Part III.

Part I Teaching Out-of-Field as a World-Wide Phenomenon: Defining and Understanding a Contextualized Issue

In Part I, the theoretical perspectives and meanings of out-of-field teaching and TAS are foregrounded in order to frame the following two parts. The three chapters provide a rationale for out-of-field teaching as a phenomenon worthy of research, beginning with Chap. 1 (Hobbs and Törner), which introduces out-of-field teaching as an international phenomenon and research, what is being researched and where, and the key stakeholders that come to bear on how teaching out-of-field is experienced. Chapter 2 (Ingersoll) explores the methodological issues associated with measuring teaching out-of-field and the need to define the parameters when trying to understand the incidence and effects. Chapter 3 (Price, with contributions from Vale, Porsch, Rahayu, Faulkner, Ní Ríordáin, Crisan and Luft) contextualizes teaching out-of-field as it is practiced and understood in a number of countries through a series of country vignettes. A cross-country synthesis of the key themes is used to set the scene for the themes presented in the following chapters.

Part II The Complexity of Teaching Out-of-Field Phenomenon

The reasons teaching out-of-field arises are many, as are its effects and the people for whom it impacts. As a result, analyses of the issues around the phenomenon need to take account of the many variables that can arise. The true impact of teaching out-of-field is in the classroom where teachers are expected to teach content that does not match their qualifications for background. We know from previous research that teaching out-of-field has a differential effect on teachers' content and pedagogical content knowledge, identity, self-efficacy, and well-being. This part explores how teaching out-of-field relates to the teacher, the knowledge, the subject, and the learner. Chapter 4 (Hobbs, du Plessis, Quinn and Rochette) provides five different theoretical lenses that have been utilized to conceptualize teachers' experience of teaching out-of-field, and the affordances and productive constraints of each of these lenses are discussed. Chapter 5 (Ní Ríordáin, Paolucci and Lyons) explores the knowledge and dispositions that teachers need when teaching across specializations. Chapter 6 (Crisan and Hobbs) then explores the influence of the maintaining curriculum as discipline bound studies and the resultant commitments, allegiances, knowledge, and skills that such school organization requires of teachers, and how these allegiances are challenged when teaching out-of-field, and with emerging restructuring of the school. And Chap. 7 (Porsch and Whannell) examines what is known about the effect of teaching out-of-field on students' experiences and learning outcomes.

Part III Confronting Dilemmas and Addressing the Issues of Teaching Out-of-Field

Due to its complexity, teaching out-of-field requires complex responses from many jurisdictions, including policy makers, school leaders, and in-service and preservice teacher education. However, these key players are subject to constraints and are beholden to particular interests that may compete with each other. In the interest of fair and equitable education, the possibilities for addressing the issues around teaching out-of-field need to take account of the scope and responsibilities of these different groups in order to identify potential for action and research at the level of administration, schools, universities and colleges, and professional development providers. Chapter 8 (Vale and Drake) explores system level responses to teaching out-of-field from the perspective of governments, subject association, and teacher unions. Chapter 9 (du Plessis, Hobbs, Luft and Vale) explores the role of the school environment and governance in supporting teachers. Chapter 10 (Campbell, Porsch, Hobbs) explores questions around what role initial teacher education might play in preparing teachers capable to teach out-of-field, given that the subject dictates teacher accreditation. Chapter 11 (Faulkner, Kenny, Campbell and Crisan) explores issues around designing professional development programs for out-of-field teaching teachers. Then Chap. 12 (Hobbs and Törner) draws together the key learnings from the preceding chapters to highlight the complexity of the issue and the importance of taking a cross-national perspective when considering response at the local and national level. Presented will be a revision to the agenda for research and action that emerged from the first TAS Collective symposium.

Linda Hobbs
Raphaela Porsch

Part I
Teaching Out-of-Field as a World-Wide Phenomenon: Defining and Understanding a Contextualized Issue

Chapter 1
Teaching Out-of-Field as a Phenomenon and Research Problem

Linda Hobbs and Günter Törner

Abstract Teacher specialisations ensure that teachers have the specialised knowledge to teach in that subject, or year level. They provide a sense of identity, and help to organise teachers around common commitments and expertise. What happens for teachers who find themselves teaching a subject or level or which they are not specialised? While we know about teaching out-of-field from practice and research, there is a need to share and learn from each other in a way that respects international differences in how this phenomenon is understood and manifested. This chapter has three intentions: to highlight the significance of teaching out-of-field as a phenomenon and a research problem; summarise the dimensions and issues associated with out-of-field teaching; and provide a rationale for taking an international perspective on examining the out-of-field phenomenon.

Keywords Teaching out-of-field · Teaching across specialisations
Definitions and dimensions of teaching out-of-field

1.1 Introduction

> YOU'VE heard a lot of pratin' and prattlin' about this bein' the age of specialization. I'm a carpenter by trade. At one time I could of built a house, barn, church, or chicken coop. But I seen the need of a specialist in my line, so I studied her. I got her, she's mine. Gentlemen, you are face to face with the champion privybuilder of Sangamon County.
>
> …
>
> As I look at the beautiful picture of my work, I'm proud. I heaves a sigh of satisfaction, my eyes fill up and I sez to myself: 'Folks are right when they say that next to my eight holer that's the finest piece of construction work I ever done. I know I done right in specializing…

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_1

From *The Specialist*, by Charles Sale (1929)

What does it mean to be a specialist? This question is at the heart of discussions surrounding teaching 'out-of-field'. Teaching out-of-field, technically, refers to when teachers teach specialisations (or year levels) for which they have no qualification or background (Ingersoll 1999; Weldon 2016). For Sale's character who revels in his accomplishments as a 'privybuilder', the aesthetic of being a specialist—the craft knowledge, skills and workmanship essential for quality—provides satisfaction, an identity as someone preeminent in his field, and a sense of pride in his work. To specialise means to become immersed and expert in a defined and bounded body of knowledge and skills such that there is coherence, connectedness and flexibility to what is known and what one can do. There is refinement borne from experience, and subtleties and nuances of what quality means permeates and is evident in the work produced.

For the subject-specialist teacher, a history of learning, knowing and using the specific disciplinary knowledge and skills through formal qualifications provides at least a background to their teaching; at most a filter that colours every pedagogical move. Even teachers who see themselves as 'teachers of students, not teachers of the subject' can often make pedagogical decisions that reflect the relationships between the nature of that subject's curriculum and subject-specific demands on student learning. For example, a mathematics-specialised teacher will understand how a sequential curriculum imposes certain demands on students, and may emphasise individual student support to 'fill the gaps' because they understand that students need to have strong foundational knowledge before they can proceed successfully. A subject specialist should understand, for example: the curriculum content structure, big ideas and relationships between ideas; teaching approaches needed to represent the content and support student learning; and how to assist students who do not understand. But above all, a specialist should know how to spin a coherent conceptual narrative, that is, how to link the ideas temporally: what to bring to the narrative and when, what to leave out and when and how to entice the learner to engage as contributors to the narrative as well as constructers of their own version of the narrative.

As with Sale's character who has carpentry as his broad field, a teacher has a set of knowledge and skills common to all teaching. A teacher who is teaching out-of-field has, in principle, this set of knowledge and skills that transcend subjects and that they take with them into all subject areas that they are required to teach. The challenge then for the out-of-field teacher is to, in the first instance, adapt what they know and can do to this new subject area; and then apprentice themselves to the new specialisation. In an ideal world, the teacher would take time to immerse themselves in the content, understand its histories and basic tenets, practice the disciplinary ways of knowing and doing, learn the teaching approaches and learning theories that reflect reformist or at least contemporary 'best practice', and practice and reflect on theories and teaching approaches implemented. Over time, the teacher would develop an appreciation for the subject and what it can do and be for their students.

In reality, however, out-of-field teachers face a number of challenges—both external (e.g. unsympathetic timetabling and cultures of support and leadership) and internal (e.g. lack of resilience and adaptability)—that can restrict, hinder or work against teacher learning. The effects of teaching out-of-field are many and varied for each individual, as are the reasons that teachers teach out-of-field, who is responsible, and the responses needed. In addition, there is a need for a way to talk about out-of-field teaching that is respectful of teachers, and does not compromise public faith in the education system and education as a profession. For example, out-of-field teaching can be considered as a technical formal condition (*I'm not qualified*), a condition of lacking the expertise (*I feel I don't have the necessary knowledge of the content or teaching approaches*), or a condition of identity and feeling out-of-field (*I feel like an outsider*) (Porsch 2016). In comparison, Hobbs (2013a, b) identified that teachers adapted to teaching out-of-field in different ways, some teachers feeling like they are 'just filling in' and hope that it is short term, others 'make the most of it' because they are committed to high-quality teaching and learning regardless of subject, and others are 'pursuing an interest' where they choose to teach the subject despite being out-of-field. Signposting this as a multifaceted and complex phenomenon within education can help to raise this as something that needs to be understood and attended to in a multi-faceted way. Is it acceptable, for example to simply accept that this is part of the teaching profession? Is there a threshold amount of out-of-field teaching at which point an education system needs to stand back and say 'too much!'? Is it acceptable to use out-of-field teaching as a long-term solution to a problem of teacher shortages or unequal teacher distribution? Serious attention needs to be given to this phenomenon so that teaching quality can be sustained, both when out-of-field teaching is needed, but also by reducing the need for it in the first place.

This book offers serious and comprehensive attention to these issues. As an introduction to this book, this chapter intends to do three things:

- **Intent 1**: **Significance**. Identify the significance of teaching out-of-field as a phenomenon and research problem internationally, and describe the labels, meanings and theories that are used by authors of this book.
- **Intent 2**: **Dimensions**. Summarise the dimensions and issues around teaching out-of-field, and introduce the theories, assumptions, tensions and dilemmas that are to be considered in the forthcoming chapters.
- **Intent 3**: **International insight**. Provide a rationale for taking an international perspective on teaching out-of-field.

1.2 The Significance of Teaching Out-of-Field as a Phenomenon and Research Problem

Teaching out-of-field arises for a number of reasons, the predominant reason being an undersupply of appropriately specialised teachers. In some countries, a general shortage of teachers exists, partly because of low status attributed to the teaching profession. Ingersoll (2002) challenges this supply/demand analysis on the basis that the problem, at least in the United States, he proposes is more of an issue of equity, with an unequal distribution of teachers away from disadvantaged schools. Certainly, data shows that in many countries that poorer or more rural schools have higher incidences of out-of-field teachers (e.g. McConney and Price 2009b). Reasons for this undersupply, therefore, can be that some schools may be more attractive than others, some school systems provide higher remuneration, and some subjects may be perceived as more difficult (such as mathematics and some sciences). Regardless of the mechanisms resulting in teacher shortages, out-of-field teaching arises because of an imperative to have teachers in every classroom, whether it is a qualified teacher specialised in the subject, or not. In this climate of teacher shortages, and under the current funding regimes and administration, without out-of-field teaching, schools can be forced to offer fewer subject choices, increase class sizes, or rely on distance education for their students. Therefore, while out-of-field teaching is not the preferred choice, it can be seen as a solution to a current problem. In any case, it is likely that out-of-field teaching will persist in many countries for some time.

The question of teachers' competence and how best to support teacher learning, therefore, becomes pertinent. A teacher's disciplinary qualifications, initial teacher qualifications, their teaching competence borne from experience, and availability and uptake of professional learning, all become part of a teacher's career trajectory. Teacher learning is a career-long process; however, opportunities to gain additional competence either through teaching experience or through additional formal qualifications potentially means that an experienced teacher is likely to have different knowledge and skills sets to when they entered the profession. At what point then might an out-of-field teaching no longer be considered out-of-field? At what point do initial teacher qualifications no longer matter for the experienced teacher?

As a phenomenon, teaching out-of-field is complex and needs to be treated as such in practice and through multilayered investigation. For teaching out-of-field to be recognised as a phenomenon, it needs to be noticed, defined and articulated. Therefore, a number of questions become critical to frame the conversations in this book: What language is used to notice it? Who is talking about it? and What is being said?

1.2.1 What Language is used to Notice the Out-of-Field Phenomenon?

A number of labels are given to this phenomenon. The label 'teaching out-of-field' is most notable, coined in the USA by Brodbelt (1990) and made popular by Ingersoll in a series of analyses of the state of teaching and teachers' qualifications from the 1990s and early 2000s. This label has been picked up almost worldwide in the research literature. In this case, we define field by the subject and the content and pedagogy specific to that subject. In the United Kingdom, the issue appears to be discussed as 'non-specialists', and this label is used within the teaching profession and through media representation of the associated issues. Given that contributions to this book have come from around the world, in this book we use two labels: ‘out-of-field’ teaching which is the more common label, as well as ‘teaching across specialisations’ (TAS), which was a label agreed upon by the TAS Collective[1] (Hobbs and Törner 2014) as being inclusive of ‘non-specialists’ teachers or teaching. In Germany, the term ‘fachfremd’ is used, which is directly translated as ‘foreign with respect to the subject’. These terms reflect the relationship of the teacher to the subject, as ‘field’ or ‘specialisation’, and the nature of this relationship: ‘outsider’, for example could be reflected in the term out-of-field, ‘foreigner’ denotes some cultural connotations, and a lack of knowledge and skills is more emphasised through the non-specialist label. The terms ‘inadequately qualified’, ‘unqualified’, ‘underqualified’ or ‘uncertified’ can also be attributed, although these labels can be debateable or misleading where teacher qualifications are universal in that teachers are registered or certified simply as teachers without reference to year level or subjects; this is the case in most Australian states, for example. Where certification is linked to specialisations, the qualifications of teachers may indeed be in question. For example in Germany teachers receive a formal qualification to teach particular subjects. Beyond the label and issues relating to ‘qualifications’ and ‘specialisations’, the variables that become the focus of analysis also determine what we consider important to know about the phenomenon. The issues surrounding measurement are discussed further in Chap. 2 (Ingersoll). International variation as to what counts as out-of-field are illustrated in Chap. 3 (Price et al.). Beyond incidence and demographics, the theoretical framing of the phenomenon determines what is interrogated and what is ignored or sidelined, as discussed in Chap. 4 (Hobbs et al.).

Broad and small-scale analysis of out-of-field teaching is being reported internationally, for example in Ireland (Ní Ríordáin and Hannigan 2009), Australia (McConney and Price 2009a, b; Weldon 2016), Germany (Bosse and Törner 2013, 2015a, b; Schueler et al. 2016; Törner and Törner 2012), South Africa (Steyn and Du Plessis 2007; Coetzer and Coetzee 2015), England (Hillman 2014), Korea (Ee-gyeong 2011), Israel (Cinkir and Kurum 2015) and the United States (Ingersoll 1998; Zhou 2012). For example, the incidences of out-of-field teaching in Germany vary from province to province, and school type to school type. Chapter 3 provides commentary on the specifics of out-of-field teaching in different countries. The fact that there are records of incidences of out-of-field teaching in many countries illustrates that it runs counter to what is approved or expected within the education systems internationally. Whether there is any effective response by regulators, policymakers, school leaders or others responsible for ensuring the quality of education is another matter. For many years the out-of-field teaching phenomenon has been the ‘elephant in the room’ or ‘tabooed’— its presence is undeniable, but either the language has been unavailable to notice or articulate it, or it is simply ignored given that it is solving a problem of teacher shortages, or unequal distribution of teachers (Ingersoll 1999).

[1]The TAS Collective is a group of researchers and practitioners with an interest in sharing and exploring issues relating to the out-of-field phenomenon.

In recent times analysis and commentary that includes the out-of-field issue have been directed to a number of subjects. The TAS Collective has thus far given voice to research relating to mathematics and science principally, although not exclusively (see Hobbs and Törner 2014). Mathematics features most strongly in the international literature, perhaps because of the high profile of mathematics and numeracy in international comparison tests such as the Trends in Mathematics and Science Survey (TIMSS). Mathematics-focused analyses of TIMSS and other mathematics-related data have been conducted in most of the OECD countries, for example Australia (AMSI 2013; Harris and Jensz 2006; Thomson et al. 2012), England (Greary et al. 2016), Ireland (Clerkin et al. 2015; Ní Ríordáin and Hannigan 2011). Science has also been highlighted, although these discussions internationally can be complicated given that 'science' can be taught as an integrated subject in some countries where a biology-specialised teacher is responsible for teaching all science disciplines in a subject called 'Science', while other countries teach science as discipline-specific subjects by teachers with a corresponding science background. These differences can make international comparisons complicated. Analyses of the issues relating to out-of-field teaching in science have come from the United States (Dee and Cohodes 2008; Neakrase 2010; Nixon et al. 2017), Australia (Bulman 2008; Harris et al. 2005; Hobbs 2013a, b; Sharplin 2014). Other subjects where commentary or analysis of out-of-field has focused include: History (Salleh 2013a, b) and Geography (Caldis 2017) given the tendency to combine Geography and History in a combined Humanities subject.

1.2.2 Who Is Talking About It, and What Is Being Said?

Who is talking about it, and what is being said? These questions are important as they show the growing presence of teaching out-of-field as a phenomenon that needs attention.

1.2.2.1 Researchers

Researchers are giving voice to the various actors or stakeholders involved: students, teachers, pre-service teachers, novice/beginning/early career teachers, school leaders, parents, policy makers, subject and discipline/learned associations, teacher and principal associations and unions. They describe processes and practices such as induction, professional development and leadership practices, putting a spotlight on the inadequacies (such as du Plessis 2005, 2018; Du Plessis et al. 2015). Researchers are also providing a language for talking about it beyond incidences, for example as 'goodness of fit' between qualification and assignments (Sharplin 2014), as a boundary crossing event (Hobbs 2013a), as a lived experience that has implications for teachers' 'at homeness' (du Plessis 2014), and as an issue of identity (Bosse and Törner 2015a, b; Hobbs 2013a), teacher beliefs and competencies (Schueler et al

2016). Issues of teacher support are a common focus of research (du Plessis 2015; Hobbs 2013a). Some researchers have focused on the minutia of classroom practice, such as focusing on the impacts on practice and classroom performance of teachers (Coetzer and Coetzee 2015; Neakrase 2010; Olitsky 2006) or their content or pedagogical content knowledge (Lee and Luft 2008), while others focus on relationships between people, such as interactions between mentors/mentees (Luft et al. 2015), and leaders/teachers (Du Plessis et al. 2015). Some are focusing on capturing the big picture of teachers in the school context (such as Du Plessis et al. 2014), and others examine the phenomenon from the system level—locally, nationally and internationally—critiquing the systems and providing recommendations for practice and policy. Researchers also provide commentary and raise the profile of the phenomenon, for example through the work of Ingersoll (1998) who identified a problem in practice and established it as a research problem that needed to be understood and attended through policy. Public academic forums are also used to profile the issues involved, but also help shape the public discourse, for example through *The Conversation* (e.g. Hobbs 2015) public inquiries (e.g. Productivity Commission 2012), and reports to government organisations that are distributed publicly (e.g. Vukovic 2017).

Higher degrees by research, such as Masters of Education and PhD/doctoral studies, offer a welcoming space for in-depth and theoretically informed analyses, potentially offering to the discourse around teaching out-of-field tremendous insight into the specific dimensions of the phenomenon. At the time of writing this book, the authors are aware of current PhD projects focusing on out-of-field teaching occurring in Germany, Australia, Ireland, Nigeria, Indonesia and the United States, some of whom have contributed to this book (Rahayu from Indonesia contributed the Indonesian case study in Chap. 3; Rochette from Australia showcased her data analysis using positioning theory in Chap. 4). Insights from past PhD studies have been provided through Australian du Plessis's contributions about her transnational study in Chaps. 4 and 9 (Crisan and Hobbs). Bosse (published also in Bosse and Törner 2013, 2015a, b) contributed insights from his German study into the identity of out-of-field mathematics teaching teachers in the early stages of Chap. 4 and was a key figure in the TAS Collective. Other doctoral studies focused on out-of-fid teaching are Neakrase (2010), Salleh (2013a) and Zhou (2012).

1.2.2.2 Teacher Educators

Professional development providers and universities are responding to a need for additional educational qualifications and teacher learning, with a number of professional development programs emerging and being reported through the literature (as discussed in Chap. 11 [Faulkner, Kenny, Campbell and Crisan]). Universities are also responding through the provision of new or modified degrees to tailor to providing new qualifications or specialisations for teachers, for example Graduate Certificates are emerging in Australia (e.g. Kenny et al. accepted), and the Professional Diploma in Mathematics for Teaching in Ireland (Faulkner et al. 2016). Universities are being funded by governments, philanthropic organisations or corporate foundations to support teacher professional development. For example, a professional development program for out-of-field mathematics teachers is delivered by the German Centre for Mathematics Teacher Education (DZLM), which is funded by the corporate foundation Deutsche Telekom Stiftung. Other Government-funded agencies are also providing professional development for teachers, for example the Teacher Development Agency in the UK (Crisan and Rodd 2011).

Contributors to this book are largely researchers and professional development providers—some are both.

1.2.2.3 Government Policy Makers and Enforcers

Government policy and direction is generally slow to respond explicitly. Governments, however, have been shown to respond to high profile unacceptable high levels of out-of-field teaching that cannot be ignored, for example in the state of Tasmania, Australia, the proportion of teachers out-of-field was 58% according to the latest *Staff in Australia's Schools Survey* (Weldon 2015, 2016); in response the government funded a new qualification at the states' only university. The funding of professional development programs to attend to the needs of out-of-field teachers is a common response and is evident in Ireland (https://www.ul.ie/graduateschool/course/professional-diploma-mathematics-teaching-level-8), and the nationally funded teacher subject specialism training in England (https://www.gov.uk/guidance/teacher-subject-specialism-training-courses). In Germany, a number of parliamentary inquiries regarding teaching out-of-field exist (see, e.g. Bürgerschaft der Freien Hansestadt Hamburg 2016), often focusing on the prevalence in a state, province or city. Some of these inquiries have resulted in databases of measures that have been taken in response, thus demonstrating that politicians are at least aware of the phenomenon. In other countries and jurisdictions teachers who are deemed out-of-field are being required to undertake further study; for example in Florida, USA, one county expects out-of-field teachers to 'complete a minimum of six semester hours or 120 in-services points in the out of field certification area to be eligible to teach out of field in succeeding years' (The School District of Volusia County 2017). Their website provides a listing of 'approved out of field teachers' for 2017–2018. This appears to be an extreme response, perhaps initiated with the intention of wanting to be 'seen' to be doing something. By comparison, governments in other jurisdictions in other countries are silent on the issue.

1.2.2.4 Associations, Unions, Councils, Authorities

Education councils and assessment authorities, as well as subject or learned associations and societies, teacher associations, and teacher and principal unions, conduct their own surveys of their members, some of which provide data on qualifications, work conditions, teacher welfare and attrition and leadership practices. Issues of out-of-field teaching are often unearthed through the quantitative data as incidences of out-of-field teachers, while the qualitative data can identify key themes. For example, issues with supply and demand and teacher distribution are raised in these reports. Teacher unions and subject associations who speak for the teachers can highlight teacher experiences, for example the New South Wales (NSW) Science Teachers Association in their newsletter, Science Education News, a letter received by an out-of-field teacher which was later reported on in a *The Conversation* blog (Hobbs 2015). The Geography association of NSW in 2016 provided a summary of out-of-field as it affects Geography teachers (Caldis 2017).

Reviews conducted by parliamentary inquiries (e.g. Productivity Commission 2012) and industry bodies provide commentary on the issues, and sometimes provide useful spotlighting of the issue if well informed by submissions (Productivity Commission 2012), but can sometimes fail to represent the issues in its complexity with teachers and their content knowledge being positioned as the focal point of change. For example, the Productivity Commission (2017) recommended that 'Teaching out of field should be addressed through targeted professional development of existing teachers willing to acquire the relevant knowledge' (p. 15). The Education Council (2018) recognised that in Australia the 'understanding of the teacher workforce is limited by a lack of robust national data' (p. 45) about teachers' qualifications and specialisations, and so is working with 'the Australian Institute for Teaching and School Leadership to implement an Australian Teacher Workforce Data Strategy' (p. 45). This is an example of Government accreditation body working with the Education Council to respond to the issues around teaching out-of-field, highlighting the significance that this issue has reached within Australia.

1.3 Dimensions of the Phenomenon

This summary of who is contributing to the discourse associated with teaching out-of-field identifies the range of issues that need to be discussed and addressed. The different stakeholders involved approach it from different vantage points and therefore see different dimensions to the problem. Researchers see it as a research problem that needs to be understood in order to inform or influence change, as indicated above. For subject associations, it is a problem of maintaining the integrity of their subject, leading to many associations providing professional development and information to improve teacher practice, but they also stand in as advocates for teachers through informing policymakers and government inquiries of the need for more teachers, greater support, better data etc. For many policymakers, it is a supply issue arising from too few teachers in some subject areas, or unequal distribution of teachers usually resulting in higher incidences in hard to staff schools or areas of disadvantage (Ingersoll 1999); this representation leads to initiatives that increase teacher supply or attract teachers to the less attractive schools and subjects. Policy makers also frame it as a teacher quality issue rather than a problem of resourcing, as discussed in Chap. 8 (Vale and Drake), although some administrations respond through the provision of funding for professional development as indicated above, and as discussed in Chap. 11. For universities, out-of-field teaching can be seen to fall outside of the responsibly of initial teacher education given the tight regulations that many countries have about what constitutes a subject specialist. The tension between generic and subject-specific conceptualisations of teaching is particularly profound for initial teacher education, however, when university entry and teacher registration requirements determine what constitutes a 'teacher' and the teachers' specialisation. These are system-level decisions, and have implications for how schools then incorporate the subjects at primary and secondary school levels. These structures then create the conditions for teachers to be considered in-field or out-of-field, or even without-field as in the case of a generalist primary teacher. These issues of teacher education are discussed in Chap. 10 (Campbell et al.).

For teachers and school leadership, the out-of-field phenomenon is a reality of the profession in many countries: for school leaders it presents as a solution to the problem of teacher shortages and a dilemma for resourcing; and for teachers it is a practice problem—how to overcome the challenges of teaching in a new area.

Indeed, in many situations and for many teachers, the prospect and practice of teaching a new subject acts as a disruptor, disrupting what they might be familiar with and feel proficient within the case of more experienced teachers or in the case of new teachers, disrupting expectations that they will be teaching as a specialist in their chosen field. Disruption is not in itself negative for a professional teacher, but it can lead to different outcomes, either positive or negative and anywhere in between. How the phenomenon is described depends on the outcomes that are emphasised. As a result, two positions in relation to these effects arise in the literature: opportunity and deficit positions.

Opportunity position: Research has shown that where teachers have some control over what they teach, where they feel adequately supported and resourced and there is a culture of innovation and collaboration amongst staff, and when the teacher adopts a disposition as learner, out-of-field teaching can lead to learning, identity expansion and new passions and interests (Hobbs 2013a, b). A teacher can develop a more comprehensive understanding of more subjects and possible links between subjects, and it can give a sense of renewal and reflection on practice. A teacher's emotions, resilience, commitments, self-efficacy and identity will influence how they orientate themselves in an out-of-field position, whether they see themselves as a learner and seek out professional development, or whether they expand or adapt their identity as a teacher of that subject and develop a 'provisional identity' (Ibarra 1999) where they try-out the new label. Bosse and Törner (2015a, b) provides a breakdown of the different responses of teachers, as does Sharplin (2014), not all leading to positive outcomes, however with respect to learning and identity expansion for the teacher and learning for the students. This view is demonstrated by the following excerpt written and published by a teacher (Selvakumaran in prep) about her experiences of being part of a team of Human Society and Its Environment (HSIE) teachers, some of whom were out-of-field:

> Although out of field teaching is often viewed as a deficit, this vignette shares personal and team reflections that highlight the positive impact when teachers view out of field teaching as an opportunity and a strategy to enhance the instructional capacity of the whole team. Working collaboratively, the HSIE team has evidence that it has strengthened teacher identities, better understood general instructional and subject-specific pedagogies, and adapted work practices to the lessons learnt. Our reflections show how valuing the experience of those working in schools is essential to flip less than ideal system realities such as out of field teaching into valuable opportunities to develop expertise. (Selvakumaran in prep)

Deficit position: On the flip side, research is also showing that disruption due to out-of-field teaching can be destructive (Coetzer and Coetzee 2015), resulting in a deficit view of out-of-field teaching as something to be prevented or eradicated. This view is justified where the stress of teaching out-of-field and the subsequent compromise to teaching competence can result in teacher stress, poor self-efficacy and disillusionment (Pillay et al. 2005; Schueler et al 2016) leading to teacher attrition. In du Plessis' (2014) research, however, it is not having to teach out-of-field necessarily that is the problem but the unsupportive and accusatory responses by principals that can result in teachers losing faith in their abilities and eventually leaving teaching. Unsupportive comments from leadership like, 'All I asked you to do was to stay in front of the students—couldn't you even do that?' (Anonymous 2013, p. 156) in situations where teachers feel vulnerable from parental critique can result in teachers losing faith in themselves and leaving teaching, as was the case for 'Colleen', a first-year mathematics and science teacher who was admonished by a parent for not knowing the Year 11 physics content:

> from that point on the Physics classes became almost intolerable for me – yet still there was nobody else capable of replacing me… Eventually I spoke to my Department Head about a possible transfer, but his reply was not helpful, telling me I was lucky to get a full-time placement, since there are plenty of new teachers still waiting. He said that a transfer after such a short time would not be considered positively, that I would need his reference, and that although I had started well, he would no longer be prepared to recommend me to other schools. (Anonymous 2013, p. 157)

Teachers' lack of knowledge of content (Lee and Luft 2008), effective teaching approaches, safety procedures (such as when teaching the sciences, technology and physical education), how to respond to student difficulties, stories of the subject, foster exploratory classroom discussion (Carlsen 1992), and how to plan (Chan and Yung 2018) are all important factors that teachers, school leaders, the whole teaching staff need to contend with when a teacher starts to teach a new subject or topic. See Chap. 5 (Ní Ríordáin et al.) for a discussion on the issues around knowledge and out-of-field teaching. Over time, support for out-of-field teachers can be removed as they usually develop enough expertise to teach without too much concern, others develop a new love for the subject and take it on as a core responsibility (Hobbs 2013a, b). Other issues that can arise related to the additional resourcing needed to support teaching (Taylor 2000), with additional strain placed on people responsible for ensuring quality teaching is maintained through the provision of support to improve knowledge of content and teaching approaches and activities, and providing emotional support where needed. Also, school leaders' knowledge of how to respond appropriately has been raised by du Plessis et al. (2015) as either contributing to teacher distress or harnessing it as an opportunity for teacher learning. The issue is further complicated by the hiring practices of principals where, for example principals prioritise other teacher qualities or factors other than teacher specialisations, such as willingness to learn or ability to relate well to students, or cheaper less experienced teachers. The following quote is from an unsolicited email from an experienced mathematics and science teacher unable to find a teaching position:

> The last school I worked at did not continue my contract at the end of the year. They chose to continue the contracts of a drama teacher and a PE [Physical Education] teacher to teach maths and science…The school I worked at in the previous year also chose to keep on a graduate PE teacher to teach a full load of science and senior biology… I found this experience very traumatic that I have been outcompeted by unqualified and inexperienced teachers. Unlike other professions your qualifications and experience seem to be a negative. (Personal communication, unsolicited email, February 17, 2018, used with permission.)

Whether out-of-field teaching is considered a 'problem' for the teaching profession is ultimately determined by the impact on students. Some research provides some indications that teacher preparation and certification strongly correlates with student achievement in Mathematics and English (Darling-Hammond 2000). Chapter 7 (Porsch and Whannell) summarises some of the data examining relationships between teacher education and student achievement. Other variables such as relationships between teachers' passions for the subjects and students engaging with the subject (Hobbs 2012), and students' preferences for teachers who know the subject and are passionate about it (Darby 2005) raise the question as to whether a teacher who lacks a background in a subject may miss an opportunity to positively influence students' affective response to and positioning in relation to the subject.

The remaining chapters of this book provide a comprehensive interrogation of many of these ideas, drawing on published commentary from a variety of sources, published research findings, and cutting-edge new findings where the research program is underway.

1.4 A Need for an International Conversation

This book is innovative because the transnational comparative lens shifts the focus from the incidence and experiences of out-of-field teachers per country, to considering culturally specific factors that influence the incidence and perceptions of, and responses to, teaching out-of-field. Such cultural analysis is often missing from investigations of this phenomenon within a single culture. A number of factors make it important to have an international conversation around teaching out-of-field:

1. Across different countries and even within countries there are different conceptualisations of, reasons for, and effects of out-of-field teaching, making it difficult to draw international comparisons of the incidences and potential impacts. International collaboration is vital for: understanding what counts as out-of-field

and how it arises transnationally; enabling greater insight into our local conditions influencing this practice; and raising possibilities for research and action to improve knowledge and practice of systems, leaders and teachers.

2. Systemic factors—such as, initial teacher education regulatory controls, school funding, governance and administration, and the policy settings that influence the availability of support and funding—can differ between regions, states and countries. Zhou (2012) raises questions, for example about the 'labour market mechanisms of supply and demand that give rise to out-of-field teaching in different contexts' (p. 4). Collaboration and comparison draw attention to systemic factors that lead to and influence both the incidence and effects of the phenomenon.
3. Since teacher education and school systems are quite different internationally, the related responsibilities, effects and potential responses to the dilemmas associated with the out-of-field phenomenon can be very different. What is possible in country A, cannot necessarily be realised in country B.
4. Teaching out-of-field has been under-researched for some time, internationally. Teacher qualifications and certification and their relationship to student achievement have been an ongoing analysis (e.g., Darling-Hammond 2000) for some years, however explicit attention to the effects of out-of-field teaching beyond incidences and student achievement has been sporadic. In the past 10 years, more countries have been documented as recognising and responding to out-of-field teaching, and more and more researchers are exploring the phenomenon in depth. The time is right to work internationally to share our insights.
5. International comparisons have the potential to highlight critical culturally specific factors that might not otherwise have been identified as being significant.
6. International comparison is important for understanding how a cultural system influences what is deemed acceptable although not desirable, that is, the conditions under which teaching out-of-field is identified as a problem or simply part of the reality of teaching.

There have been but a few international comparison studies that have explored explicitly differences between the out-of-field phenomenon in different countries. A transnational study by du Plessis's (2013) doctoral thesis, for example draws together important insights from across South Africa and Australia but does not interrogate the differences between the two countries specifically. There exist a number of studies and surveys that provide data on teacher qualifications, some of these can be used to compare qualifications with student achievement and other engagement variables (e.g. TALIS,[2] TIMSS, PISA[3]). This data can be useful for looking for trends in the data and are often reported per country. Zhou's (2012) doctoral thesis used OECD data to compare in-field and out-of-field teacher practices, distribution and supports available across countries. Evident in this dissertation is an assumption that, when

[2]The *Teaching and Learning International Survey* (*TALIS*) asks teachers and school leaders about working conditions and learning environments at their schools.

[3]The *Programme for International Student Assessment (PISA)* examines the performance of 15-year old students of science, mathematics and reading.

teachers indicated whether what they were teaching was 'part of one's academic training' as per the TALIS survey (Question 36), there is a consensus in what constitutes the subject and a subject teacher. A comparison of the teacher qualifications and teacher preparation in six countries has been edited by Ingersoll (2007), and achieves a similar collation of data as is offered in Chap. 3 of this book, although our country summaries provide additional information about how teaching out-of-field is conceptualised and defined and some known effects in order to ameliorate the assumptions that can ignore international differences. In other chapters in this book, we have attempted to explore aspects of the out-of-field phenomenon from the perspectives of more than one country.

1.5 Conclusion

By exploring the various dimensions of out-of-field teaching in this book, we hope to promote a more nuanced understanding of its complexity, including conditions that result in teachers teaching out-of-field as well as the conditions that shift the experience from a destructive one to a productive and generative one. This is a phenomenon worthy of attention as a research problem.

At the heart of discussions around out-of-field teaching is the nature of conflicting or contradictory discourses regarding the knowledge and craft of teaching and development of teaching competence and quality, and their relation to a teacher's qualifications, specialisations, and background in the discipline. What counts as 'qualified' is context dependent. For example, teacher registration in Australia does not take account of a teacher's specialisations such that a teacher is 'qualified' as a teacher only and can therefore legitimately teach any subject and year level—at the discretion of the school principal. In Germany, primary teachers are sometimes trained as subject specialists but in other states and other countries they are not.

Of critical importance here is how disciplinary knowledge is situated in relation to teachers' craft, the inherent contradictions between teaching as generic transferable knowledge and skills versus the disciplinary nature of subject teaching and learning, and the tensions between the ideal and practicalities in the face of teacher shortages.

These tensions and contradictions arise at the chalk face when a teacher is expected to teach content they are not familiar with, or have just learned for teaching purposes, and as the teacher positions themselves in relation to a role that they may not have been expecting. But responsibility for attending to the out-of-field phenomenon cannot fall solely on the teachers. Other key stakeholders, such as school leadership, those responsible for determining the policy settings around education, and those tasked with the responsibility to advocate for, support, educate and promote teachers and schools, such as universities, associations, unions, all shoulder some of this responsibility.

Research exploring these issues is emerging, however cultural variation as to what defines a person's 'field' or 'specialisation' makes international comparison difficult. Coming to understand the teaching out-of-field phenomenon becomes complex when comparing and contrasting how the phenomenon is created and perpetuated by the specific conditions of each country, even each state or province within a country. The Teaching Across Specialisations (TAS) Collective is a group of academics and practitioners from different countries exploring different aspects of the out-of-field phenomenon in an attempt to understand how and why the practice occurs in different contexts, the effects of out-of-field teaching, and what can be done to alleviate and minimise the problems that can arise. This book represents some of the research being discussed in this group and beyond.

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Chapter 2
Measuring Out-of-Field Teaching

Richard M. Ingersoll

Abstract This chapter is concerned with the empirical measurement of the phenomenon of out-of-field teaching—teachers assigned to teach subjects for which they have inadequate training and qualifications. In the 1990s, this problem began to receive much attention and it became common for major education reports and studies to include indicators of out-of-field teaching in their assessments of educational systems. However, there are a large number of different ways of defining and assessing the extent to which teachers are assigned to teach in fields for which they are inadequately qualified and, there has been little understanding of the variety of measures available, nor their differences and limitations. This chapter seeks to address this issue by describing, comparing and evaluating a wide range of different measures of out-of-field teaching that have been developed. My central point is that how one chooses to define and measure out-of-field teaching makes a difference for the amount of out-of-field teaching one finds. My objective is to clarify the strengths and limits of different types of measures in order to aid researchers in their decisions as to which is best to use in their analyses, and to help users interpret what any given measure actually indicates about the extent to which underqualified teaching exists in classrooms.

Keywords Teaching out-of-field · Measurement · Evaluation
Strengths and limitations of types of measurement

Background research for this paper was partly supported by a grant from the American Educational Research Association which receives funds for its “AERA Grants Program” from the National Science Foundation and the National Center for Education Statistics (U.S. Department of Education) under NSF Grants #RED-9452861. Opinions reflect those of the author and do not necessarily reflect those of the granting agencies.

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of “Teaching Out-of-field”*, https://doi.org/10.1007/978-981-13-3366-8_2

2.1 Introduction

The phenomenon of out-of-field teaching—school teachers assigned to teach subjects for which they have inadequate training and qualifications—has long been a widespread phenomenon in American schools (Conant 1963; Sizer 1985; Shanker 1985; Robinson 1985). It is an important problem because highly qualified teachers may actually become highly unqualified if they are assigned to teach subjects for which they have little training or education. Wider recognition of this problem grew in the U.S. with the release, beginning in the early 1990s, of the Schools and Staffing Survey (SASS), a major survey of the elementary and secondary schools and teachers conducted by the National Center for Education Statistics (NCES), the statistical arm of the U.S. Department of Education. Several analysts at NCES, including myself, discovered it was possible to accurately estimate the magnitude of out-of-field teaching using these data (e.g., Bobbitt and McMillen 1995; Ingersoll 1995a, 1996).

These analyses documented that out-of-field teaching is an ongoing and serious practice in a wide range of schools across the U.S. Since then, NCES has periodically issued research reports using this survey to closely examine the levels and variations of out-of-field teaching in the U.S (e.g., Henke et al. 1997; Smerdon 1999; Seastrom et al. 2004; Morton et al. 2008; Hill 2011; Hill and Stearns 2015). I have also undertaken detailed analyses of the SASS data on the sources of, and reasons behind, out-of-field teaching (see References section for a listing of my publications on out-of-field teaching).

The findings of this research generated widespread interest, were featured in numerous high-profile education policy reports released by groups such as the National Commission on Teaching and America's Future, the Education Trust, the National Education Goals Panel, the National Science Foundation, the Council of Chief State School Officers, and the National Science Board, and were widely reported in the national media. As a result, beginning in the late 1990s, the problem of out-of-field teaching became a major concern in the realm of educational policy in the U.S. Both Presidents Clinton and Bush, for example, made solving the problem of out-of-field and underqualified teaching a key part of their education agendas. It became common for major education reports, forums, documents, and studies concerned with teacher quality, in particular, and educational resources, in general, to include measures and indicators of out-of-field teaching in their assessments of educational systems. Moreover, numerous efforts were initiated to collect and analyze data on out-of-field teaching at local, state, national and international levels. Indeed, a comprehensive universal collection of data on the extent of out-of-field teaching became federal law in the U.S. with the enactment of the No Child Left Behind Act (NCLB) in January 2002. This legislation required school districts and states to annually assess and make public the numbers of classes in their schools taught by out-of-field teachers. With the replacement of NCLB with The Every Student Succeeds Act (ESSA) at the end of 2015, collection of such data was ceded to the discretion of states and school districts and no longer falls under the purview of federal law in the U.S.

Despite interest and attention, however, controversy and misunderstanding have surrounded the problem of out-of-field teaching, especially in regard to three issues. The first issue involves understanding and explaining the causes of out-of-field teaching. It is widely believed that out-of-field teaching is a result of either inadequate training on the part of teachers, or a result of shortages of qualified teachers. A close examination of the data shows, however, that out-of-field teaching is not primarily due to either a deficit in the quality or the quantity of teachers (Ingersoll 1999, 2001, 2004, 2005, 2008a, b, 2017). The data show that out-of-field teaching typically involves the assignment of otherwise well-qualified individuals to teach subjects that do not match their qualifications.

The data also show that out-of-field teaching frequently takes place in schools and in fields that do not suffer from teacher shortages. These findings have important implications for policy. Following the assumption that the roots of underqualified teaching lie in deficits in teacher quality and quantity, the dominant policy response to the problem has been twofold—to upgrade teacher preservice and in-service education and training standards; and to recruit new candidates into teaching (Hirsch et al. 2001; Liu et al. 2008; Rice et al. 2009; Ingersoll 2003). While perhaps otherwise worthwhile reforms, the data clearly show that such efforts will alone not solve the problem of out-of-field teaching.

The second issue concerns the outcomes of out-of-field teaching and whether out-of-field teaching is a problem and, hence, whether it is worthy of attention. It is important to acknowledge that underlying concern with out-of-field teaching is an assumption that adequately qualified teachers ought to have some background education and training in the fields they teach. Research on out-of-field teaching does not test this assumption; measures of out-of-field teaching simply indicate how many of those who teach in a particular field meet a particular standard of qualification, or combination of qualifications, in that field. Of course, having some degree of education and training in a field is no guarantee a teacher is highly qualified in that field. The assumption underlying this research is that some background is a prerequisite. In plain terms, we assume that teachers trained, for example, to teach history are unlikely to have a solid understanding of how to teach mathematics and that for most teachers it is difficult, at best, to teach well what one does not know well.

It is important to explicitly acknowledge this underlying assumption because not all share it. To be sure, there is almost universal agreement that teachers do matter, and, moreover, there exists widespread agreement with the assumption that student learning is tied to the qualifications of teachers.[1] But, there is much controversy,

[1]Unlike other occupations and professions, empirical assessment of teachers' qualifications is a well-worn path. There are large numbers of empirical studies, going back decades, devoted to evaluating the effects of preservice teacher education and preparation on teacher performance (see, e.g., Cochran-Smith & Villegas, 2014; Greenwald et al. 1996; Rivkin 2007). Typically, such studies try to assess the relationship between various measures of teachers' qualifications and various measures of the performance of those teachers' students. The findings are mixed and numerous

and little consensus, concerning how much education, what types of training, and which kinds of preparation and credentials teachers ought to have to be considered qualified in any given field (e.g., Ingersoll 2002, 2008b, 2017). One implication of this lack of consensus is that there are many ways of defining and assessing the extent of out-of-field teaching. This leads to the third issue, and the focus of this chapter, which is methodological, and involves how the phenomenon of out-of-field teaching is measured.

2.2 The Challenges of Measuring Out-of-Field Teaching

Measures of out-of-field teaching are distinctly different than most measures of teacher qualifications that have traditionally been used in educational research. Measures of out-of-field teaching do not simply focus upon the quantity and quality of the training, education and experience teachers bring to the job. Measures of out-of-field teaching focus upon whether teachers are qualified in each of the fields they are assigned to teach, once on the job. This seemingly simple distinction has important implications.

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commentators and researchers have concluded that there is little or no empirical evidence supporting the use of teacher licenses, credentials, education degrees, and certificates. But contrary to such skeptics of teacher education, a number of studies have indeed found teacher education, preparation, and qualifications, of one sort or another, to be significantly and positively related to student achievement.

For example, at the high school level (Clotfelter et al. 2010) used data on statewide end-of-course tests in North Carolina to examine the relationship between teacher credentials and student achievement. They found that teacher credentials, particularly state licensure and certification, affected student achievement in systematic ways, with magnitudes large enough to be policy relevant. Their findings suggest that the uneven distribution of teacher credentials, by the race and socioeconomic status of high school students, contributes to achievement gaps in high schools.

At the elementary school level (Riordan 2009), analyzing data from National Center for Education Statistics' (NCES) Early Childhood Longitudinal Study (ECLS-K), examined the cumulative effects of having certified teachers on students' mathematics and reading achievement. Her results showed that students who were taught by certified teachers scored significantly better than those taught by uncertified teachers, and that this had a cumulative effect; in other words, for every year from kindergarten through 3rd grade that a student had a teacher who was certified in elementary education, there was a significant increase in the student's mathematics and reading scores. The effects were greater in reading than in mathematics, but of a strong magnitude in both.

For a middle school example, in a multilevel analysis of 1992 National Assessment of Educational Progress (NAEP) data, Raudenbush et al. (1999) found that teacher education in mathematics (as measured by a major in mathematics or in mathematics education) was "consistently positively and highly significantly related to mathematics proficiency" in 8th-grade students. Likewise, in our own multilevel analyses of NAEP data, using school fixed-effects methods, we found that teacher preparation in both subject-matter and teaching methods was positively and significantly related to the proficiency of 8th-grade students in several fields. For instance, in analyzing 2003 NAEP data, we found that 8th-grade students whose mathematics teachers had a regular teaching certificate in mathematics, or had a major or minor in mathematics or in mathematics education, scored significantly higher on an 8th-grade mathematics test. We found similar results in our analyses of NAEP data for 8th-grade reading, science, geography, and history (Ingersoll et al. forthcoming).

Empirical examination of out-of-field teaching is not as straightforward as it may appear. There are a large number of different ways of defining and measuring the extent to which teachers are assigned to teach in fields for which they are, or are not, adequately qualified. Measures vary according to the standard by which they define a "qualified" and, hence, "unqualified" teacher. There are differences according to how measures define the boundaries of teaching fields and how they distinguish among one field and another. Measures vary as to whether they include all or part of those teaching in any given field. Measures of out-of-field teaching differ according to whether they focus on the numbers of teachers instructing out of their fields, on the number of classes taught by out-of-field teachers, or on the numbers of students taught by out-of-field teachers. Finally, measures vary according to which school grade levels are included in the analysis.

The central point of this chapter is that these choices are consequential; how one chooses to define and measure out-of-field teaching makes a difference for the amount of out-of-field teaching one finds. Analysts have developed over a dozen different measures of out-of-field teaching, each of which yields different estimates of the extent of underqualified teachers in classrooms. No two measures seem to agree and this raises the question—which is correct?

On one end of the spectrum, there are measures that almost "define the problem out of existence." On the other end, there are measures showing the phenomenon is a "crisis." Some measures that focus on whether teachers have an undergraduate or graduate major or a minor in the fields they teach have been criticized as "arbitrary" and "idiosyncratic." Other measures that focus on whether teachers have a teaching certificate in the fields they teach have been deemed "irrelevant." Observers often incorrectly assume that measures of out-of-field teaching solely assess whether teachers have subject-matter knowledge and possess an academic, as opposed to an education, degree in their teaching fields. While out-of-field teaching data have been reported and commented upon, both by the media and major education policy organizations, commentators often have not understood the variety of measures available, nor their differences and limitations. In some cases, major education reports have misinterpreted and mis-portrayed what particular measures do and do not indicate about the extent and variations of this phenomenon.

This chapter defines, presents, compares and evaluates a wide range of different measures of out-of-field teaching that have been developed and used by analysts over the past two decades. Moreover, while the chapter's data and discussion refer to the U.S. context, the issues are relevant to any similar educational system. My objective is to clarify the strengths and limits of each type of measure in order to aid analysts and researchers in the task of choosing and developing appropriate measures of out-of-field teaching for their particular purposes. However, technical and definitional issues surrounding measurement are not solely relevant to producers of data on out-of-field teaching. These issues are also relevant to consumers of data on out-of-field teaching—whether they be policy makers, education officials or public commentators.

Issues of measurement are central to both the diagnosis of, and solutions to, the problem of out-of-field teaching in classrooms. Understanding and addressing this

Decisions (with choices discussed)	Comments
I. Setting the Standard for a Qualified Teacher	
a.) Those who have passed a subject-area exam	data availability problems
b.) Those with a set number of courses in the field	self-report data less reliable
c.) Those with a teaching certificate in the field	the conventional standard, consistent with the standard used in states, but varies across states
d.) Those with at least an undergraduate or graduate minor in the field	a minimal standard most can agree on, but does not indicate how many teachers are fully qualified
e.) Those with both a major and a certificate in the field	a rigorous standard, consistent with federal guidelines
II. Defining Teaching Fields and Matching Them with Fields of Preparation and Training	
a.) Broadly -- e.g., mathematics, science, English, social studies	consistent with departmental divisions (at the secondary level), but masks unqualified assignment within broad fields
b.) Narrowly -- by subfield or by discipline	captures misassignment within broad fields
III. Identifying Those Assigned to Teaching Fields	
a.) Only those for whom it is their main field	easier to calculate, but overlooks a key source of out-of-field teaching
b.) All those teaching one or more classes in a field	includes all those who teach in a field, but more difficult to calculate
IV. Selecting the Entity to be Measured	
a.) Teachers out-of-field	useful for teacher supply/demand/quality analyses, but does not indicate how much out-of-field teaching each teacher does
b.) Classes taught by out-of-field teacher	accounts for how many classes a teacher has out-of-field; useful for state-to-state comparisons
c.) Students taught by out-of-field teacher	captures the "bottom line," useful for equity analyses, but more difficult to calculate
V. Choosing School Grade Levels to Be Examined	
a.) 9-12th grades	most compelling case, but less comprehensive
b.) 7-12th grades	includes junior secondary grades
c.) 7-12th grades, including teachers in middle schools	captures the high levels of out-of-field teaching in middle schools
d.) K-12th grades	most comprehensive case, but less compelling

Fig. 2.1 Five decisions in measuring out-of-field teaching

problem requires first assessing its magnitude and variations and such assessments are highly dependent upon appropriate and consistent definition. Especially in an era of increased attention to school and teacher accountability, accurately assessing out-of-field teaching is essential to accurately assessing the quality and performance of teachers, schools and students. Assessments of, for example, the classroom performance of teachers that do not take into account whether those being evaluated have been assigned to teach subjects for which they have little background, may incorrectly conclude that qualified teachers are unqualified and may unfairly hold such teachers accountable for problems which are not their fault.

After briefly discussing, below, the data used in the analyses, this chapter proceeds by reviewing in sequence five major sets of decisions confronting assessments of out-of-field teaching (see Fig. 2.1):

I Setting the standard for a qualified and unqualified teacher
II Defining teaching fields and matching them with fields of preparation and training
III Identifying those assigned to teaching fields
IV Selecting the entity to be measured—teachers, classes or students
V Choosing school grade levels to be examined

2.3 The Source of Data

The out-of-field teaching measures that are discussed and evaluated in this chapter are based on statistical analyses, I have undertaken utilizing NCES' Schools and Staffing Survey. This is the largest and most comprehensive data set available on teachers and on the staffing, occupational, and organizational aspects of elementary and secondary schools in the U.S. (For more information on SASS, see Cox et al. 2016). Indeed, this survey was specifically designed to remedy the lack of nationally representative and comprehensive data on these issues (Haggstrom et al. 1988; Ingersoll 1995b).

The U.S. Census Bureau collects the SASS data for NCES from random samples stratified by state, sector, and school level. To date, eight independent cycles of SASS have been completed since the late 1980s. (Note, the last cycle 2015–16, was renamed the National Teacher Principal Survey [NTPS]).

The data used in this chapter are from different cycles and years during which SASS was conducted. Which cycle of SASS is used does not alter the findings in this chapter since the objective of this analysis is not to document levels of out-of-field teaching at a particular time, but to compare different measures at one point in time, and moreover, there has been little change in levels over the cycles of SASS (Seastrom et al. 2004).

SASS samples typically contain over 40,000 teachers employed in over 10,000 elementary, secondary, and combined (K-12) schools. Moreover, this analysis focuses on public schools and primarily focuses on the secondary school level (grades 9–12), a decision I address in detail in part V. Throughout, this analysis uses data weighted to compensate for the over- and under-sampling of the complex stratified survey design. Each observation is weighted by the inverse of its probability of selection in order to obtain unbiased estimates of population parameters.

The validity and reliability of the data collected have been concerns for research on out-of-field teaching. Out-of-field teaching is politically sensitive, and can adversely affect school accreditation and, hence, in the past researchers have been skeptical of data on this phenomenon obtained from local or state school officials in the U.S. (Robinson 1985; Haggstrom et al. 1988, p. 52). One of the strengths of the SASS data on out-of-field teaching is that they are not obtained by asking school officials how much out-of-field teaching occurs in their schools nor by asking teachers themselves if they are assigned to teach out-of-field. SASS collects extensive information on both the daily course assignments and the educational background from its large nationally representative sample of teachers. Teachers report the numbers and types of certification and licensure they hold and the major and minor fields of study for degrees earned at both the undergraduate and graduate levels. In addition, each teacher reports the subject taught, grade level, and the number of students enrolled for each of the classes they teach each school day.

From these data, I have independently created the measures of out-of-field teaching reviewed here.

Although the data and measures presented here are drawn from analyses of the SASS, this is not the only source of data on this phenomenon and the methodological issues discussed below are not limited to this particular source and type of data. Other data sources have been used to generate data on teacher qualifications in the U.S., such as the National Survey of Science and Mathematics Education (NSSME),[2] the National Educational Longitudinal Survey (NELS:88), High School Longitudinal Study of 2009 (HSLS:09), and for international data on teacher qualifications, such as the Trends in International Mathematics and Science Study (TIMSS). The methodological issues surrounding measuring out-of-field teaching discussed below are relevant for any source of such data, whether it is based on a sample or a full count of all the teachers in a particular jurisdiction.

[2]A widely cited and used data source on teacher's qualifications is the *National Survey of Science and Mathematics Education* (NSSME). NSSME is a survey focusing on science and mathematics educational practices in public schools in the U.S. periodically conducted from 1977 to 2018 by Horizon Research with support from the National Science Foundation. NSSME is a smaller and more focused data source than SASS. For reports presenting data from NSSME, see e.g., Weiss (1994), Weiss et al. (2001), Horizon Research (2013). For an earlier widely cited report that uses NSSME data on teacher quality, see Oakes (1990).

2.4 The Measures

2.4.1 I. Setting the Standard for a Qualified Teacher

One of the key areas of debate over the definition of a qualified teacher is the relative value for teachers of subject knowledge and pedagogical knowledge. On one side of this debate are those who argue that subject content knowledge—knowing what to teach—is of primary importance for a qualified teacher. At its extreme, this viewpoint assumes that training in teaching methods is unnecessary and that having an academic degree in a subject is sufficient to be a qualified teacher in that subject. On the other side of this debate are those who argue pedagogical or methodological knowledge—knowing how to teach—is of primary importance to be qualified. In this view, in-depth knowledge of a subject is less important than in-depth skill at teaching. At its extreme, this viewpoint holds that "a good teacher can teach anything."

Others have argued persuasively that these two types of expertise are neither exclusive nor exhaustive. From this perspective, the "knowledge base" underlying exemplary teaching is far more sophisticated, complex, and broader than simply a grasp of subject knowledge and/or general pedagogical skill (e.g., Shulman 1986; Kennedy 1992; Ball and Forzani 2010). It includes numerous other distinct, specialized types of expertise, such as an understanding of student diversity, knowledge of curricular materials, understanding of how to design curricula, grasp of communication skills, understanding of student assessment, possession of classroom management skills, and knowledge of the educational context (teacher knowledge for out-of-field teaching is discussed further in Chap. 5). In this inclusive view of the teaching knowledge base, one of the most central and distinctive components lies at the interface of the subject and pedagogical knowledge,—an expertise which Shulman calls "pedagogical content knowledge"—knowing which methods to use with which subject content, for which types of students, and in which settings. This kind of expertise is distinct from both subject knowledge and generic pedagogical skill; it represents a subject-specific pedagogical expertise. For instance, one could have a Ph.D. in mathematics and also be a very good communicator, but still have little knowledge of how best to teach decimals to 9th graders, nor how this might vary depending upon the abilities and backgrounds of the students in the class.

The implications of this lack of consensus surrounding, and the multiplicity of components comprising, standards for a qualified teacher is that there are multiple standards by which to assess out-of-field teachers. Below, I review five possible standards that have or could be utilized. These are also listed in Fig. 2.1.

(a) Teacher Examination Scores

One method to assess teachers' educational and pedagogic qualifications in specific fields they teach is to screen teachers' scores in field-specific examinations, such as the National Teacher Examination or the Praxis series of exams. To date, such data have not been available in existing nationally representative sources that also include adequate data on teachers' assignments.

(b) Course Work in the Field

A second method that has been used in some analyses of out-of-field teaching assesses teachers' educational qualifications in specific fields by counting the actual number of post-secondary courses teachers have completed in those fields. However, there can be problems of validity and reliability with self-report data on post-secondary coursework. Analysts at NCES have documented that teachers can find it very difficult to accurately recollect the exact number of post-secondary course credits they have previously completed in different fields. As a result, these analysts concluded that accurate course counts require analysis of actual course transcripts—a time-consuming and expensive process if done on a large-scale basis (Chaney 1994). As a result, studies of out-of-field teaching usually turn to more readily available indicators of qualified teachers—whether teachers have particular certificates or degrees in the fields they teach.

(c) Certification or Licensure in the Field

A third measure that has been widely used in the analyses of out-of-field teaching examines whether teachers in each field hold a license or teaching certificate in that field. (For examples of publications and documents that have used this measure, see, Bobbitt and McMillen 1995; Ingersoll 2003; Seastrom et al. 2004; Morton et al. 2008; Hill 2011; Hill and Stearns 2015). States are the entities responsible for setting teacher certification requirements, and the latter usually include post-secondary coursework in the content of the field, teaching methods, pedagogy, student teaching, and passage of a teacher examination. This measure of teacher qualifications is often preferred by school officials because certification is the normal indicator by which school systems decide whether a candidate is qualified to teach in particular fields and, hence, is consistent with the kinds of measures used in state and district-level regulations and guidelines. The value of certification as an accurate and consistent indicator of a qualified teacher is, however, a hotly debated issue. The kinds of certification provided and the depth and breadth of teacher certification requirements all vary widely across states. There are large state-to-state variations in the content of teacher certification standards, especially the amounts and kinds of courses and degrees required. Some, for instance, require the equivalent of an undergraduate degree in an academic discipline, others do not (National Association of State Directors of Teacher Education and Certification 2018).

In addition to state-to-state variations in the content of teacher certification standards, there is also variation in the types of certificates issued by states. For instance, in addition to regular, standard or full certification, there are a number of less-than-full certificates available in many states, including temporary, emergency, alternative, provisional, and probationary licenses. Moreover, some states issue endorsements to teachers' certificates upon completion of coursework in an additional area of specialization. Certification-based measures of out-of-field teaching vary according to which, if any, of these less-than-full certificates and endorsements they count as an adequate qualification in any given field. In addition, because some states and also federal legislation require a different kind of certificate, or none at all, of teachers employed in charter and private schools, this measure is less useful for analyses that include those kinds of schools.

Moreover, certification varies for broad multi-disciplinarian fields, such as science and social studies. Teachers in these fields are routinely required to teach any of a wide array of disciplines and subjects within the field. But, states differ as to whether they offer certification according to these broad fields (e.g., certificates in science or in social studies) or whether they offer narrower discipline-specific certification (e.g., certificates in biology, history). The problem with the former is that simply having a certificate in the broad field may not mean teachers are adequately qualified to teach all of the subjects and disciplines within the field. For example, a teacher who has completed a bachelor’s degree in biology and has obtained a teaching certificate in science, may not be qualified to teach physics. Hence, measures of out-of-field teaching that focus on whether teachers have certificates can lead one to underestimate the amount of underqualified teaching within broad multi-disciplinarian fields—a point I will return to later.

(d) Major or Minor in the Field

Because of the above kinds of variations, many prefer a fourth measure of out-of-field teaching—whether teachers in each field have an undergraduate or graduate major or minor in that field. (For examples of publications and documents that have used this measure, see, for example, Bobbitt and McMillen 1995; Hill 2011; Hill and Stearns 2015; Ingersoll 1995a, 1996, 1999, 2017; Jerald and Ingersoll 2002; Morton et al. 2008; Seastrom et al. 2004). This measure has been criticized as “arbitrary” and “idiosyncratic”, because it adopts a different standard than education officials conventionally use to evaluate the qualifications of teachers. And, indeed, given the way this measure is typically defined it does ignore certification; the focus of this measure is on the actual majors and minors teachers have completed in the field, regardless of whether the teacher has applied for and obtained a teaching certificate in that field from their state or not. While this may seem to unfairly hold teachers to a standard they may not have been asked to meet in some states, its substantive emphasis makes it an appealing measure to many.

The strength of this measure of out-of-field teaching is that it indicates the proportion of those instructing in any given field, who lack a minimal level of educational prerequisites in that field. The major or primary field of concentration typically required by a bachelors’ and master’s degree usually entails completion of at least ten courses in that speciality or field of concentration. An optional additional concentration, or minor, usually entails a far lower standard—often as few as four to five courses in the second speciality or field of concentration. Thus, this measure of out-of-field teaching sets a relatively low standard. The power of this measure, as shown below in Fig. 2.2, is that it documents that, even at such a basic and minimal standard, there are substantial numbers of out-of-field teachers in American classrooms. In short, few parents would expect their teenagers to be taught, for example, 11th-grade trigonometry by a teacher who did not have at least a college minor in mathematics, no matter how bright the teacher. However, the data clearly indicate that this is the case.

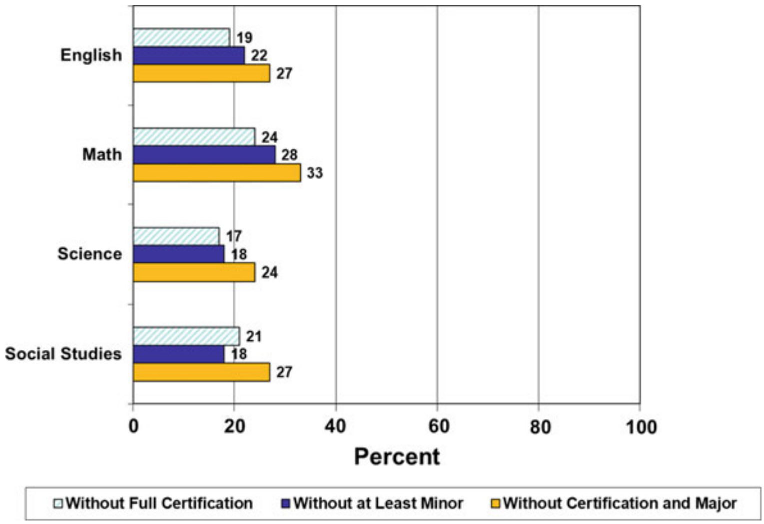

Fig. 2.2 Setting the standard for a qualified teacher (Percentage Unqualified Public School (9–12) Teachers in the Core Academic Fields, by Three Definitions of Unqualified)

Although this measure is widely used, it is also often misunderstood. Some observers assume that this measure of out-of-field teaching refers to a lack of subject knowledge on the part of teachers and it strictly indicates how many teachers have academic, as opposed to education, majors or minors in the fields they teach (e.g., Friedman 2000). For example, some assume that this measure counts a mathematics teacher with a minor or major in mathematics as in-field and a mathematics teacher with a minor or major in mathematics education as out-of-field. Underlying this assumption is the widely held view that subject-area education degrees, such as mathematics education, tend to be overloaded with required courses in pedagogy to the neglect of coursework in the academic subject itself.

To be sure, depending upon when they were completed, some subject-area education majors and minors may not have required much academic subject-matter coursework. But, this assumption is often incorrect. At least since the publication in 1983 of the *Nation at Risk* report (National Commission on Excellence in Education 1983), there has been a push to upgrade teacher education requirements, and contrary to conventional stereotypes, education degrees often require substantial coursework in an academic discipline (National Association of State Directors of Teacher Education and Certification 2018). In many universities, a degree in mathematics education requires as much coursework in the mathematics department as does a degree in mathematics itself. Hence, measures of out-of-field teaching that do not count both academic and education majors and minors would count some qualified teachers as underqualified and overestimate the latter. For this reason, analysts usually count both academic *and* education majors and minors in calculating the above major/minor measure out-of-field teaching (e.g., a mathematics teacher with a minor or major in either mathematics *or* in mathematics education is counted as in-field). Moreover, for the same reason this measure of out-of-field teaching, like most, is not especially effective at distinguishing between content knowledge and pedagogical knowledge and probably captures some degree of both.

(e) Major and Certification in the Field

The strength of the above measure—it is a minimal standard—is also a limitation. The major/minor measure defines a qualified teacher at a basic level and, hence, tells us how many teachers *are not* minimally qualified, but it does not tell us how many *are* fully qualified. The latter question is addressed by a fifth measure of out-of-field teaching—whether teachers in each field have both a full major and a full teaching certificate in that field. (For examples of publications and documents that have used this measure, see, Bobbitt and McMillen 1995; Ingersoll 1999, 2003; Education Trust and Ingersoll 2008). This measure is especially useful to policy groups that propose that a fully qualified teacher ought to have met this kind of relatively high standard in the fields they teach.

The above five measures do not exhaust the range of standards by which an out-of-field teacher can be defined. The number of possible standards is only limited by the number of possible combinations of the array of basic credentials and qualifications for which data are available in conjunction with data on teachers' assignments. But, these five measures serve to document the central point of this chapter—that there are numerous different standards by which one can define a qualified teacher and the standard one chooses makes a difference for the amount of out-of-field teaching one finds.

Figure 2.2 illustrates some of these differences; it displays estimates from SASS for three of the above-described measures of out-of-field teaching for public school teachers of grades 9–12 in the four core academic fields. These data show, for example, that 24% of all those who teach one or more classes of mathematics do not have a regular or full teaching certificate in mathematics.[3] A slightly higher amount 28%, of those teaching one or more classes in mathematics, do not have an undergraduate or graduate major or minor in mathematics, in mathematics education or in related fields, including physics and engineering. When the definition of a qualified teacher is upgraded to include only those who hold both a full major and a regular or full teaching certificate in the field, the amount of out-of-field teaching, understandably, shows an increase. For example, 31% of all those teaching mathematics in grades 9–12 do not have both a regular certificate in mathematics and a degree in mathematics, mathematics education, physics or engineering. In other words, only 67% of all those teaching mathematics in grades 9 through 12 meet this higher standard of

[3]In Fig. 2.2, regular certification is defined as all those with regular, standard, full, advanced, or probationary certification. It does not count those with temporary, alternative or provisional certificates. Probationary refers to the initial license issued after satisfying all requirements except completion of probationary period.

in-field teaching. (Note that the amount of in-field teaching is simply the complement of out-of-field teaching. Each is calculated by subtracting the other from 100%).[4]

One limitation common to the three measures of out-of-field teaching illustrated in Fig. 2.2 is that all probably slightly overestimate the amount of underqualified teaching. There are no doubt some teachers who are actually qualified to teach a particular field, despite not having a minor or major or a certificate in a particular field. Some may be qualified by virtue of knowledge gained through previous jobs, through life experiences or through informal training. Others may have completed substantial college coursework in a field, but not have received the particular qualification chosen in that field. Moreover, there may be those who are both willing and able to learn new subjects once on the job and for whom out-of-field assignments are welcome. In all of these cases, a teacher would be defined as out-of-field who is, or would soon be, qualified in that field. For this reason, the major/minor measure is useful. The premise underlying this measure is that even a moderate number of teachers lacking the minimal prerequisite of a college minor signals the existence of serious problems in schools and the data in Fig. 2.2 clearly indicate that this is the case.

Another important issue to recognize with all measures of out-of-field teaching based on majors, minors or certificates, is that most teachers have more than one of these qualifications and, hence, often have specialized in more than one field, discipline or subject. The SASS data show that virtually all public school teachers have a bachelor's degree and about half of these have a minor, in addition to a major, associated with their undergraduate degree. Another third have a second undergraduate major and a smaller portion (about 3%) have a second bachelor degree. Moreover, about one-half of all public school teachers have a masters degree and about 20% of these have either a minor or a second major associated with this graduate degree. A smaller portion (about 5%) have a second master's degree. Less than 1% have a doctorate degree. Finally, about one-third of public school teachers have more than one regular or full teaching certificate.

The implication of this for measurement is that if not all of the relevant majors, minors, and certificates held by teachers are counted the results will be inaccurate. More than one major education report has failed to take this into account, produced or reproduced measures that did not count all of the credentials that teachers have and, as a result, presented a misleading portrait. For instance, if a report that measures in-field qualifications only counts teachers' undergraduate degrees and overlooks whether they had graduate degrees in the field, the resulting data are not useful for gauging the overall extent of underqualified teaching in classrooms. This is because any teacher without an undergraduate major in a field is counted as underqualified, *even* if that same teacher had a master's or a doctorate degree in that field.

The same implication holds, of course, for data collection instruments. In order to be able to provide accurate data on the qualifications of those surveyed, teacher survey questionnaires must collect data on all the qualifications teachers hold. Some widely used data sources have not done this. For instance, the National Educational

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[4]See Bobbitt and McMillen (1995) for a more comprehensive presentation of estimates for these three types of measures.

Longitudinal Survey of 1988 (NELS:88) questionnaire for teachers failed to include a comprehensive range of answer options in its' items on teachers' undergraduate and graduate majors and minors. The list of possible options for these items included academic disciplines (e.g., mathematics, physical sciences, history, English) and simply "Education." It is unclear which of these answer options teachers, who held subject-specific education degrees (e.g., mathematics education) would choose. As discussed above, behind the design of these questionnaire items may have the assumption that education degrees do not include coursework in an academic subject. Hence, depending upon the issue under consideration, NELS:88 data may or may not be accurate or useful for assessing teacher qualifications.

A similar limitation appears in the questionnaire for mathematics and science teachers in TIMSS. The questionnaire items for the teacher-respondents' qualifications ask what the major or main area of study was for their bachelor's and master's degrees. The list of possible options for these items included academic disciplines (e.g., mathematics, biology, physics, chemistry), education subject areas (mathematics education, science education) and "other." It is unclear how those who held unlisted majors would answer these questions. For example, someone with a major in engineering, statistics, or computer science might answer "other," and consequently be classified as unqualified to teach mathematics. But, such majors could make them highly qualified to teach mathematics. Moreover, the TIMSS teacher questionnaire items did not collect information on teachers' second undergraduate or graduate majors, second bachelor's or master's degrees or doctorate degrees. Hence, reports using these data cannot reliably indicate the extent to which there are qualified or unqualified teachers of mathematics and science (see, e.g., Mullis et al. 2000).

The fact that many teachers have multiple certificates or degrees and also have specialized in one or more majors or minors is especially pertinent for those wanting to distinguish between teachers with academic degrees and those with education degrees. The SASS data show that many teachers have both an education major/minor *and* an academic major/minor and, hence, such analyses must decide which way such teachers are to be counted. Analyses that prioritize education degrees, for example, could come to the incorrect conclusion that fewer teachers have academic degrees than really do.

This is illustrated by Fig. 2.2 which shows two different ways of counting the undergraduate and graduate majors and minors of all those who teach mathematics classes at the grade 9–12 level in public schools in the U.S. Column I only counts one major or minor per teacher (hence, they total to 100%). The column prioritizes academic over education majors and minors and for each teacher it counts their major or minor that "best-fits" mathematics. These priorities run top to bottom, rows A to G. Thus, for example, "generic" education majors or minors (i.e., in a general field, such as secondary education, curriculum, guidance, etc.), listed in row F, are only counted if the teacher has no other major or minor listed in higher rows—A through E. The bottom four rows (rows D to G) of column I, which sum to 28%, comprise those I defined earlier in Fig. 2.2 as out-of-field in mathematics—those teaching mathematics who do not have a major or a minor in mathematics, mathematics education or related disciplines, such as physics or engineering. Of course, the cut-off bar distinguishing in-field from out-of-field could be set at a different level in the column. For instance, if I defined in-field in mathematics more narrowly by only counting those with an academic major or minor in mathematics, physics or engineering (i.e., rows A and B), and excluded mathematics education (row C), then the amount of out-of-field teaching would substantially increase—from 28% to 61%. But, as mentioned earlier, this would count some qualified teachers as underqualified and overestimate the latter.

Column II, on the other hand, counts all the majors and minors of all those who teach mathematics classes at the grade 9–12 level in public schools. (Because many teachers have more than one major or minor, the total of these comes to 200%). The differences between column I and column II are dramatic. For example, row F in column II shows that a sizable proportion of high school mathematics teachers—35.4%—have "generic" majors or minors in education, such as secondary education or curriculum. Data such as these are often seized upon by critics of teacher training programs in colleges of education who argue that the latter are overloaded with non-substantive education courses, to the neglect of academic coursework. The data show, however, that this viewpoint overstates the case. While many mathematics teachers do have generic education credentials, very few have *only* a generic major or minor in education (2.4% of the total, as shown in column I). In other words, the source of the problem of out-of-field teaching in mathematics is not that those out-of-field lack a specialization in a field, but rather the majors or minors they have are not mathematics related. Indeed, 41.3% of those out-of-field in mathematics *do* have academic majors or minors, but in some field other than mathematics, physics or engineering (column II, row D). In short, out-of-field teaching is not due to a lack of academic training, but to a lack of fit between a teachers' preservice training and their assignment once on the job.

This discussion of the data also illustrates another limitation of most existing analyses of out-of-field teaching. Such analyses usually indicate whether teachers do not meet a particular standard of qualification in a particular field, but they usually do not indicate the background the out-of-field teachers do possess, nor do they indicate how far out-of-field a teacher is. This latter information is relevant because not all instances of out-of-field teaching are of equal magnitude. For instance, a teacher with a degree in English is probably less prepared to teach mathematics than a teacher with a degree in chemistry and, hence, probably represents a more egregious instance of misassignment. However, most analyses do not, or cannot, focus upon these distinctions and define both of these cases similarly as out-of-field. Answering these related, but different, questions requires a different kind of analysis of the data, such as that illustrated in Fig. 2.3. Among other things, such an analysis could also tell us whether particular kinds of teachers are more prone to be misassigned than others.

Field of Education/Training	I. One "Best Fit" Major or Minor Selected (Academic Majors and Minors Given Priority)	II. All Majors and Minors Included
A). Academic major or minor in mathematics	36.1%	36.1%
B.) Academic major or minor in physics or engineering	3.2%	7%
C.) Education major or minor in mathematics education	33.2%	42.2%
D.) Academic major or minor in field other than mathematics, physics or engineering (e.g., English, art, biology, etc.)	14%	41.3%
E.) Education major or minor in field other than mathematics education (e.g., English education, art education, etc.)	11%	37.7%
F.) Education major or minor in general field (e.g., secondary education, curriculum, guidance, etc.)	2.5%	35.4%
G.) No Degree (BA or above)	0%	0%
Total	*100%*	*200%*

Fig. 2.3 Undergraduate and graduate majors and minors of public school mathematics teachers (grades 9–12). *Source* Schools and Staffing Survey

2.4.2 II. Defining Teaching Fields and Matching Them with Fields of Preparation and Training

Along with setting the standard by which to define qualified teachers, analyses of out-of-field teaching also must define the teaching fields of interest and match them with the post-secondary disciplines and specializations deemed to make a teacher qualified in each teaching field. These matching decisions are not always straightforward.

Teaching fields vary according to their breadth and boundaries. Typically, analyses at the secondary level define teaching fields parallel to conventional departmental divisions in secondary schools, such as mathematics, science, social studies, English/language arts, foreign languages, vocational education, arts/music, and physical education. Some of these departmental fields represent a single discipline, such as mathematics. But others, such as science, social studies, foreign language, and art/music, are broad, multi-disciplinarian fields comprised of a number of related, but distinct, disciplines and subjects. Analysts must decide how to define and subdivide these amalgam fields along a continuum from broad to narrow (see Fig. 2.1).

For example, a broad definition of the field of science might include anyone who teaches any science course and define as in-field those instructors with a college major or minor in any of the sciences, including chemistry, physics, geology, space science, or biology. This definition assumes that simply having a major or minor in one science qualifies a teacher to teach any of the sciences. As mentioned earlier, the obvious shortcoming of this broad definition is that it overlooks the problem of within-department, out-of-discipline, teaching; a teacher with a degree in biology may not be qualified to teach physics. Likewise, a broad definition of the field of social studies might consider within-department, out-of-discipline assignments to be in-field. But, someone with a major in economics, for example, might not be qualified to teach history.

On the other end of the continuum, a narrow definition of the sciences might subdivide the field along disciplinary lines and, for instance, require teachers of chemistry to have a major or minor in chemistry itself to be considered in-field. Likewise, a narrow definition of social studies, subdividing the field along disciplinary lines might require teachers of history to have a major or minor in history to be considered in-field.

Regardless of how broad or narrow the teaching fields, matching teaching fields to training fields is complicated by the wide array of disciplines and specializations at the post-secondary level. Often more than one undergraduate or graduate specialization overlaps with the scope and content of a particular teaching field. For instance, a degree in physics requires substantial coursework in the field of mathematics and, hence, might be considered in-field in mathematics. On the other hand, the reverse may not hold; a degree in mathematics might not necessarily qualify a teacher to teach physics courses. Likewise, there are numerous related specializations, such as literature, communications, speech, journalism, and reading, that could be defined as a match with the teaching field of English.

Figure 2.4 shows a typical scheme that I and others have used for defining teaching fields and matching them with training fields, for the core academic fields at the secondary level (see, e.g., Ingersoll 1996, 1999, 2003). Column I lists teaching fields. Column II categorizes secondary-level courses according to their teaching field. Column III matches undergraduate and graduate specializations with each teaching field.

In this set of matches, there are multiple training specialties (column III) counted as in-field for most of the teaching fields (column I). For instance, in addition to those with a specialization in mathematics, this scheme considers a teacher who has specialized (e.g., a major or minor) in physics to be qualified to teach mathematics courses. Moreover, this scheme counts both academic and education majors and minors; for example, this set of matches counts as in-field in mathematics a teacher with a specialization in either mathematics *or* in mathematics education. In addition, this scheme illustrates both broad and narrow definitions of the fields of science and social studies. In the former case, it subdivides the sciences into the life sciences and the physical sciences and, hence, examines them separately. In the latter case, it separately examines the discipline of history.

I. Teaching Fields	II. Teachers' Course Assignments	III. Teachers' Majors, Minors and Specializations
English	literature composition/journalism/creative writing reading other English/language arts courses	communications & journalism English English education literature reading education speech
mathematics	general mathematics business math algebra, elementary algebra, intermediate algebra, advanced geometry, plane/solid trigonometry analytical geometry probability/statistics calculus other mathematics	engineering mathematics mathematics education physics
social studies	social studies history world civilization political science/government	psychology public affairs & services social studies/social sciences education economics
	geography economics civics sociology/social organization other social science psychology	history political science sociology other social sciences other area, ethnic studies
history	history world civilization	history
science	general science biology/life science chemistry physics geology/earth science/space science other physical science other natural science	science education biology chemistry earth science/geology physics other natural sciences
life science	biology/life science	biology
physical science	chemistry physics geology/earth science/space science other physical science	earth science/geology physics chemistry

Fig. 2.4 Matching teaching fields with training fields

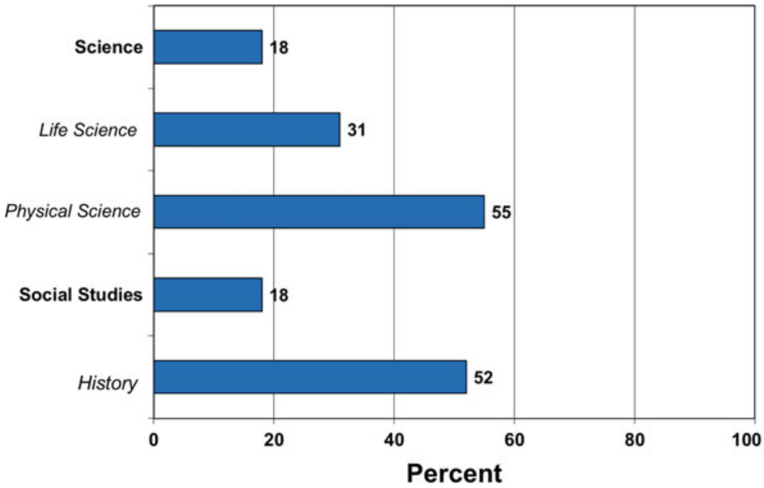

Fig. 2.5 Defining fields and subfields (Percentage of Public School [Grades 9–12] Teachers in Science and Social Studies Without a Minor or a Major In The Field, by Definition of Field)

How broadly or narrowly one defines fields makes a dramatic difference in the amount of out-of-field teaching one finds, as shown in Fig. 2.5. These data show that 18% of all those teaching one or more science courses in grades 9–12 in public schools do not have an undergraduate or graduate major or minor in any one of the sciences. However, of those specifically teaching life science or biology classes, the data show 31% are without a major or minor in biology itself. Moreover, of those specifically teaching physical science classes (i.e., chemistry, physics, geology, earth science, or space science), over half are without a major or minor in any of these physical sciences.

A similar situation holds for social studies. The data show that 18% of 9–12$^{\text{th}}$-grade social studies teachers in public schools are without an undergraduate or graduate major or minor in any of the social sciences, in public affairs, in social studies education, or in history. On the other hand, over half of all those teaching history or world civilization classes are without an undergraduate or graduate major or minor in history itself.

2.4.3 III. Identifying Those Assigned to Teaching Fields

A third decision for assessments of out-of-field teaching is identifying which teachers are assigned to each of the teaching fields. This determination is also consequential. Many analyses focus on teachers' main or primary teaching assignments—the teaching field in which they teach the most classes. For each field, these data show the proportion qualified, of those for whom the field is the main assignment. The advantage of this kind of measure is that the requisite data are often relatively easy to obtain and the measure is itself relatively easy to calculate. Perhaps, for this reason, main-field-only measures of out-of-field teaching have been featured in numerous education reports.

Although widely reproduced, this measure has two serious flaws. The first is substantive and involves the question one seeks to address with the data. From the viewpoint of policymakers seeking to focus on, perhaps, the more egregious case—teachers misassigned for the majority of their day—this measure is useful. But, to many, the important question is not *of those whose main field is mathematics*, how many are not qualified in math? Rather, the important question is—*of all those teaching mathematics*, how many are not qualified in mathematics? In plain terms, from the viewpoint of students taught by an out-of-field teacher, it little matters whether their teacher is misassigned for part or all of the day—it comes to the same thing. Main-field-only measures also suffer from a second problem—accuracy. Most teachers, especially at the secondary level, have a main or primary field or department with which they are identified and it is in this main field that they are relatively likely to have substantial education and training. But, the SASS data show that in any given year, over one-quarter of secondary school teachers teach in more than one field or department and some have more than two fields, even if fields are defined broadly. It is in these other or additional assignments that teachers most often have little education or training. In other words, main-field-only measures do not count the very teachers most likely to be out of their fields.

The difference in the amount of out-of-field teaching between measures solely focused on teachers' main fields and measures that include all those teaching in each field, regardless of whether they do it for one class or for the entire day, is dramatic, as illustrated in Fig. 2.6. These data show, for example, that only 12% of all public 9–12th-grade teachers, whose main field is mathematics, do not have an undergraduate or graduate major or minor in mathematics, mathematics education, physics or engineering. In contrast, if we include all those who teach mathematics in grades 9–12, the data show over twice as many—28%—are without an undergraduate or graduate major or minor in mathematics, mathematics education, physics, or engineering. Similar gaps hold for the other fields and, indeed, main-field-only measures provide lower estimates of out-of-field teaching than any of the other many measures discussed in this chapter.[5]

These limitations are not widely recognized or understood, but even if an education report that utilizes main-field-only measures does openly acknowledge their limitations, they are not immune from criticism, especially if more accurate measures are available. Public policy documents using measures that underestimate contentious social problems, whether they be poverty, teenage pregnancy, or underqualified teaching, are bound to be perceived as attempts to mislead, whether true or not (see, e.g., the critique by Ravitch 1999 or Smerdon 1999).

[5] See Bobbitt and McMillen (1995) for more comprehensive documentation of the gap between main-field-only and other measures.

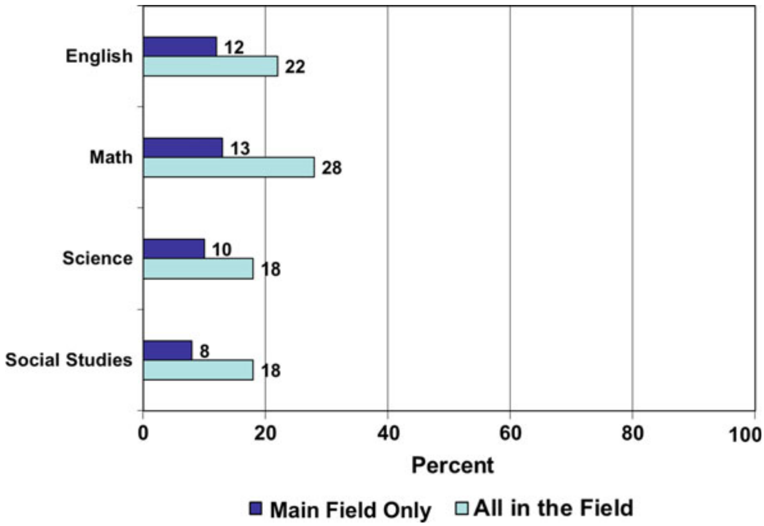

Fig. 2.6 Identifying those assigned to teaching fields (Percentage of Public School [grades 9–12] Teachers in the Core Academic Fields Without a Major In The Field, By Definition of Those in Teaching Field)

The widespread use and inaccuracy of main-field-only measures are probably tied to the kinds of regulations that exist for out-of-field teaching in the U.S. States are not only responsible for licensing requirements, but also for regulations on how teachers are employed and utilized once on the job. And most states do, in fact, have rules and policies designed to restrict out-of-field assignments. But, teacher employment regulations are often weak or rarely enforced and, finally, many states routinely allow local school administrators to bypass even the limited requirements that do exist (Robinson 1985). For example, in some states, teachers are only counted as out-of-field if they are misassigned for over half their classes per day. Perhaps because of this, most teacher's misassignments are 1–3 classes per day, out of a typical secondary-level schedule of 5 classes per day. The end result is that this way of counting out-of-field teaching almost defines the problem out of existence.

The issue of deciding who to identify as teaching in a field also has implications for the collection of data on out-of-field teaching. Accurate assessment of the extent of out-of-field teaching requires data on all of those who teach in any given field, not simply those primarily associated with a particular field or department. For instance, data collection efforts that derive their secondary-level teacher sample from school administrative lists of teachers by the department may not be able to generate accurate estimates of out-of-field teaching. One of the advantages of SASS is that it does not rely on school listings of teachers by field, but identifies teachers' fields from the extensive data collected from the teachers themselves on their daily course schedules, their education, and their certification.

2.4.4 IV. Selecting the Entity to be Measured—Teachers, Classes or Students

Measures of out-of-field teaching also vary according to the entity measured. Existing analyses have focused on three: the percent of teachers instructing out of their fields; the percent of classes taught by out-of-field teachers; the percent of students taught by out-of-field teachers (see Fig. 2.1). Thus far, this chapter has centered on the first of these three choices—teachers who are out-of-field. This type of measure is the most frequently used of the three because interest in out-of-field teaching originally arose in a context of research and policy focused on problems of teacher supply, demand, and quality. This type of measure is especially useful to those concerned with the characteristics of the teaching force and those who want to know what portion of the teaching force is not qualified in their assigned fields. But, it does not distinguish, nor weight, the amount of out-of-field teaching each teacher does. This type of measure counts teachers as out-of-field whether they teach only one class out-of-field or five classes out-of-field (unless it is a main-field-only measure). Because, as mentioned above, the data show that the former is more likely the case than the latter, counting all teachers has the opposite effect of only counting those for which the misassignment is in their main field—it can overestimate the overall amount of classes or students actually taught by underqualified teachers.

For this reason, a second type of measure is useful—the percentage of teachers' total classes taught for which they do not have a particular qualification. This measure indicates the proportion of classes offered in schools that are taught by out-of-field teachers. The SASS data show, for example, that about 15% of all grade 9–12 classes are taught by teachers without at least a college minor in the fields taught.[6] An advantage of this measure is that it largely avoids the above-mentioned problems of either underestimation (as in main-field-only measures) or overestimation (as in measures that include all those who teach one or more classes in a field). However, while this measure tells us how many classes are subject to out-of-field teaching, it does not weight for the size of classes and, hence, does not tell us the number of students so affected.

This latter question can be answered by a third type of measure—the percent of all students enrolled in each field who are taught by out-of-field teachers. This measure does an even better job of avoiding problems of underestimation and overestimation. It also illuminates the "bottom line"—the proportion of students actually exposed to out-of-field teaching and for that reason it is especially useful for analyses of inequities in student access to qualified teachers (see, e.g., Ingersoll 1996, 2004, 2008a).

Figure 2.7 compares measures focusing on the proportion of teachers teaching out-of-field and the proportion of students receiving out-of-field teaching, for the core fields at the 9–12th grade level in public schools. The data show, for instance, that while 28% of all those teaching mathematics do not have an undergraduate

[6]This measure refers to all classes in the following 8 fields: mathematics, science, social studies, English/language arts, foreign languages, vocational education, arts/music, and physical education.

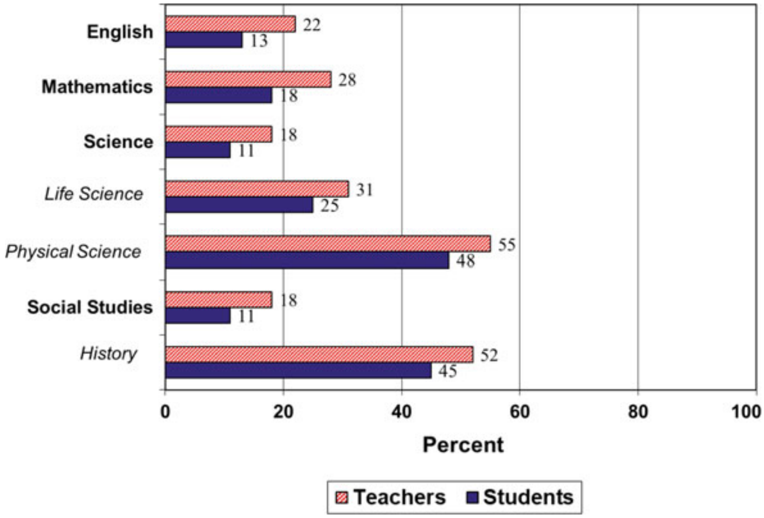

Fig. 2.7 Selecting the entity measured (Percentage of Public School [Grades 9–12] Out-of-field teaching in the Core Academic Fields, By Entity Measured)

or graduate major or minor in mathematics, mathematics education, physics or engineering, this impacts about two-thirds of this amount—18% of public students enrolled in 9– 12th-grade mathematics classes.

An additional advantage of this third measure is that it can be used to calculate the actual numbers of students affected. This is a useful and revealing statistic. For example, the SASS data show that in each of the fields of English and mathematics and history, every year well over 4 million secondary-level students are taught by teachers with neither a major nor a minor in the field. There is also a disadvantage to this student measure—it is more difficult and time-consuming to calculate, requiring cumulating for each field the class sizes of all teachers both in-field and out-of-field in order to derive the number of students both in-field and out-of-field.

2.4.5 V. Choosing School Grade Levels to be Examined

The discussion thus far has focused solely on the secondary school level and, indeed, empirical analyses of out-of-field teaching usually focus on the secondary level and usually exclude data on elementary-level teachers. This choice reflects the differences in curriculum and organization of elementary and secondary education in the U.S.

Secondary schools are typically departmentalized by fields. Most teachers employed at the secondary level are "specialists" assigned to teach specific subject-matter courses (e.g., history, typing, music) to classes of different students all or most of the day. In contrast, elementary schools are usually not divided into departments.

Most teachers employed in elementary schools are "generalists" assigned to self-contained classes where they teach multiple fields (mathematics, English, science, reading, social studies, etc.) to the same class of students all or most of the day. Hence, ostensibly, there is less possibility of cross-field, cross-speciality misassignment of teachers within elementary schools.

But, there is no reason why analyses of out-of-field teaching cannot be done for the elementary level. Although the choices made will differ, the same five decisions must be confronted (see Figure 1). Take, for example, the typical case of teachers employed in elementary schools (grades K-6) who are assigned to teach regular self-contained classes in the general fields of prekindergarten, kindergarten or general elementary. The SASS data show that of these about 95% hold a regular teaching certificate in one of these same fields and about 85% have completed an undergraduate or graduate major or minor in one of these same fields. Hence, for these two standards for a qualified teacher, the data indicate 5% and 15%, respectively, are out-of-field in these fields.

Although there may be a clear boundary, in substantive terms, between elementary and secondary education, in practical terms, that boundary is far less clear. In the U.S., schooling takes place in a variety of overlapping organizational entities—elementary schools, middle schools, junior high schools, senior high schools, secondary schools and combined schools. These entities widely vary in the sets of grade levels they include: K-12; 1–6; 1–8; 6–8; 7–9; 7–12; 9–12. These variations have implications for measurement. Analyses of out-of-field teaching must decide which of these different types of schools and grade levels to include. For example, analyses of secondary-level teachers differ according to whether they focus solely upon the upper secondary, high school grades (i.e., 9–12th), or whether they include junior high schools and focus upon all the secondary grades (7–12th). In the latter case, analyses further vary as to whether they include 7th and 8th-grade teachers that are employed in middle schools. The latter is an especially thorny issue because middle schools, by definition blur the boundary, and lie in-between, elementary and secondary schooling. Some middle schools are primarily organized like elementary schools; hence, 7th- or 8th-grade teachers in these schools are treated as generalists assigned to teach multiple fields in self-contained classes to the same group of students for all or most of the day. Some middle schools are primarily organized like departmentalized secondary schools; hence, 7th- or 8th-grade teachers in these middle schools are treated as specialists assigned to teach subject-matter classes to several classes of different students for all or most of the day. Some middle schools are organizationally mixed and have a combination of departmentalized instruction and self-contained classes.

Choosing the grade levels to be examined can also be influenced by one's perspective and values. There are opposing views over which grade levels most warrant qualified teachers and whether grade-level differences in the amount of out-of-field teaching are good or bad. On one side are those who argue that because qualified teachers are a scarce resource, it makes sense to place the most qualified teachers in the most advanced courses. In this view, classes at the senior high grade levels require a greater level of mastery and training on the part of teachers than those at, for instance, middle school levels and, therefore, getting an in-field or out-of-field teacher is more consequential for students at the former level. Hence, in this latter view, assignment of the most qualified teachers to teach at the highest levels is a matter of efficiency (e.g., Glazer 1987). Some in this group go further and argue that out-of-field teaching in the junior high and middle school grades is of little consequence.

Others argue the opposite, that it may be more important for students at their younger and more formative years, such as those in middle schools, to be exposed to qualified teachers (e.g., Friedman 2000). I know of no analyses of out-of-field teaching have empirically tested either of these viewpoints; research on out-of-field teaching simply examines whether students at different grade levels experience different amounts of out-of-field teaching.

The SASS data show that, indeed, these grade-level choices are consequential. Which grade levels are included makes a difference for the amount of out-of-field teaching found, as illustrated in Fig. 2.8. The data show, for example, that 28% of those teaching one or more mathematics classes in grades 9–12 in public schools do not have an undergraduate or graduate major or minor in mathematics, physics, mathematics education, and engineering. When the scope of secondary is broadened to include those teaching 7th and 8th grades, as in junior secondary schools, the amount of out-of-field slightly increases to 31% for math. Finally, if we even further expand to include the relatively small number of elementary school subject-matter “specialists” assigned to teach “enrichment” and “pull-out” courses (e.g., mathematics, science) to classes of different students all or most of the day, the level of out-of-field teaching goes even higher, to 46% in math. (Note the change in life science, physical science and history when including all of K-12 is negligible, no doubt because these kinds of courses are rarely taught at that level). Very few analyses include the latter subset of K-6th-grade subject-matter teachers because there is little consensus as to how much subject knowledge ought to be required of elementary teachers.

It should also be noted that even though there is more misassignment at the lower secondary level, this problem is not absent at the senior high level. SASS data document, (not shown here), for example, that 24% of 12th-grade public school students enrolled in mathematics classes are taught by teachers without a major or minor in mathematics or related subjects, such as mathematics education, physics or engineering. Moreover, at the 12th-grade level, 41% of public school students in physical science classes are taught by someone with neither a major nor a minor in either chemistry, physics, geology, earth science, or space science. (For more detailed data on grade-to-grade differences, see, Ingersoll 1996, 1999, 2003).

There are also some methodological limits to these distinctions. Teachers’ actual course assignments do not always conform to the categories chosen for analysis and it is very difficult to exclude from the analysis the portions of teacher’s assignments that lie outside of the grade levels selected. For example, teachers employed in junior high schools or in combined (K-12) schools might be assigned to teach classes at both the 7th-grade and 9th-grade level in the same semester. Analyses that decide to focus solely on those who teach in 9–12th grades will most likely find it difficult to exclude the non-9–12th portions of such teacher’s schedules. Hence, the separation between different sets of grades is not always “clean” and slippage can occur across

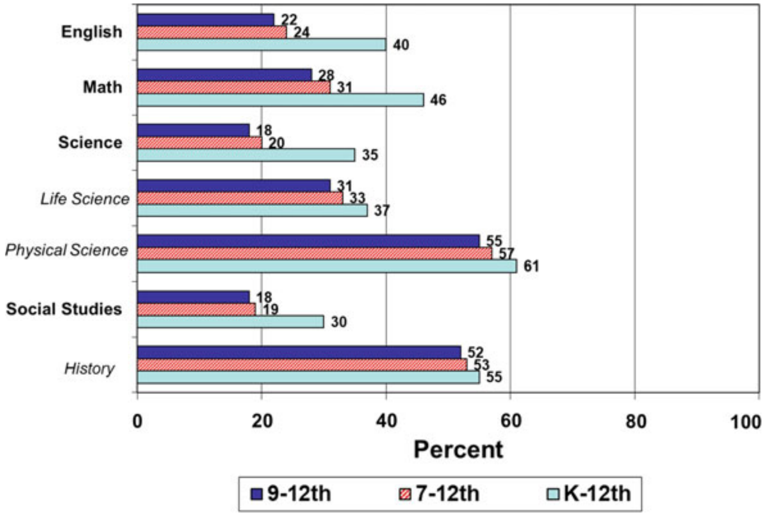

Fig. 2.8 Choosing grade levels to be examined (Percentage of Public School Teachers In The Core Academic Fields Without a Major or Minor In the Field, by 3 Sets of Grade Levels)

boundaries, resulting in a slight contamination of the data and slight differences in the results—a problem that can be fixed if the analyst has access to information on the grade levels of each of the classes taught.

2.5 Conclusion

The above discussion does not exhaust all the issues and choices related to the empirical assessment of out-of-field teaching, but it does cover the major decisions confronting assessments of this phenomenon. The main point of this chapter is that these measurement decisions are consequential; different measures result in different estimates of out-of-field teaching. As the data show, these differences can be dramatic. For instance, some measures find less than one-tenth of social studies teachers to be out-of-field, while other measures indicate that well over half of history teachers are out-of-field. One type of measure finds 12% of English teachers underqualified, another type finds over twice as many underqualified English teachers. One kind of measure finds just one-tenth of those teaching science out-of-field, while another measure, focusing on physical science alone, finds five times as many underqualified teachers. The question arises—which is correct?

The most problematic are main-field-only measures—those that focus only on teachers in each field for whom it is their main field. These provide lower estimates of out-of-field teaching than most other measures. They have also been among the most commonly used measures. But these measures are both inaccurate and misleading.

In a technical sense, other than this one exception, all of the above-discussed measures are correct—their differences result from the fact that they simply look at the same phenomenon in different ways. Depending upon the purpose and audience to be addressed, they do, however, vary in their usefulness.

For example, for those interested in documenting how many teachers are assigned to teach subjects for which they do not meet minimal standards of preparation, the most useful measure is probably one that focuses on the portion of all those teaching the core academic subjects (science, mathematics, social studies, English) at secondary school level without at least a college minor in the field, broadly defined.

For those interested in documenting how many teachers are assigned to teach subjects for which they do not meet official state standards of preparation, the most useful measure is probably one that focuses on the portion of all K-12th-grade teachers teaching in fields or subjects without a regular state certificate, license or endorsement in that field or subject.

For those interested in documenting how many teachers as assigned to teach classes for which they do not meet high standards of preparation, the most useful measure is probably one that focuses on the portion of senior secondary teachers teaching in fields or subjects without both a regular state certificate and an undergraduate or graduate major in that field. For those interested in documenting inequities in access to qualified teachers between different types of students, the most useful measures are probably ones that focus on the portion of either classes or students in K-12th grades taught by teachers without a basic or minimal level of background—at least an undergraduate or graduate minor in that field.

The central lesson here for both producers and consumers of data on the phenomenon of out-of-field teaching is to choose carefully the measure, or preferably measures, to be utilized, and understand and explicitly acknowledge the strengths and weaknesses, advantages and disadvantages of each.

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Chapter 3
Teaching Out-of-Field Internationally

Anne Price, Colleen Vale, Raphaela Porsch, Esti Rahayu, Fiona Faulkner, Máire Ní Ríordáin, Cosette Crisan and Julie A. Luft

Abstract This chapter presents vignettes from six countries regarding the phenomenon of Teaching Across Specialisations (TAS) or as it is often known teaching out-of-field. The vignettes provide an overview of the education system and policies and practices relating to teacher education, certification, recruitment and assignment to subjects or year levels. They also provide insights into how teaching out-of-field is conceptualised, if or how it is officially reported, its extent and importantly, any local, state or national responses to teaching out-of-field. The six countries included are Australia, Germany, Ireland, the United Kingdom, the USA and Indonesia. These

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_3

countries have been selected because they have the most available published research relating to teaching out-of-field. The vignettes have been written by researchers and academics from each country who is working in the field. The vignettes highlight the need for a nuanced understanding of the phenomenon as it occurs in different contexts including both commonalities and differences. The chapter concludes with an overview of the occurrence of teaching out-of-field from an international perspective and provides a synthesis of the key insights gleaned from the vignettes. These insights are further elaborated in subsequent chapters to facilitate a deeper understanding of the phenomenon.

Keywords International perspectives · Teacher assignment · Vignettes Teaching out-of-field · Teaching across specialisations

3.1 Introduction

Over the past decade, researchers have begun to examine and report on the phenomenon of teaching out-of-field as it occurs across a range of international settings. This research indicates that there are commonalities in relation to the extent, possible causes, implications for students, teachers and education systems, attitudes about it and responses to it, but there are also differences. This, of course, is not surprising as even at a practical/technical level education system, the way teachers are educated (or trained), teacher certification and assignment practices and understandings about teacher quality and the very nature of teachers' work vary both within nation states and across national borders. The phenomenon of teaching out-of-field cuts across a range of deeply contested issues regarding not only the nature of teachers' knowledge and teachers' work but even more broadly how knowledge itself has, could or should be divided into traditional (Cartesian) subject areas such as mathematics, science and social science.

Given the varied ways in which teaching out-of-field is defined and understood internationally at a practical/institutional level, philosophically and attitudinally there is great value in gaining a broader international perspective. International comparisons have the potential to highlight culturally specific factors that might not otherwise have been identified. Beliefs about the nature of teaching influence how teaching out-of-field is formally and informally understood and defined and therefore recorded, reported and importantly addressed. Understanding culturally specific variables that impact on the way teachers' knowledge and work is defined impacts on the extent to which the phenomenon of teaching out-of-field is deemed acceptable and a normal part of teaching or as a problem that needs redressing.

Thus it is insightful, as with any educational phenomenon within an increasingly globalised education system, to examine teaching out-of-field from different country perspectives, as local contexts matter. International collaboration is vital for understanding what counts as out-of-field teaching and how it arises transnationally; enabling greater insight into how local conditions influence this practice; and raising possibilities for research and action to improve knowledge and practice of systems, leaders and teachers. This chapter provides an overview of teaching out-of-field in a number of countries, from which we can extract some key themes. The vignettes will provide an introduction to the phenomenon of out-of-field teaching as it currently exists across a range of international settings and will form the basis for further detailed exploration of the phenomenon in subsequent chapters.

3.2 Australia

3.2.1 Education System

There are three school system providers in Australia—the public or government school system, the Catholic school system and private or independent schools. Each of these systems provide schooling for students from preschool to upper secondary, typically in early childhood settings (less than 5 years old), primary schools from years K−6 (5−12 years old) and secondary schools from year 7−12 (12−18 years old). However, many schools in each system provide schooling for students in more than one sector. For example, many new schools in high growth metropolitan areas are K−9 schools, with schools catering for upper secondary (year 10−12) serving a much larger area. Accessing secondary schooling for students living in remote locations, including remote indigenous communities, is difficult. These students access secondary schooling remotely or leave home and attend boarding schools in near or far away towns and cities. These characteristics of the Australian education system have implications for out-of-field teaching and teaching across subject boundaries.

3.2.2 Teacher Education and Certification

In Australia, both state and federal governments have a role in policy and funding of schooling. Up until 2014, state governments controlled school curriculum, requirements for qualifications and teacher education course accreditation. This meant that not only were there some differences in administration and regulation of the public school system, there were also some differences in the secondary subject specialisation requirements across the systems. The national entry and course requirements for secondary teaching specialisation specified 'at least a minor[1] study… and a minimum of one-quarter of discipline-specific curriculum and pedagogy studies' (AITSL 2011, p. 14). The requirements recommend completing a major study to teach senior secondary level (year 11 and 12) and for some disciplines such as physical education. These new requirements were higher for some subject specialisations in some Aus-

[1]Minor study is defined as two years of tertiary study equivalent to two units of first year study followed by two units of second year study.

tralian states than their previous minimum standards. The Australian Government has also mandated new requirements for primary teacher course accreditation so that teacher education student complete specialist studies in mathematics, science or a foreign language as a means of improving the quality of primary teachers who will still be regarded as generalist teachers.

3.2.3 Terminology Used for Teaching Out-of-Field

'Teaching across subjects' is not a term that is used in Australian education staffing or policy documents or by administrators and principals in systems. Whilst 'out-of-field' is used in some recent reports on teaching staff, the most common term used to describe teachers who are teaching subjects or year levels without completing specialist requirements is 'less qualified' (Vale et al. submitted). This term is commonly used by principals.

3.2.4 Teacher Assignment Policies and Practices

In all but one state in Australia, New South Wales, teachers are registered as teachers rather than teachers of students in a particular sector or year level or of particular secondary subjects. In New South Wales, graduating teachers receive 'approval to teach' specific subjects or levels of schooling from the registration body. However, this approval does not constrain teacher appointment or subject allocation which is at the discretion of the principal.

In the Australian public school sector, school autonomy with respect to the appointment of teachers varies from state to state. Victoria is the most autonomous; principals advertise and appointment of all staff. In Western Australia, there are varied models with for example, the recently established Independent Public Schools allowing principals to advertise and appoint staff directly and other public schools having a centralised state staff allocation system. Where the appointment of staff to schools is more centralised, principals still have the autonomy to allocate staff to teach out-of-field.

3.2.5 Reporting and Incidence of Teaching Out-of-Field

Reporting and tracking the incidence of out-of-field teaching in Australia overtime has proved problematic, due to differences in and changes to requirements for qualification between states and nationally. Weldon (2016) provided further analysis of the Staff in Australian Schools 2013 report to take into account of the changing definitions. Three definitions of out-of-field were used when reporting the findings shown

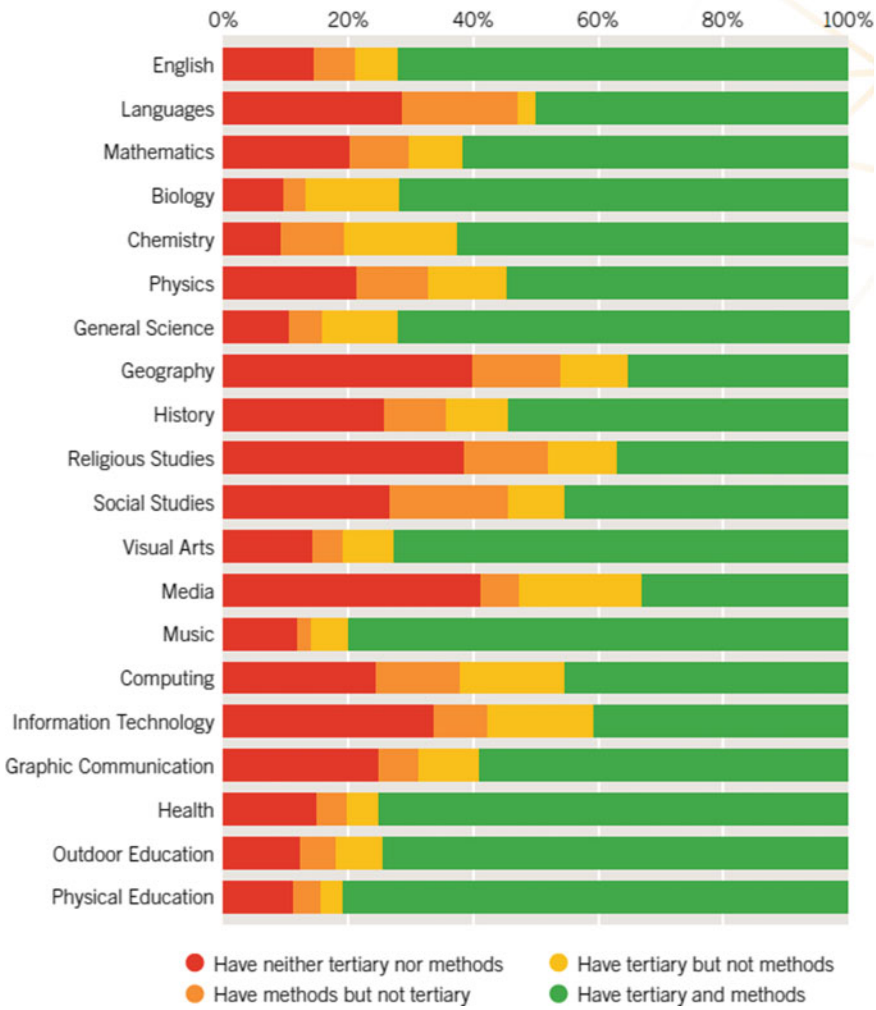

Fig. 3.1 Proportion of year 7—10 teachers teaching out-of-field in selected subjects. (*Source* Weldon 2016, Fig. 1, p. 3)

in Fig. 3.1. The highest incidence of out-of-field teaching is for humanities subjects such as media, geography and languages. Among the STEM subjects information technology, physics and mathematics have the highest incidence of out-of-field teachers. However, these data are likely to be underestimates as the definitions used when gathering data only identified study of at least one second-year tertiary subject rather than completing two second-year subjects. Note that Science is normally taught in year 7—10 as General science, therefore a teacher with a physics background for example, is required to teach the other science disciplines.

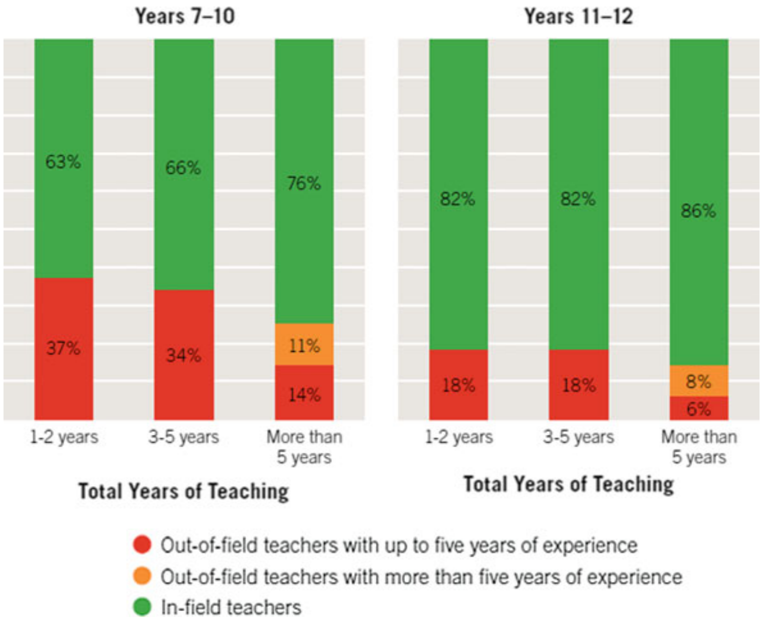

Fig. 3.2 Proportion of year 7–10 and year 11–12 teachers teaching out-of-field. (*Source* Weldon 2016, Fig. 5, p. 10)

Figures 3.1, 3.2 and 3.3 provide information about the incidence of out-of-field teachers according to year levels, location and socio-economic status. However, these figures report findings that use the original SiAS definition of specialist as having 'either studied the subject at a second-year tertiary level or above, or trained in teaching methodology for that subject at tertiary level' (Weldon 2016, p. 2). This definition then potentially includes teachers with a primary teacher qualification. Figure 3.2 includes information about the number of years teaching experience as less than 5 years and more than 5 years and show that a higher proportion of less experienced than more experienced teachers are teaching out-of-field. Another Australian study reported that up to 23% of graduate teachers with secondary discipline specialisations qualifications are teaching out-of-field (Mayer, Doecke, Ho, Kline, et al. 2014) with secondary graduates with specialisation in humanities, the arts and health and physical education the most likely to be teaching out-of-field.

Figure 3.3 shows the incidence of out-of-field teachers, using the SiAS definition of in-field, is highest for secondary schools in remote and provincial locations and low socio-economic schools. Consequently, schools in Northern Territory and Tasmania have the highest incidence (40% and 37%, respectively). Surprisingly, Victoria has a relatively high incidence (32%) since there are fewer remote locations when compared with other states. The incidence of out-of-field teaching does not vary much between school systems.

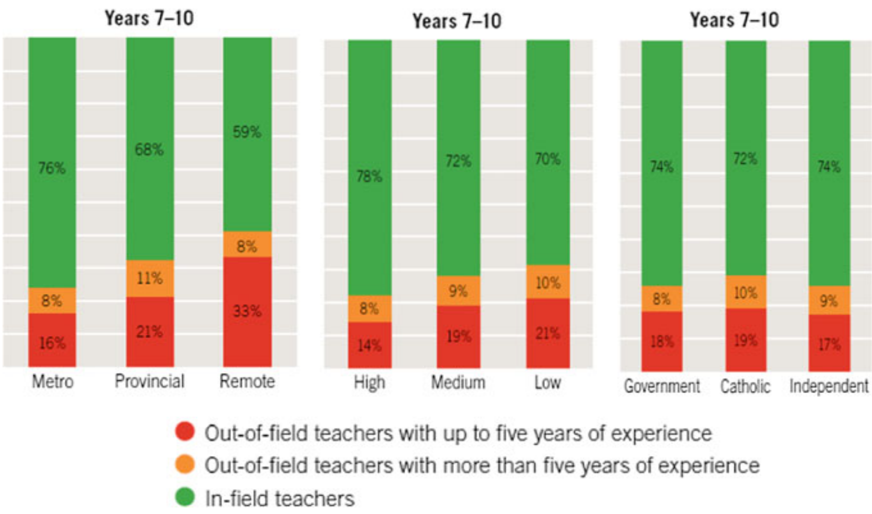

Fig. 3.3 Distribution of out-of-field teaching by location, socio-economic status and system. (*Source* Weldon 2016, Figs. 6, 7 and 9, pp. 10 and 12)

The effect of out-of-field teaching can also be considered from the student perspective. The 2011 Trends in Mathematics and Science Survey (TIMSS) report found 34% of year 8 mathematics students and 14% of year 8 science students were taught by teachers with neither a tertiary major in the subject or teacher education for the subject compared to the international average of 12% and 8%, respectively.

3.2.6 Responses at a National, State or Local Level

Across Australia, a number of projects have used financial assistance to attract teachers to take up positions in remote and provincial locations. However, retaining teachers in these schools beyond the initial contract, continues to be a problem (Handel et al. 2013). Almost all states have implemented professional learning programs for out-of-field teachers, though the structure of these programs varies and are not necessarily ongoing or still operating. In New South Wales, the University of Newcastle is an example of a university that offers enrichment courses for mathematics teachers.

In Western Australia, the state government has implemented the SWITCH program which is a tailored training program to support: http://www.det.wa.edu.au/careers/detcms/navigation/teachers-and-school-leaders/career-opportunities/switch-program/

- Primary teachers to teach in secondary subject areas of need: science, mathematics and design and technology.

- Secondary teachers to teach in an additional specialist learning areas. Currently, mathematics, science and design and technology.
- Lower secondary science teachers to teach upper secondary physics, chemistry and maths.
- Teachers with languages experience to teach primary languages.

The WA state government provides funding for the course fees, teacher relief and other expenses where required. Courses are offered via tender by universities and can range from short courses (from one day) to Graduate Certificate level (e.g. one semester). Similarly, in Queensland, a restructuring of their school system to with the rest of the states and territories by bringing ‘grade 7’ into the secondary school (previously in primary school), has seen Graduate Certificates offered to teachers.

In Tasmania, Graduate Certificates were introduced specifically to attend to the high proportion of out-of-field mathematics and science teachers (Kenny and Hobbs 2015).

In the state of Victoria, a Graduate Certificate in STEM Education is offered through the State funded STEM Catalyst’ program, and was muted initially to support a junior teacher and a more leading teacher from 30 disadvantaged schools in the state (http://www.education.vic.gov.au/about/news/Pages/stories/2017/storiescatalyststem.aspx).

At a national level, a related to supply issues, the Teach For Australia (TFA) program was initiated to meet the shortfall of teachers (https://www.education.gov.au/teach-australia-0). While not specifically attending to marinating the quality of teaching by out-of-field teachers, programs such as TFA and other state-run initiatives designed to stimulate teacher recruitment is important for reducing the need for out-of-field teaching.

Providing professional learning, and funding and resources to enable mentoring, coaching and support in planning, teaching and assessment through collaborative practices is urgently needed for early career teachers as they transition from teacher education to teaching positions to teach within their specialisation and across subjects. Mentoring for example, has been shown to be critical in a smooth transition of early career teachers into the profession. Most states have a policy that enables new teachers to have a formal mentor and have slightly reduced teaching hours to support their transition, however, it is at the principal’s discretion as to whether both of these allowances are provided.

3.3 Germany

3.3.1 Education System

The Federal Republic of Germany consists of 16 independent federal states which have the full authority on education both at schools and universities. As a consequence, their policies are different and influenced by the parties running the government (see e.g. Cortina and Thames 2013). Although there are some common features of teaching out-of-field in Germany, differences in regulations between the states complicate generalisations. The way initial teacher education, particularly in primary school, is organised can be one potential reason for the situation of teaching out-of-field. Future teachers need to study two subjects and gain a master's degree for teaching at secondary school level in all states, however, for primary education two, three and only in some states even more subjects are to be chosen (Porsch 2017). In the primary sector, it is possible to gain teaching certification without having studied mathematics for example which results in a large extent of mathematics being taught in primary schools by teachers who can be considered out-of-field.

3.3.2 Teacher Education and Certification

Initial or pre-service teacher education is university-based. In Germany, it is followed by a pre-service school-based training phase, which in the German context is also called the 'second phase'. By the end of this second phase, which takes up to 2 years, teachers graduate by completing their (first or second) state examination in both their subjects—or in even more subjects if they become primary school teachers. That means teachers receive their formal qualification that allows them to teach a specific subject at a specific school level after having gained both a master's degree and having passed a state examination at the end of a school-based training. As in-service teachers, there is the possibility of receiving this qualification after participating in an intensive in-service training course. With a few exceptions (e.g. second-career teachers) all other teachers teaching a subject without the subject-specific qualification, have to be considered as out-of-field teachers. One needs to know, however, that at primary but also at lower secondary level, particularly in year 5 and 6, the class teacher principle exists. That means that teachers normally teach the majority of subjects in one class. Due to a teacher shortage, especially in some subjects (STEM but also art and music education), the application of this principle has the consequence that German teachers might be faced with teaching out-o-field on a regular basis.

3.3.3 Terminology Used for Teaching Out-of-Field

In Germany, teachers are politically and juristically not considered as out-of-field in a subject if they have received a formal subject-related qualification (so-called *Lehrbefähigung*).

3.3.4 Teacher Assignment Policies and Practices

If there is a lack of teachers for teaching a specific subject, it is the task of the principal to cover all needs at his/her school. Thus, it is at the principal's discretion. Reasons for the existence of teaching out-of-field have for many years been related to the shortages in teacher supply. For example, the job market for science graduates is optimal and many students within teacher education courses at university are accepted into science-based industry although their previous study had been orientated towards schools.

3.3.5 Reporting and Incidence of Teaching Out-of-Field

Since the principal at a school is responsible for covering all teaching assignments at his/her school, deficiencies in specific subject teacher supply have not been captured by provincial administrations so far and there has been little or no public discussion of the phenomenon of teaching out-of-field. As indicated above, teaching out-of-field in primary school has not been considered a problematic issue since primary school teachers are seen as generalists even if they have passed an education for specialists. Thus, no data from the government or the states is available. A representative national survey among 4th graders and their teachers in all 16 states conducted in 2011 provided some numbers on the incidence of the phenomenon (Richter et al. 2012): On average, 34% of all German teachers and 48% of all mathematics teachers regularly teach out-of-field. However, the numbers differ considerably between the states. By comparison, there are more sources on the incidence for lower secondary level available. Again, there is data from a national survey conducted in year 9 shows that up to 36% of mathematics teachers, 31% of biology teachers 25% of chemistry teachers and 34% of physics teachers teaching in year 9 have no formal qualification for teaching the respective subject.

A recent study on language skills in year 9 indicates that up to 14.3% of German teachers and up 14.7% of all English as Foreign Language (EFL) teachers teach without having obtained the subject-specific qualification in their initial teacher training (Hoffmann and Richter 2016). Unfortunately, a distinction between school types is not made. The yearly report by the state of North-Rhine Westphalia with a variety of school types shows that the incidence of teaching out-of-field is highly related to the school type and the year level but also differs between subjects (latest version MSW 2016). For example, in the school year 2015/16, about 3.1% of the EFL lessons at *Gymnasien* and 18% at *Gesamtschulen* were taught out-of-field. These school types are comparable to High schools and provide the chance to enter university after 12 or 13 years. At schools that provide education only from year 5 to 10 teaching out-of-field occurs more often. For EFL, the proportion of EFL lessons taught out-of-field ranges from 15 to 43.3% (MSW 2016, p. 114–116). Official data on the number of teachers teaching out-of-field in higher secondary or tertiary education are not known. To sum up, the incidence of teaching out-of-field in Germany differs between subjects but also between school grades and school types and can be regarded as a substantial number.

3.3.6 Responses at National, State or Local Levels

Studies into teaching out-of-field and its consequences are relatively new in Germany and have only played a marginal role in the German research context. Discussions regarding how to handle the phenomenon of teaching out-of-field were mainly instigated by the publications of Törner and Törner (2012) with respect to the subject mathematics. The phenomenon was regarded as a taboo subject in Germany (Törner and Törner 2012). Since then, a growing number of research studies on the effects on students' proficiency (e.g. Klusmann and Richter 2014) or on teachers' identity (Bosse 2016) have been conducted. Moreover, training for professional development targeted at teaching out-of-field teachers are offered in some German states. Accompanied by intensive research are courses by the *German Centre for Mathematics Teacher Education* (DZLM) that is addressing the needs of teaching out-of-field mathematics teachers. It should be noted that these courses have been initiated by the university sector rather than being driven by the government. Within an IQB-cooperative study for the first time research into teaching, out-of-field is being discussed in particular whether out-of-field teaching is leading to a restricted competence for the students. Richter et al.'s (2012, 2013) study found that this was the case and thus the phenomenon has gained momentum within educational research in Germany for the first time.

Despite these university and researcher-led initiatives to address the potential problems caused by out-of-field teaching, while the phenomenon remains an expedient solution to teacher shortages in mathematics, science and other subject, any coherent system-level initiatives to handle out-of-field teaching are potentially limited.

3.4 Indonesia

3.4.1 Education System

According to Law 20/2003 on the National Education System, the Indonesian Education System is organised into three paths: formal (conducted in schools), non-formal (out-of-school education) and informal education (education within the family and community). The national formal education system consists of basic, secondary and tertiary education. Basic education consists of 6 years in elementary school and 3 years in junior secondary school. Senior secondary school consists of general and vocational senior secondary schools.

As it is shown in Table 3.1, there are general school and Islamic school. The Ministry of Education and Culture (MOEC) supervises the general schools, while Ministry of Religious Affairs (MORA) has the responsibility to supervise the Islamic schools.

3.4.2 Teacher Education and Certification

In the Indonesian language, a teacher is called *guru*. In Javanese, a guru is someone who must be *digugu* (obeyed) and *ditiru* (as a role model). Yet, one of the famous Indonesian artists once wrote a song, entitled Oemar Bakrie, to describe the teachers' condition in Indonesia. In this song, he depicted an Indonesian teacher, called Oemar Bakrie, who is a loyal civil servant, who has been a teacher for more than 40 years, a humble man who goes to school by his cycle, his students become ministers, professors, doctors and he is underpaid. The Law No. 14 of 2005 on Teachers and Lecturers passed and changed this condition. Based on this law, the teachers, who have been certified, earn increased salary. The World Bank report (2015) clearly stated that the certification doubled a teachers' take-home pay. However, the report also highlighted that after a decade of the enactment of the law, the increased teacher's salary did not lead to substantial improvement in student learning outcomes. Numbers of teacher by academic qualification and status in Indonesia are listed in Table 3.2.

According to the World Bank Report (2015), there is an oversupply of teachers as the teacher training colleges produce 250,000 university trained teachers each year, while the school system needs only 50,000−100,000. In addition, UNESCO (2015) stated that there is an uneven distribution of teachers, with an oversupply in urban areas and shortages in very remote locations.

3.4.3 Terminology Used for Teaching Out-of-Field

Teaching out-of-field is known as nonlinearity in Indonesia. According to the Minister of Education and Culture Regulation No. 46 of 2016, the nonlinearity is between teachers' certifications and the subject they teach. Before the enactment of the new regulation in 2016, the former Minister of Education and Head of Cooperation at the Ministry of Education and Culture called teaching out-of-field as mismatch, which was defined as the unsuitability between the teachers' education background and the subject they teach (Zakaria 2014; Nuh 2013). Currently, scholars in Indonesia often use both nonlinearity and mismatch interchangeably to denote teaching out-of-field.

Table 3.1 Education system in Indonesia

<table>
<tr><th rowspan="2">Age</th><th colspan="4" rowspan="2">School/Education level</th><th colspan="3">Out-of-school education</th></tr>
<tr><th>Non-formal</th><th colspan="2">Informal</th></tr>
<tr><td>>22</td><td colspan="4">Post graduate/islamic post graduate</td><td rowspan="3"></td><td rowspan="9">Courses</td><td rowspan="9">Family education</td></tr>
<tr><td>19–22</td><td colspan="4">Higher education/islamic higher education</td></tr>
<tr><td rowspan="3">16–18</td><td colspan="4">Senior secondary school</td></tr>
<tr><td colspan="2">General</td><td colspan="2">Vocational</td><td rowspan="2">Apprenticeship
Packet C</td></tr>
<tr><td>General senior secondary school</td><td>Islamic general senior secondary school</td><td>Vocational senior secondary school</td><td>Islamic vocational secondary school</td></tr>
<tr><td>13–15</td><td colspan="2">Junior secondary school</td><td colspan="2">Islamic junior secondary school</td><td>Packet B</td></tr>
<tr><td>7–12</td><td colspan="2">Primary school</td><td colspan="2">Islamic primary school</td><td>Packet A</td></tr>
<tr><td>4–6</td><td colspan="2">Kindergarten</td><td colspan="2">Islamic Kindergarten</td><td>Play group</td></tr>
<tr><td>0–3</td><td colspan="4"></td><td>Day care centre</td></tr>
</table>

Source Shah et al. (2015)

Table 3.2 Numbers of teachers by academic qualification in Malaysia

School level	Academic qualification							Total
	<=Senior high school	D1	D2	D3	Bachelor	Master degree	Ph.D	
Kindergarten	**110,742**	**9.440**	**32,382**	**3,097**	**18, 657**	**115**	**1**	**174,429**
Civil servant	19,977	770	5,955	336	5134	63	–	32,235
Non civil servant	90,765	8670	26,427	2761	13,518	52	1	142,194
Elementary school	**417,389**	**11,529**	**589,034**	**23,841**	**207,074**	**1,161**	**4**	**1,250,032**
Civil servant	266,331	7,213	505,119	15,328	152,090	1,077	2	947,160
Non civil servant	151,058	4,316	83,915	8,513	54,984	84	2	302,872
Junior high school	**39,133**	**36,202**	**37,446**	**72,822**	**299,319**	**3,277**	**7**	**488,206**
Civil servant	16,060	29,327	25,785	51,441	164,388	2,870	4	289,875
Non civil servant	23,073	6,875	11,661	21,381	134,931	407	3	198,331
Special needs	**1,666**	**238**	**2,883**	**803**	**4,514**	**50**	**–**	**10,154**
Civil servant	577	68	1,839	505	2,644	42	–	5,675
Non civil servant	1,089	170	1,044	298	1,870	8	–	4,479
Senior high school	**6,301**	**1,200**	**4,082**	**22,964**	**189,753**	**3,106**	**27**	**227,433**
Civil servant	2,056	345	2,071	13,853	101,752	2,436	5	122,518
Non civil servant	4,245	855	2,011	9,111	88,001	670	22	104,915
Vocational school	**5,172**	**1,341**	**2,842**	**23,942**	**120,764**	**1,691**	**9**	**155,761**
Civil servant	900	230	834	9,429	40,282	1,054	3	52,732
Non civil servant	4,272	1,111	2,008	14,513	80,482	637	6	103,029
Primary islamic schools	**94,755**	**23,580**	**45,933**	**9,086**	**31.312**	**108**	**–**	**204,774**
Civil servant	4,478	4,480	18,267	2,358	6,997	45		36,625
Non civil servant	90,277	19,100	27,666	6,728	24,315	63		168,149

Source Jalal et al. (2009)

3.4.4 Teacher Assignment Policies and Practices

According to the Education Law 20/2003, lower government is responsible for the principle responsibilities, authority and resources for delivery of education. This responsibility comes with significant decision-making power being transferred to schools themselves. Local education offices are now playing a much more significant role in planning, implementing and monitoring the delivery of education services. Decentralisation has given authority to schools and community members to participate more in local education decision-making. Ministerial Regulation 44/2002 mandated the School-Based Management (SBM) which assigns responsibilities—such as school planning and budgeting, staff management and curriculum development—to principals and school committees (Tobias et al. 2014).

3.4.5 Reporting and Incidence or Teaching Out-of-Field

Although teaching out-of-field has attracted considerable attention from the Ministry of Education and Culture, current data on teaching out-of-field is not available in any official statistics or anecdotal evidence. The most updated data was provided by Zakaria (2014) in his article published in the Education and Culture Journal—Ministry of Education and Culture, in which he noted that from 33 provinces in Indonesia, 21% elementary school classroom teachers (homeroom) are out-of-field and 54% of religion teachers nationwide are out-of-field. This data was taken in 2012.

3.4.6 Responses at National, State or Local Level

Several teacher reforms have been implemented. In 2003, the government issued Education Law, followed by Teacher Law in 2005 when teacher certification was implemented, teachers' salary doubled and the education bar set higher (4-year degree). Many regulations were issued for both pre-service and in-service teachers including teachers' linearity between the certification and the subject they teach in 2016. It is believed that the Ministry of Education and Culture has monitored all of the implemented policies and conducted evaluations but the Ministry does not publish the results of its monitoring and evaluation to the public. Such information is important as transparency to the public regarding the effectiveness of the government policy.

3.5 Ireland

3.5.1 Education System

Schooling in Ireland is compulsory from the ages of 6–16. Children begin primary school at age 5 approximately and undertake 8 years of schooling. They then enter secondary school at age 12 approximately where they undertake 5−6 years of school. Post-primary education in Ireland is broken down into the Junior Certificate (lower secondary, year 1−3) and the Leaving Certificate (upper secondary, year 5−6). An optional Year 4—Transition Year—exits between the Junior and Leaving Certificate. The Irish post-primary education system operates on a centralised education model and contains very prescriptive syllabi, with a state examination after year 3 and year 6. State examination of the Leaving Certificate dictates entry into further and tertiary education. The vast majority of primary and post-primary schools in Ireland are public and state funded (Coolahan 2015).

3.5.2 Teacher Education and Certification

The teaching profession in Ireland is held in high esteem and school leavers who go into the teaching profession are amongst the top 15% of academic achievers at school level (Hyland 2012). In much of the policy documentation in the 90s, the government commended the work of teachers, acknowledged the importance of their roles and set out a proposal in which teaching careers could be supported. Since 2012 teaching is an all graduate career, and given its relatively high salaries and status, it continues to attract high-quality entrants to the teaching force (Coolahan 2015). Teachers teaching at primary level need to complete a specialist primary teaching degree/postgraduate programme and are teachers of all subject areas (no subject specialism exists at primary level in Ireland). Post-primary teachers have to complete degree level studies in their specific subject area(s) and complete a specialist post-primary teaching qualification.

3.5.3 Terminology Used for Teaching Out-of-Field

The Teaching Council of Ireland has defined teaching out-of-field in its 2011 report, *Policy on the Continuum of Teacher Education* report, ‘Teachers teaching a subject in respect of which their qualifications do not meet the subject-specific criteria set down by the Teaching Council for registration purposes’ (Teaching Council 2011, p. 5).

3.5.4 Teacher Assignment Policies and Practices

In theory, the teaching profession in Ireland is governed by the Teaching Council. In practice, however, the Teaching Council has greater control over the regulation of initial teacher education and registration than on in-service teaching and school governance arrangements. Deployment of teachers and timetabling lies with individual school principals.

3.5.5 Reporting and Incidences of Teaching Out-of-Field

Constraints such as teacher quotas, subject offerings, location and contractual issues have led to out-of-field teaching occurring at the post-primary level in Ireland. Like many countries worldwide, the phenomenon of out-of-field teaching in Ireland has not been characterised extensively in education literature. Only mathematics teaching at post-primary level has been examined. One relatively early study found that 28% of teachers teaching mathematics, within schools partaking in a PISA study, were qualified in disciplines which did not include mathematics as a major component (Cosgrove et al. 2004). A Royal Irish Academy (2008) report estimated that 80% of teachers teaching mathematics in Ireland were unqualified to do so. However, a clear need emerged for evidence-based research analyses to be conducted on the level and impact of out-of-field mathematics teaching in the Irish post-primary context, rather than relying on 'soft' or anecdotal evidence up to that point. Accordingly, a national quantitative study was undertaken to establish a factual basis for further research into mathematics teacher education (Ní Ríordáin and Hannigan 2009). One of the significant findings emerging from the research was that nearly half (48%) of teachers teaching mathematics were not specifically qualified to do so. The qualified mathematics teachers were predominantly assigned the state examination years (year 3 and year 6) and upper secondary mathematics classes. Out-of-field teachers were predominantly deployed in the non-exam years and with less academically able (Foundation and Ordinary level mathematics) and younger (year 1 and year 2) students. There was also cause for concern given that a considerable number (63%) of these out-of-field teachers felt suitably qualified to teach mathematics even though their degrees and postgraduate qualifications do not contain sufficient mathematics.

3.5.6 Responses at a National, State or Local Level

To improve the quality of mathematics teaching and to support practicing teachers, CPD opportunities were considered an immediate priority by the government. Accordingly, a Professional Diploma in Mathematics for Teaching (PDMT) was developed as a blended learning, national programme designed to develop out-of-field teachers' content and pedagogical knowledge through 60 credits of mathematics and 15 credits of mathematics pedagogy-related material. The first intake into this programme was in September 2012. Applicants to the PDMT must meet the following criteria in order to be considered for a place on it, teachers must be:

- Currently, teaching mathematics in a post-primary school in Ireland;
- a qualified, post-primary teacher in a discipline other than mathematics; and
- registered with the Teaching Council.

In terms of academic eligibility, there is no specific mathematics requirement for the programme. However, there is an expectation that the teachers applying have mathematics to a standard which is beyond the second level, i.e. an expectation that they have studied some undergraduate mathematics.

Several research projects are currently being undertaken in an attempt to evaluate the effectiveness of the PDMT from a number of theoretical perspectives. For example, examinations into teachers' subject and pedagogical content knowledge before and after undertaking the course have been carried out, in conjunction with a doctoral study examining teacher identity after undertaking the course. These findings, along with more extensive details regarding how the PDMT is coordinated and run, can be found in Chaps. 5 and 11. Although the programme may be considered to be in its infancy, it provides a format and key insights for professional development in an international context, which have not been documented up to this point.

3.6 United Kingdom

3.6.1 Education System

The school system in England is directed centrally by the Department for Education, which sets educational standards and regulations.

Children between the ages of 3 and 5 are entitled to 600 h per year of optional, state-funded, preschool education. Full-time education in England, UK is compulsory; it begins at age 5 through to age 16. After age 16, young adults are required to continue their full-time education. The age at which a student may choose to stop education is commonly known as the 'leaving age' for compulsory education and this age was raised to 18 by the Education and Skills Act 2008. Most students move from primary to secondary school at age 11. Many secondary schools offer education for students until age 18; however, students may choose to enter a Sixth Form or Further Education (FE) college, apprenticeship, or traineeship at age 16 where they will stay in full-time education until the age 18.

Schools in England are state-funded or private (independent). State-funded schools include maintained schools, voluntary aided schools (which are mostly of a religious nature), academies, and free schools. Higher education in England is provided by Higher Education (HE) colleges, university colleges, universities and private colleges. Students normally enter higher education as undergraduates from age 18 onwards, and can study for a wide variety of vocational and academic qualifications.

3.6.2 Teacher Education and Certification

Teaching is a graduate profession into which there are two main routes: (i) university programmes of study and (ii) in-school training.

University programmes of study offer teacher training courses for both undergraduates and postgraduates as:

- a 3-year or 4-year undergraduate degree, combining the study of one or more academic subjects with professional training in aspects of education) and
- the Postgraduate Certificate in Education (PGCE).

The PGCE route is a popular route for secondary school teachers, and most have a subject specialisation based on their first degree (https://www.prospects.ac.uk/postgraduate-study/teacher-training/routes-into-teaching last accessed 19th February 2017). Both university routes involve trainee teachers spending significant blocks of time in-school classrooms under the supervision of practicing teachers (in-school subject mentors).

> Across England there are school-led training options for graduates who want hands-on training in a school such as School Direct and Teach First and School-centred initial teacher training (https://www.prospects.ac.uk/postgraduate-study/teacher-training/routes-into-teaching last accessed 19th Feb 2017).

If applying for teacher training in a priority subject (biology, geography, mathematics, physics, chemistry, computing, design and technology or a language), applicants who need to acquire more subject knowledge in these subjects may still be able to train to teach these subjects (and be eligible for the bursaries they attract) by building up or refreshing your existing knowledge with a Subject Knowledge Enhancement (SKE) programme. SKE programmes are available all over England at universities, schools or third parties. They can be completed before, or alongside some or all of the teacher training and are available full-time or part-time, classroom-based or online. Most people do a short course lasting 8–12 weeks immediately before the start of their training course. SKE courses are designed to bring participants subject knowledge up to the appropriate standard needed to teach at secondary level.

3.6.3 Terminology Used for Teaching Out-of-Field

In England, a 'specialist mathematics teacher' is a teacher with Qualified Teacher Status, who has a relevant post A-level qualification where 'A level' is the standard university entrance requirement for university entrance.

3.6.4 Teacher Assignment Policies and Practices

Regardless of the training route they follow, all trainee teachers must meet the Teachers' Standards (Department for Education 2013) at an appropriate level before the Qualified Teacher Status (QTS) can be awarded. QTS is needed by teachers to work in all maintained school, and may also be required by some independent schools, academies and free schools. The Teachers' Standards are set by the Secretary of State, and also are used to assess teachers' performance following their training as part of the annual appraisal process. Following their formal training, teachers start their careers as Newly Qualified Teachers (NQTs) with QTS. They are supported by in-school mentors and are assessed against a set of national standards during a statutory 12-month induction program. This model is designed to link initial teacher education and practical effective professional practice.

3.6.5 Reporting and Incidence of Teaching Out-of-Field in England: The Case of Mathematics

The demand for mathematics teachers in England has outstripped supply: of mathematics lessons in state schools in England in November 2012, 18% were taught by non-specialists, indicating a shortfall of 5,500 'specialist mathematics teachers' (Hillman 2014, p. 23), and this shortfall of 18% is also reported in the 2014 government statistics. The 2015 statistics on teacher supply in England gathered by the Department for Education revealed '79.8% of mathematics lessons taught to pupils in year groups 7−13 were taught by teachers with a relevant qualification; a decrease from 82.7% in 2013' and '75.8% of teachers of mathematics to year groups 7−13 held a relevant post A-level qualification (down from 77.6% in 2013)' (Ross 2015, p. 13). The shortage of specialist mathematics teachers continues to be an issue for secondary schools in England.

3.6.6 Responses at National, State or Local Levels

To improve the quality of mathematics teaching and to support practicing teachers, CPD opportunities were considered an immediate priority by the Government. One such CPD opportunity was the *Mathematics Development Programme for Teachers* (MDPT) launched by the Teacher Development Agency (TDA) in 2009. This course was for secondary school teachers who aimed to improve their knowledge of mathematics along with their pedagogical skills in mathematics teaching yet do not have a post A-level mathematics qualification nor an initial teacher training mathematics specialism. To be enrolled on such a programme, the teachers needed to also be supported in their application by their current Head Teacher, who needed to ensure that the participants had mathematics teaching on their timetable during the training year and the following year.

The successful applicants had to be from schools that provide education for pupils within year 7−11 (11−16 years old) of secondary school education, had to have some mathematics teaching experience and had to have completed their teacher training, had to have achieved their QTS as well as completed their NQT year. To be eligible to enrol on an MDPT course, teachers had to satisfy these two criteria: 1. Their degree that qualified them for QTS should not have not 'mathematics' (or 'mathematical sciences' or similar) as part of the degree subject title; 2. They had not undertaken initial teacher education (ITE) in secondary school level mathematics.

The course tuition fees were fully funded by the TDA for teachers from maintained schools, special schools and academies. Teachers from independent schools and further education colleges had to pay a fee of £4000. TDA also provided supply cover funding for teachers funded by them for days of the course that took place in school time. Each school was under obligation to provide evidence to show that supply cover costs have been incurred and would be able to claim for these costs (up to a maximum of £150 per day). Each school was expected to provide a suitable mentor for the teacher, such as an experienced member of the mathematics department.

There were two elements of the summative assessment for this programme: a required structured portfolio assessed at 60 H-level credits and an optional essay assessed at 30 M-level credits. In the event that a participant attended and participated in the course but had not successfully completed the MDPT, the participant received a certificate of attendance.

The first intake into this programme was in September 2009. A participant was eligible for a financial incentive of £5,000 at the end of the course provided that he or she had: 1. Successfully completed the course, gaining the H-level credits; 2. Had 80% attendance rate or better; 3. Had confirmation from their Head Teacher that they would be teaching the subject in a maintained secondary school, special school or academy in England after the conclusion of the course. In terms of academic eligibility, this course was for secondary school teachers who aimed to improve their knowledge of mathematics along with their pedagogical skills in mathematics teaching yet do not have a post A-level mathematics qualification nor an initial teacher training mathematics specialism.

The MDPT course run by UCL Institute of Education, University College London (Crisan and Rodd 2011), was one of the eight similar national courses. It aimed to provide professional development for teachers who had the aspiration to enhance their subject and pedagogical knowledge in mathematics and to become confident and competent teachers of secondary mathematics The findings of research undertaken by Crisan and Rodd (2011, 2014) alongside this programme, along with more extensive details regarding how the MDPT was coordinated and run, can be found in Chaps. 5 and 11.

In 2011, in England, the MDPT course described above was decommissioned and replaced by a cheaper-to-run 20 day subject knowledge enhancement course for non-specialist teachers. In England, Crisan and Rodd (2014) introduced the term non-specialist teachers of mathematics. These courses shared many of the MDPT programme design features, with the exception of the school-based element, and implications for assessment approaches.

In 2015, the National College for Teaching and Leadership in England launched another initiative to address the shortage of teachers of mathematics and physics in England, UK: the Training Subject Specialist Teachers (TSST) aimed at improving the mathematics and physics subject knowledge of non-specialist teachers and those teachers looking to return to the profession and increase the number of hours taught, by offering school-led teacher subject specialism training opportunities. The aim is for a total of 15,000 participants to have undertaken the training by July 2020, at no financial cost to the participant. The TSST programmes follow a school-led model where lead schools design and deliver TSST in secondary mathematics and/or physics to meet local and regional needs.

Teachers eligible for TSST include: (i) Non-specialist teachers who are currently teaching mathematics or physics (either full-time or in addition to the specialist subject); (ii) teachers whose specialism is not mathematics or physics, but who could potentially teach mathematics or physics in addition to their main subject; (iii) teachers who want to retrain as mathematics or physics teachers; (iv) teachers wishing to return to the profession who need to update their subject specialism knowledge.

3.7 USA

3.7.1 Education System

Students in the United States can attend public schools or private schools, with most students attending public schools. Most of the funding and oversight of the public schools is the responsibility of the state/local government, and not the federal government. Property taxes are a major source of school funding. This oversight of schools includes the standards that will be taught to students and the assessment of student learning. The qualifications of teachers and the process by which they are evaluated are also guided by state/local policies. Within each state, there are school districts that contain elementary schools (kindergarten—5th/6th grade), middle schools (6–8th grades) or high schools (9–12th grade). Most districts contain schools that range from elementary to high school.

3.7.2 Teacher Education and Certification

In the US, there are many different paths and ways to complete an initial teaching certificate. The two broad areas are traditional and alternative routes, and again—there is significant variation within these routes. The most common traditional routes consist of acquiring a teaching certificate from the state after the completion of a 4-year Bachelor of Science in Education (BSEd) program or a 5-year combined BSEd and Master of Arts in Teaching (MAT) program. These programs have coursework in the field of education, specified work in classrooms, and often involve higher education faculty as instructors. Upon completion of the coursework, which aligns with state policies for teacher certification, potential teachers often take various exams and are recommended by the institution for their certificate in teaching. With adequate scores and a good recommendation, potential teachers receive their teaching certificate.

Alternative programs can vary from virtually no teacher preparation coursework to a 2-year MAT program following an undergraduate degree in a subject area. These programs differ from traditional programs in the composition and sequencing of the coursework, and they often have a variety of people involved in the instruction of the course. Alternative certification programs were developed in order to increase the number of teachers in the US system, and to explore different paths towards teaching. Alternative certification programs still have to comply with state policies. However, the policies are addressed in different ways. For instance, most states require student teaching, which is a period of time in a classroom under the guidance of a mentor. In an alternative route, student teaching may not exist, and the new teacher may just have weekly meetings with a mentor to discuss his or her teaching. In the alternative certification route, a teaching certificate is earned when the probationary period of teaching has been completed and various state requirements have been met.

In the US, these different certification routes and each states' own scope and sequence for teacher certification contributes to uneven knowledge thresholds among teachers (National Council on Teacher Quality 2010). For instance, in the area of science, many state policies do not adequately determine if teachers have mastered the content they are teaching. Instead, some states have a general content area certificate, which is a collection of courses that count as content expertise. According to the National Council of Teacher Quality (2010), 'all but 11 states allow secondary science teachers to obtain general science certifications or combination licenses across multiple science disciplines (pg. 1).'

General certificates are a problem for a teacher can be assessed as '*highly qualified*,' but have no deep understanding of the field. For instance, middle school science teachers, who have a general certificate, maybe teaching courses in which they have only a course or two in each content area. In Georgia, for example a 7th grade science teacher who is 'highly qualified' in *general science* will teach biology, physics, chemistry, and earth science. If this teacher completed a K–8 certification program at a major university, he/she may only have two or three courses in science. Even though the initial certification program complies with the guidelines for 'highly qualified' at the state policy, the degree may not adequately prepare a middle school teacher to teach science. As a result, a teacher with a general certificate, which is most often a middle school teacher, can be assigned to teach any number of classes that are outside of his or her expertise.

The problem of out-of-field teaching is not just found among middle-level teachers; it also occurs at the high school level. High school teachers certainly have more subject matter coursework than their K–8 counterparts. Typical degrees consist of a major in a discipline, with supporting content from other similar areas. In the sciences, for example, biology majors often take a few courses in chemistry and physics, while chemistry majors may take a few courses in physics. While these teachers certainly are qualified in their primary discipline, the curriculum of the school may be at odds with their preparation. For instance, in some states, 9th grade students take an introductory course that is called Physical Science. This course has elements of both physics and chemistry. While the content is certainly basic, finding a teacher who is 'highly qualified' in both chemistry and physics is difficult.

The problem of out-of-field teaching also occurs in schools in remote locations or in high poverty settings. These schools do not attract a significant number of teachers, and often experienced teachers are required to teach courses in which they have do not have adequate content knowledge.

3.7.3 Terminology Used for Teaching Out-of-Field

Even though policymakers require that teachers be 'highly qualified teachers' (see No Child Left Behind Act of 2001 (NCLB), different variations of 'highly qualified' have emerged over the year that take into account the supply of teachers in a specific location. This problem in the US has been discussed by Ingersoll (e.g. 1998, 1999).

3.7.4 Reporting and Incidence of Teaching Out-of-Field

In order to understand if 'out-of-field', teaching was a problem among newly hired science teachers, Luft et al. (2013) completed an analysis pertaining to collected beginning science teacher data. This data came from two NSF-funded studies that followed 100 secondary science teachers from 2005 to 2010 (in the time of NCLB). Approximately, half of the teachers were in middle school and half were in high school. This data included the instructional practices (activity and topic) of the science teachers, which consisted of approximately 40 daily lessons per teacher, per year. This is approximately 5 days of lessons per month. This data was examined with attention given to the teacher's declared content major.

The analysis examined the percentage of time that new secondary science teachers were teaching outside of their content major during their first 2 years of teaching. To do this analysis, a research assistant coded the teachers' degree major (e.g. biology, chemistry), the socio-economic status of the teacher's school, as well as the setting (e.g. urban) of the school.

Using the teacher's major as the indicator for teaching in-field or out-of-field, the teacher's instruction was coded as in-field (consistent with the major) or out-of-field (inconsistent with the major) during each day of recorded instructional practice data. The results from this simple analysis were surprising. Specifically, when major was linked to the instructional data, more than 50% of the science teachers were teaching out-of-field between 60 and 100% of the time during *all* eight weeks of their first (N = 128) or second year (N = 103) (Fig. 3.1). Additional analyses revealed that 60% of the middle school teachers were out-of-field more than 50% of the time, as were teachers in urban and predominately low socio-economic settings. Finally, there was no difference in the amount of time that science teacher were out-of-field from the first to the second year. That is, a newly hired science teacher was just as likely to be teaching out-of-field in the second year as in his/her first year.

3.7.5 Responses at the National, State or Local Levels

As new standards (e.g. the *Next Generation Science Standards,* Achieve 2012) and new teacher evaluation policies begin to take hold in the US, the subject matter knowledge of a teacher will take on renewed importance. New standards direct teachers towards interdisciplinary ideas and require a depth of knowledge. Emerging teacher evaluation policies will result in assessments of teacher quality, which will link back to the teacher's preparation and certification institution. If a teacher does not fare well on the assessment, his/her credentialing institution will be potentially held accountable. With both of these wide-reaching changes, understanding the connection of teacher preparation to the first years of teaching will be important. In addition, it will be important to understand how out-of-field teaching is manifested in this emerging political climate.

3.8 Discussion

The vignettes included in this chapter from six countries highlight the complexity of the phenomenon of teaching out-of-field. The way in which education systems are structured, the nature of the curriculum and how traditional subjects are divided, teacher education and certification requirements and beliefs about the nature of teachers' knowledge and work (e.g. content vs. pedagogical knowledge) vary within and across nation states. The vignettes provide readers with a transnational perspective on these complexities which inevitably will enhance understandings about the phenomenon beyond narrow local and culturally specific parameters. Importantly they also provide opportunities to see how various countries have responded to the phenomenon from which local jurisdictions can gain valuable lessons.

Clearly, in all six countries, a significant number of teachers have been identified either by researchers or government reports as teaching out-of-field but the extent is difficult to accurately measure for a number of reasons. Whether a teacher is considered officially or anecdotally as teaching out-of-field is dependent on what it means to be qualified to teach a particular subject or year level. Qualifications vary within jurisdictions and can change according to legislative requirements. In most cases, though it is assumed that in order to be qualified to teach a subject a teacher would have studied at the very least one or two units of the subject content at a tertiary level. In most cases, there is also a requirement for some pedagogical training in that subject. The way in which these two elements of teachers' knowledge (that is content knowledge of a subject and knowledge of how to teach it) are weighted within teacher education programs and teacher certification requirements reflects dominant views about teaching and learning and the nature of teachers' work. This much debated and critically important theme is further explored in Chap. 5.

Second, the vignettes demonstrate the complexities in delineating what 'counts' as teaching out-of-field and this varies within jurisdictions and across national borders. These complexities accordingly impact on the adequacy of empirical data on teaching out-of-field and thus require a nuanced approach to such data. The data can be complicated by, for example, the inclusion of generalist primary school teachers who are unlikely to have formal qualifications to teach all subjects in the curriculum. A further complicating factor can be the variety that exists within broad subject categories such as Science (which can include physics, chemistry, biology etc.) or Social Sciences (often made up of history, geography, economics, politics etc.). So, for example, a science teacher may have a tertiary degree in biology but is required to teach chemistry in a subject called general science. This draws attention to long held and dominant views that differentiate subjects not just based on the content but also to a whole range of differing key concepts, modes of inquiry, and discursive practices that vary from one subject to another and even within broad subject categories such as physics and chemistry or history and economics in a traditional school curriculum. In Chap. 6 the implications of such subject-specific demands on teaching out-of-field teachers are explored both in terms of the challenges and the possibilities for cross-fertilisation of modes of inquiry.

Third, while the official reporting of teaching out-of-field is complicated by the factors articulated above as well as a reluctance in some cases to acknowledge its existence, the evidence here clearly suggests teaching out-of-field exists to varying degrees in all countries and can be up to a staggering 50% or more in some subjects or schools. A consistency across all the vignettes is that while national or state government authorities publicly make claims that teachers should be qualified to teach specific subjects or year levels and various measures such as certification requirements are in place, the actual assignment of teachers to classes largely remains at the discretion of principals who are required assign a teacher to every class. Where teacher shortages exists the use of out-of-field teachers is a means to address this. Critical questions about who is responsible for teacher certification and assignments are raised in Chap. 8. Clearly, a gap exists between official pronouncements about subject-specific teacher qualifications and certification and their links to teacher quality are called into question by the existence of teaching out-of-field.

Fourth, a concerning pattern raised in the vignettes is that most often teaching out-of-field occurs in rural, remote or low SES schools. Also, teaching out-of-field teachers, as is reportedly the case in all the vignettes are more likely to be assigned to lower years, non-exam years or less academically able students. Similarly, teaching out-of-field teachers are more likely to be early career teachers in their first or second years. The vignettes provide insights into some of the distinctive characteristics of teaching out-of-field teachers and the school environments in which they often work. Such knowledge is invaluable in the development of appropriate strategies to support the specific needs of teaching out-of-field teachers. These strategies include attention to the phenomenon within pre-service teacher education programmes, Teacher Professional Learning opportunities and localised school-based support. Such possibilities are further explored in Chaps. 9, 10 and 11.

Finally, a key theme that has emerged for the vignettes has been that responses to teaching out-of-field have increasingly been to develop professional development programmes for teachers to improve their content and or pedagogical skills to teach subjects for which they do not have formal qualifications. Such professional development programmes vary widely in length and scope from 1 day short courses to 1–2-year Certificate or Diploma level courses. A range of professional learning models that have recently been developed are examined in Chap. 11.

3.9 Conclusion

Increasing shifts towards more rigorous teacher certification requirements including ongoing teacher appraisal systems, linked to promotion or pay in the USA, UK and Australia, for example aim to monitor and control the qualifications required of teachers. These requirements have implications for Out-of-field Teachers. Ongoing international debates about what constitutes quality teaching and the nature of teachers' work are also significant in considering the way in which out-of-field is conceptualised, reported on and addressed. The vignettes included in this chapter help to provide an understanding of the phenomenon of teaching out-of-field as it exists in six countries enabling researchers, educators and policymakers a view from an international perspective. Further research into the impact of teaching out-of-field on student learning is required. This was not dealt with in these vignettes as it is an emerging area of study and the focus of Chap. 7 based on TIMMS and PISA data. The vignettes have provided an introduction to the phenomenon of out-of-field teaching as it currently exists across a range of international settings and from the perspective of those teaching and researching in the field. The vignettes have formed the basis of relevant issues that are explored in more detail subsequent chapters.

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Part II
The Complexity of the Teaching Out-of-Field Phenomenon

Chapter 4
Examining the Complexity of the Out-of-Field Teacher Experience Through Multiple Theoretical Lenses

Linda Hobbs, Anna E. du Plessis, Frances Quinn and Emily Rochette

Abstract This chapter will draw on and interrogate a range of theoretical approaches to examining teachers' experiences of teaching across specialisations. Teaching is a complex work, but teaching a subject without the necessary background presents its own set of challenges, both practically in the classroom and personally for the teacher. Different theoretical perspectives highlight different aspects of the experience. Four theoretical perspectives will be explored for their emphasis on where the individual teacher is placed within and how they negotiate the intersection of their practice, sense of self and the social and cultural context. The four theoretical perspectives will include Positioning Theory, Cultural Historical Activity Theory, Boundary Crossing and Lived Experience. The chapter will use research from the authors to illustrate the explanatory power of these theories in understanding the experience of teaching across subjects.

Keywords Teaching out-of-field · Teaching across specialisations
Cultural-historical activity theory · Boundary crossing
Epistemological perspective · Context-consciousness · Lived experience
Positioning theory

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_4

4.1 Introduction

In this chapter, we examine a number of theories that have been used to examine teachers' experiences of teaching out-of-field. Teaching is a complex work. Teaching out-of-field, that is teaching a subject or year level that is outside of their area of expertise or specialisation, adds additional layers of complexity that have implications for the teacher personally, practically and socially. Researchers can examine this phenomenon at a technical level, such as through quantification of the incidences of out-of-field teachers based on qualifications and subjects studied at universities—these are valuable for highlighting the extent of out-of-field teaching (see, for example, Chap. 2). The effect of teacher characteristics on the student experience remains as an important question for researchers, practitioners and administrators, although, as described in Chap. 8, meaningful comparisons and correlations between teacher qualifications with student achievement can be difficult to establish definitively. Other variables can be used to examine the effects on the individuals in ways that cannot be established through correlations between test scores and measurable teacher attributes. Complex social issues, such as teaching out-of-field, can be more deeply understood through the lens of theory, rather than through the so-called 'gold-standard' level of research promoted through federally funded educational research, that of randomised control trials and experiments (Dimitriadis 2008). Socio-cultural theoretical frameworks can shed light on this phenomenon at a deeper level by paying attention to such things as effects on individuals, relationships and interactions between different players, effects of context, and acceptance or rejection of responsibilities and actions.

Given the complexity of the out-of-field phenomenon, what people choose to attend to when attempting to research and understand this issue is influenced by the theoretical stance from which they look. Their choice of theory is in turn influenced by what story they want to tell about a particular part of the research problem. It is beyond the scope of this chapter to examine the different interpretations, uses and forms that theory takes in qualitative research. Suffice to say that in qualitative research, theory can be thought of in multiple ways and can be useful at different points throughout the research process (Anfara and Mertz 2015). On the one hand, theory can be conceived of as a means for 'thinking otherwise' (Ball 1995), allowing us to 'open up spaces for the invention of new experiences' (Adams, Cochrane and Dunne 2012, p. 2). On the other hand, theory carries a point of view, and therefore informs the choice of events or experiences to include in the analysis (Anyon 2008): 'one does not go into the field to "see"—one goes into "look" for various sorts of patterns and themes' (Anyon 2008, p.4). In this chapter, theories are applied to research as 'lenses' through which to study the phenomenon of teaching out-of-field (Anfara and Mertz 2015).

Drawing on Anfara and Mertz (2015), using a theoretical framework has the effect of: organising and focusing research on particular aspects of the phenomenon; revealing and concealing meaning and understanding due to the productive constraints associated with the theory; situating the research within a scholarly discourse by providing a language to articulate the phenomenon in ways that might be useful for furthering our theoretical and practice understanding; and revealing the limitations of the theory and signalling a need for additional theories to help highlight other aspects of the phenomena. Choosing a suitable theory is, therefore, influenced by those aspect of the out-of-field phenomenon that the researcher wishes to illuminate.

Within social research, there are a plethora of theories that can be applicable to an analysis of the out-of-field phenomenon. Anfara and Mertz (2015, p.6) classified theories into four categories focusing on the following:

1. Individual: an individual's development, cognitive behaviour, personality, learning and interpersonal interactions;
2. Organisation: bureaucracies, institutions, organisational structures and function, and organisational performance;
3. Group: family issues, work teams, employer-employee relations, interpersonal networks; and
4. Social: group behaviour, cultural institutions, urban development

All four types of theory are relevant when examining the out-of-field phenomenon. 'Individual' theories can be used to focus on individual teacher and student learning, and teacher content and pedagogical content knowledge in relation to teacher standards and competencies, for example, the effect of learning to teach a new subject could be examined through cognitive behaviour theories or self-efficacy theory. An examination of the effect of out-of-field teaching on student achievement and school performance generally, teacher recruitment and allocation practices, or system level analyses could use 'organisation' theories. 'Group' theories can focus on the effects of the whole school staff, or examine the networks that teachers draw on to support their learning. 'Social' theories can examine the teacher in the context of school culture or community, and identify the various actors or participants that might be involved, impacted upon, or perpetuate the need for out-of-field teaching.

The four lenses in this chapter largely focus on the teacher as the unit of analysis: teachers' experiences, the teacher in context, the teacher and their roles and identities, other peoples' perceptions and experiences relating to the teacher and their work, influences on the teacher, and teacher in relation to others. The first lens, Positioning Theory (from Harré), is a theory focused on the individual, analysing the discursive practices of the teacher to better understand his/her interpretation of the social, cultural, and historical facets of the local moral order. The second and third focus on the teacher as they move between two fields: Cultural Historical Activity Theory (CHAT) (from Engeström), which considers the teacher as part of a system of interactions and activity, and boundary crossing (from Akkerman and Bakker 2011), which focuses on the learning mechanisms that arise as a result of the boundary. CHAT accounts for the system within which the teacher operates and could be considered a social theory, while Boundary Crossing focuses on the individual learning of the teacher, although the theory acknowledges that the individuals are part of a cultural setting. The fourth perspective illustrates how multiple theories relating to Lived Experience (Gattamer, van Manen, Vygostsky) can be used to analyse teacher experiences and their effects on the teacher and others involved in this complex phenomenon. This lens is informed by two theorists that focus on the individual and their experience as well as the social theory of learning by Vygotsky. This fourth lens illustrates how the use of complementary multiple theories can provide a more complex analysis of the out-of-field phenomenon.

The following sections describe each of these theories, their explanatory power when used to understand the out-of-field phenomenon, illustrate their application with some data, and provide a critique of the strengths and limitations in understanding this research problem. This juxtaposition of theoretical lenses serves to highlight the relative usefulness and limitations of the different theoretical lenses, that is their explanatory power when exploring the out-of-field teaching. By focusing on the teacher as the unit of analysis the chapter also serves to highlight, from different theoretical perspectives, the complexity of teaching out-of-field.

4.2 Positioning Theory[1]

Positioning theory originated from a social constructionist epistemic tradition (Harré and van Langenhove 1999; Howie and Peters 1996). Informed by the philosophies of Vygotsky (1962, 1978) and Wittgenstein and Anscombe (1953) positioning theorists take an interpretive theoretical perspective where reality is conceived of as dynamic, changing moment-to-moment in conversational acts. Descriptions of the social world are possible and positioning theorists acknowledge that they are numerous and dependent on an individual's identity (Harré and van Langenhove 1999). Figure 4.1 introduces the positioning triad which can be used to better understand individuals' perceptions and interpretations of the social, cultural and historical facets of the local moral order; the system of rights and duties within which intentional acts are done (Davies and Harré 1990; Harré and Slocum 2003; Harré and van Langenhove 1999).

A *position* is accepted to be an interpretation of a cluster of rights and duties that permit or forbid individuals from performing actions that might be deemed significant. As individuals are actively and dynamically positioned they sense and understand that they have a repertoire of acts to negotiate social episodes (Harré and Moghaddam 2003). A mis-/match between what is said and done may indicate how an individual has perceived and understood their agency. Harré (2012) reminds us to avoid presuming symmetry between our self-identified rights and another's duties. As a teacher, it is my duty and right to assign homework to students. Depending on my students' perceptions of their personal agency, however, they may publicly or privately reject my duty and fail to complete their homework, thus repositioning themselves.

Discursive practices, or speech acts, include the speaking or writing of words and non-verbal symbolic exchanges (Davies and Harré 1990; Harré and van Langenhove

[1] Section 4.2 by Emily Rochette. We acknowledge the contribution of Christine Redman (University of Melbourne) and Paul Chandler (Australian Catholic University) to this section.

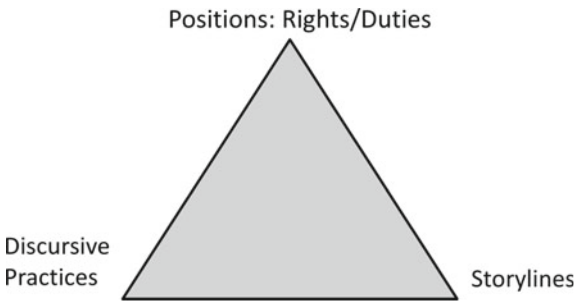

Fig. 4.1 The Positioning Triad (Adapted from Harré and van Langenhove 1999)

1999) indicative of the ways people do things and the meanings ascribed to their actions (Harré and Moghaddam 2003). Discursive practices possess illocutionary forces (Austin 1975) where the meaning of what has been said or done lies beyond the meanings of the words themselves. The illocutionary forces of speech acts depend on the local moral order within which they have been spoken, written or performed and are evident when seen to permit or forbid a person to act as individuals interpret the conversation. A deadline set by the chief executive officer of a company will have a very different illocutionary force for an employee than a deadline set by his 5-year-old daughter, for example, Pronoun grammar analysis (Redman and Fawns 2010) refers to considering pronouns, like *I* or *we*, and contributes to a fine-grained analysis of speech to understand an individual's sense of dis/affiliation in a group (Tan and Moghaddam 1999). Identity, therefore, becomes a product of an individual's interpretation and acceptance or rejection of interpersonal actions (Harré and van Langenhove 1999). In the example above, a student may reposition herself by rejecting the duty to complete homework by a certain date: *I've got dance lessons tonight, so I'll do Monday's homework on Wednesday.*

Storylines arise and are influenced by the history of interactions and events. They emerge from the discursive practices and positions assigned to but also accepted or rejected by individuals (Redman and Rodrigues 2008). Storylines can reflect not only an individual's interpretation of his or her rights and duties but also his or her interpretations and acceptance of others' rights and duties (Redman 2013a). The storyline emerging from the example above could be called *the responsible student*. A busy extra-curricular schedule has enabled the student to claim the right to organise her homework time as she sees fit. Rather than rejecting the duty to complete homework altogether, the responsible student does it on another day. The plot in this storyline may shift depending on whether or not the teacher accepts or rejects the student's repositioning.

4.2.1 Application of Positioning Theory to Teaching Out-of-Field

To the best of our knowledge, application of positioning theory explicitly linked to the out-of-field teaching context seems to be an under-explored area of research in peer-reviewed literature. However, positioning theory has been used across several areas of education including understanding midwifery students' identity formation (Phillips et al. 2002; Phillips and Hayes 2006, 2008), beginning teachers' socialisation processes (Tan 2015), dyslexic tertiary educators' professional identities (Burns and Bell 2011) and understanding habitus and capacities as teachers engage with a website as a teaching tool (Redman and Rodrigues 2008). This list of some of the applications of positioning theory in education research highlights a central theme worth exploring in the out-of-field teaching context: identity formation.

Hobbs (2013a) suggests that situations like out-of-field teaching provide opportunities for teacher identity expansion and re-conceptualization of teaching practice. One strength of positioning theory is that it provides an alternative framework to the static concept of role (Davies and Harré 1990; Harré and van Langenhove 1999). An individual's perceptions of his or her position, and associated rights and duties, may shift as the social situation unfolds. Applied to out-of-field teachers, positioning theory can be used to understand and track changes in teacher identity formation and perceptions of personal agency as they negotiate unfamiliar curricular contexts. This research is significant as it contributes to better ways of teaching students by understanding the constraints and benefits that out-of-field teaching creates.

4.2.2 Interpreting Mary's Out-of-Field Geoscience Experience Through the Positioning Triad

In the Australian state of Victoria, general science teachers are expected to instruct year levels from 7 to 10 students across biology, chemistry, geoscience and physics (Victorian Curriculum and Assessment Authority VCAA 2015). Geoscience is the study of Earth's physical structures and processes acting on them and, internationally, is largely taught by general science teachers without a degree in Geoscience (King 2008; Lewis and Baker 2010). Victorian teachers are also expected to develop students' understanding of contemporary scientific practices through inquiry-based pedagogies that use digital technologies (VCAA 2015, 2016). The digital technologies curriculum standards add to the complexity of the out-of-field teaching experience because educators are assumed and expected to know *of* and *how* to employ digital technologies for geoscientific inquiry. How do secondary science teachers negotiate teaching geoscience out-of-field while using digital technologies?

Mary is a trained general science and senior chemistry teacher. By 2016, she had taught 8 years at Riverside High, a Melbourne secondary school known in the local community for providing high-quality education. Prior to her teaching career, Mary

Table 4.1 Mary prepares for a year 8 geoscience rocks and minerals unit

Line-by-line coding	Interview transcript	Story line
Teacher self-identified duty to re-learn material Teacher self-identified duty to know material at a deeper level than the students Teacher-identified student right to have questions answered	And so, I then re-learnt-it's not like I was going into it and I was reading the information and going: 'I don't have any understanding of it.' But it's-you can't be at the same level as the kids when you teach the kids. You've always gotta be that one bit higher. 'Cause then how do you answer questions?	The accountable out-of-field geoscience teacher who may not fully understand what she is meant to teach

Table 4.2 Mary's perceptions of digital technology use in science

Line-by-line coding	Interview transcript	Story line
Teacher self-identified duty to use digital technologies in science class Teacher self-identified duty to engineer pedagogically valuable experiences for students with digital technologies Teacher self-identified duty to develop curriculum that 'adds value' to learning experiences	I didn't want to sound like I don't use them 'cause I do, but I just think that with every, um, process of using a technology in class, there's a lot of thought that goes on behind it that I don't think anyone ever… I don't think anyone kind of gets up and goes: 'Ah, I'm just gonna use this technology just for the sake of using it.' There's a lot of thought that goes on behind it because we spend so much time developing curriculum that we then wanna make sure anything new that we introduce value adds to that	The accountable teacher with digital technologies who understands and accepts the challenge of teaching with digital technologies

completed an honours degree researching fluorescent chemical compounds. Despite identifying as out-of-field in geoscience, Mary's skills using digital technologies for her chemistry research might prove useful for her geoscience classroom practice.

Some of Mary's interview data is closely examined here to better understand the out-of-field geoscience teaching experience. Tables 4.1 and 4.2 present data analysed line-by-line (Charmaz 2014) and use the positioning triad to bring to the fore the emergence of storylines.

In Table 4.1, Mary shared how she began planning to teach a geoscience unit of work for her year eight class for the first time in 2015. Mary's use of *I* is indicative of her personal duty to re-learn the material and she justified her actions by identifying her duties as an accountable teacher who is acting responsibly.

The data in Table 4.2 data was collected at the end of an interview when I asked Mary if she felt there was anything about her experiences that I should know or understand better. Mary continued the accountable teacher storyline reflecting on digital technology use in science. For Mary, digital technologies that added value were those that provided students with problem-solving scenarios. Even though Mary would have used digital technologies to this effect in her honours laboratory work, Mary reflected that in her science classes digital technologies were mostly used after scientific theory was explicitly taught.

This and other interview data suggested that although Mary and her colleagues may assume the duty to incorporate digital technologies into their lessons, their abilities to do so may not reflect the intentions of state-mandated curriculum or even their own understandings of best practice. Earlier in the interview, Mary explained:

> In material that maybe I'm new to teaching […] I find that I need to have almost a bit of a traditionalist approach (nervous laughter) to begin with so where you're more in control, 'cause I think that there are some parts of using digital technologies where you relinquish the control […] and that I wanna-I wanna make sure that they're [students are] getting everything that I want them to […] understand […]

At this school, the 'traditionalist approach' seems to be a common practice where teachers use Microsoft PowerPoint to deliver content as students take notes. Mary's nervous laughter suggested this approach may be disconnected from what she feels to be best practice developing her students' science inquiry skills as required by state-mandated curriculum.

4.2.3 Critical Analysis of Positioning Theory

Positioning theory has been applied to students, teachers and researchers in science, technology and mathematics education for some time. Examples include Jakab (2013), Redman (2004, 2013c), Roe (2015) and Herbel-Eisenmann et al. (2016). Although positioning theory has been used as a powerful analytical tool, some aspects of positioning theory require critical analysis to better understand the wider application of it.

Herbel-Eisenmann et al. (2015) bring our attention to linguistic uncertainties arising from the synonymous use of the terms *position* and *positioning* within Harré and van Langenhove (1999). A position is considered to be an object and positioning a process (Harré and van Langenhove 1999). More recently, position has been defined in terms of rights and duties (Harré 2012; Harré et al. 2009; Moghaddam et al. 2008). Herbel-Eisenmann et al. (2015), however, point out that the earlier work of positioning theorists is most often used in mathematics education, and thus may continue to promote misunderstandings of these terms. Teaching out-of-field is a dynamic space where teachers negotiate unfamiliar content and pedagogical practices, their duties to their students and their capacities to attend to these duties. Theories are conceptualizations of our interpretations of the world, and thus evolve with new insights and understandings. When using the *position* construct, researchers may want to define it in terms of rights and duties while highlighting that positions change moment-to-moment thus enabling us to better understand teaching out-of-field as a complex and dynamic experience for the individual.

Another shortcoming of positioning theory pointed out by Herbel-Eisenmann et al. (2015) is the apparent lack of text about storylines. Although Herbel-Eisenmann et al. (2015) acknowledge that storylines can be referred to in a variety of ways, including narrative and narrative convention, these authors suggest that there is no way of establishing a 'correct' storyline and point out that within a social episode, multiple storylines could be at play. Positioning theorists acknowledge the existence of multiple storylines, see for example, Harré and Dedaic (2012) and Harré (2012). From our perspective, referring to storylines as narratives and narrative conventions are seen as an opportunity to marry positioning theory with other theoretical perspectives.

Positioning theory is a useful methodology to understand teachers' relationships to influences from the broader institutional setting (Redman 2013b, p. 271). Clandinin and Connelly's (1996) cover, sacred and secret stories can be powerful when paired with positioning theory to make sense of the complex and dynamic professional landscape teachers navigate. Cover stories are those that might be promoted by school administrators to the wider community: *Our school provides technologically advanced learning spaces and teachers utilise these to teach science inquiry with digital technologies*. Sacred stories, however, are the theory-driven view of professional practices shared by teachers, policymakers and theoreticians: *Mary is an accountable out-of-field geoscience teacher who seeks to utilise digital technologies to add value to her inquiry lessons.* Secret stories, often more personal and individual, are about classroom practice that can indicate tension with cover stories: *Mary is unsure how to teach geoscientific inquiry with digital technologies.*

One of the strengths of positioning theory is providing an alternative to role. Role is a static concept, represented on paper in written contracts and policy documents. State-mandated curriculum requires general science teachers to teach across year levels 7–10 and also across biology, chemistry, geoscience and physics while incorporating digital technologies into classroom practices. Using Weldon's (2016) definition of in-field to categorise teachers as in-/out-of-field may not represent the complexity of the professional landscape Victorian general science teachers are expected to navigate. For Weldon (2016) in-field teachers have the following:

1. Studied a subject for at least one semester at second-year tertiary level with no tuition in subject-specific teaching methodologies; or
2. Met the criteria for 1. *and* were instructed in subject-specific teaching methodologies.

Although Mary would be considered an in-field general science teacher, her role as presented in state-mandated curriculum documents seems to assume Mary's capability to teach across all sciences incorporating digital technologies. The value of positioning theory lies in demonstrating how teachers' perceptions have become reified and discursively active (Davies and Harré 1990; Harré 2002). The tension between Mary's sense of professional responsibility to use digital technologies to teach science inquiry skills and her confidence to do so by relinquishing control in out-of-field areas of the curriculum have been brought to the fore in our conversations. Using positioning theory, researchers begin with individuals' self-perceptions to understand how they re-/negotiate their rights and duties through their experiences. In this way, positioning theory enables researchers to better understand what it means to be teaching science out-of-field.

Finally, although not formally labelled as a methodology in handbooks of qualitative research, positioning theory has been shown to philosophically and methodologically complement Charmaz's (2014) well-established constructivist grounded theory methodology (Rochette et al. 2017). The example of Mary demonstrates how line-by-line coding (Charmaz 2014) procedures could be initially employed to begin to understand out-of-field teachers' perceptions as they negotiate uncharted curricular landscapes. Grounded theory coding procedures can be used further to build a conceptual framework for professional development that may challenge and scaffold out-of-field teachers' pedagogical capacities.

4.3 Cultural Historical Activity Theory[2]

Cultural Historical Activity Theory (CHAT) is a conceptual framework, emanating from the work of Russian cultural-historical scholars in the 1920s and 1930s, that has been applied to the analysis of a range of human activity systems, including education. Vygotsky (1978, 1981; cited in Engeström 2001) posited that human activity is object-oriented, involves a dialectical relationship between a subject (an individual), the object (goal of action) and is mediated by cultural artefacts such as tools and signs. Leontiev (1981) and subsequently Engestrom and colleagues (e.g. Cole and Engeström 1993; Engestrom 1987) extended this initial focus on individual actions to encompass the collective object-oriented activity of humans in social contexts, the multiple social mediators of activity such as culturally and historically located rules, patterns of division of labour, and the wider community involved. In multiple publications (e.g. Engeström 2001, p. 135), the collective activity system is depicted as a series of interlinked triangles (Fig. 4.2) representing the interactions between the different elements of the system, which become the focus of analysis of activity.

Drawing on the work of seminal activity theorists (Cole and Engeström 1993; Engeström 1990, 1998, 2015; Engeström and Sannino 2010; Leontjev 1981), elements of the activity system in a traditional western secondary classroom might be described and exemplified as follows:

- Subject: The subject is the agent from whose perspective the activity system is being viewed. This may be the teacher, other individuals engaged in the activity

[2]Section 4.3 by Frances Quinn.

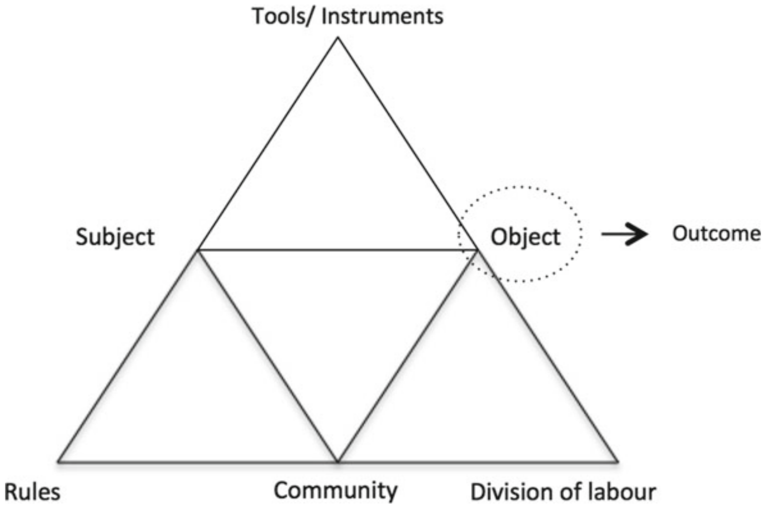

Fig. 4.2 The structure of an activity system (after Engeström 1987, p. 78)

system such as a student, or groups of teachers such as the science or mathematics staff.

- Object: The object of activity is fundamental to the CHAT conceptual framework, in a sense defining the activity. It relates to the motive and purpose of the activity (Engeström and Sannino (2010, pp. 4-6), with some researchers highlighting the complexity and ambiguity of multiple motives comprising 'a complex and contradictory assembly of entities embedded in economic, social and power relationships…' (Kaptelinin and Miettinen 2005 p. 2).
- Tools: These are the instruments, artefacts or 'cultural resources' (Engeström and Miettinen 1999) that mediate the activity, such as textbooks, syllabuses, prior knowledge, classroom activities and forms of representation such as images and models (Engeström 2015, p. 201; Yamagata-Lynch and Haudenschild 2009, p. 508).
- Rules: These prescribe acceptable behaviours via formal school policies and regulations and broader social and school expectations and norms (Engeström 2001), such as the expectation that teachers are competent to teach their subject area.
- Community: The community comprises other individuals in the activity who are involved with and share the same object, so may include the students in the classroom, the head teacher and colleagues in the staffroom.
- Division of labour: This relates to the way that the tasks, powers, responsibilities and rewards associated with the activity are distributed among the participants of the activity system (Cole and Engeström 1993, p. 7).

The more recent third generation of Activity Theory recognises that activity systems are interlinked, interact with and influenced by other related systems. Interacting activity systems with a partially shared object become the units of analysis

(Engeström 2001). Contradictions and tensions can occur within and between elements of activity systems (Engeström 2015, p. 70), and can drive learning and change as people attempt to resolve them (Cole and Engeström 1993; Engeström, Miettinen, and Punamäki 1999; Miettinen, Paavola, and Pohjola 2012; Miettinen and Virkkunen 2005, Yamagata-Lynch and Haudenschild 2009).

4.3.1 Application of Cultural Historical Activity Theory to Teaching Out-of-Field

To our knowledge CHAT has not been utilised in published research into teaching-out-of-field. Its potential in this area is suggested by the theoretical and structural considerations of the model described above which facilitate exploration of the complexities of out-of-field teaching, and the interconnections between the development of CHAT and concepts such as identity and boundary crossing, which have been applied in understanding the situation of teaching out-of-field (see below and elsewhere in this chapter). The application of CHAT in other educational research (reviewed by Roth and Lee 2007) is relevant to some of the important issues in teaching out-of-field identified in this volume. For example, Engeström and Office (1994) investigated the transition of beginning teachers to the teaching profession through exploring the contradictions they encountered, and their attempts to resolve them. Similarly, Saka, Southerland, and Brooks (2009) used CHAT to explore beginning teachers' transition into science teaching, identifying the importance of a supportive community of practice, and the personal and contextual influences on transitioning teachers' practices and goals. Using CHAT to explore beginning teachers' developing PCK was the subject of doctoral research by Diaz (2012), while Dubois and Luft (2014) used CHAT in their examination of professional growth in science teachers required to 'float' between different classrooms.

4.3.2 Cultural Historical Activity Theory Applied to Our Research

We have explored the utility of CHAT in framing the experiences of secondary teachers teaching out-of-field in Australia, focusing in this chapter on the out-of-field activity of Gary, a young early career teacher in a very small rural K-12 school. Gary's passion and area of expertise was agriculture but he was also tasked with teaching science. He subsequently upgraded his qualifications to formally qualify him to teach science but still felt to some extent out-of-field teaching in that area.

> I'm Agriculture through and through and I'm very comfortable in that area but with a lot of the sciences - I did that at uni to give myself another option - and I feel that's very, very foreign to me.

For the purposes of this chapter, we adopt the personal plane of sociocultural analysis (Rogoff 2008) to focus on the inner contradictions within the activity system of Gary's science teaching, shown in Fig. 4.3. Gary's activity in this system is directed towards a complex of objects. He is committed to doing a good job and to helping the students learn science, and he is also driven by the desire to 'give everybody a chance', which is a strong part of his identity: 'I'm passionate about, my one thing is to give everybody a chance. That's what I'm about'. In terms of tools, Gary considers that he has good rapport with students and good agriculture pedagogical content knowledge (PCK), but limited PCK in his out-of-field area of science. He has had to deploy new mediating tools such as a different syllabus and some different teaching strategies that he has sought from science-specific professional development. The rules enabling Gary's employment as a teacher of science prior to gaining relevant qualifications included the 'Willing to teach' category of relevant employment policies, and he was also operating within social expectations that teachers are qualified and competent to teach the subjects they are allocated. Gary is a member of the broader community of practice of teachers at the school, especially the four other teachers sharing the combined IT, agriculture, science and mathematics staffroom, with whom he discusses day-to-day issues of professional practice. Gary also has a close friend at another school who is a science teacher and with whom he discusses his science teaching. In the division of labour at the school Gary was one of two teachers allocated to secondary science classes. Using the CHAT framework as a lens to analyse Gary's interview transcripts illuminates several tensions associated with his out-of-field activity, as shown in Fig. 4.3.

Tensions (a) are evident between the multiple objects of Gary's out-of-field teaching. His specific object of helping students to learn science contradicts with his desire of 'giving everybody a chance', which he sees as less achievable through science than through his in-field area of agriculture:

> I always sort of focus more on the agriculture side of things, to give them an awareness and sort of just an appreciation and to develop some of those skills, that if they do step out into the Ag field they'd be more than capable and comfortable. Whereas my view for science, I see that I'm there to teach them what they need to know. All the same skills but … especially for junior [science], the skills I teach them now, I don't really feel will help them as much in future science life.

Tensions (b) are also created in Gary's science teaching activity because of the limitations in some of the tools he has at his disposal, such as PCK in science, conflict with his object of teaching science and doing a good job:

> I understand a lot of the concepts but trying to adapt and find ways to teach those concepts, I find quite difficult.

Tension (c) existed between expectations that teachers are qualified to teach their subject areas, and the division of labour that resulted in Gary being asked to teach science although not formally qualified. He resolved this tension by upgrading his qualifications:

> just to have that backing behind yourself and go, well in case something does blow up and they get a complaint or something - it'll never happen - but saying, "Oh well I've got my kid

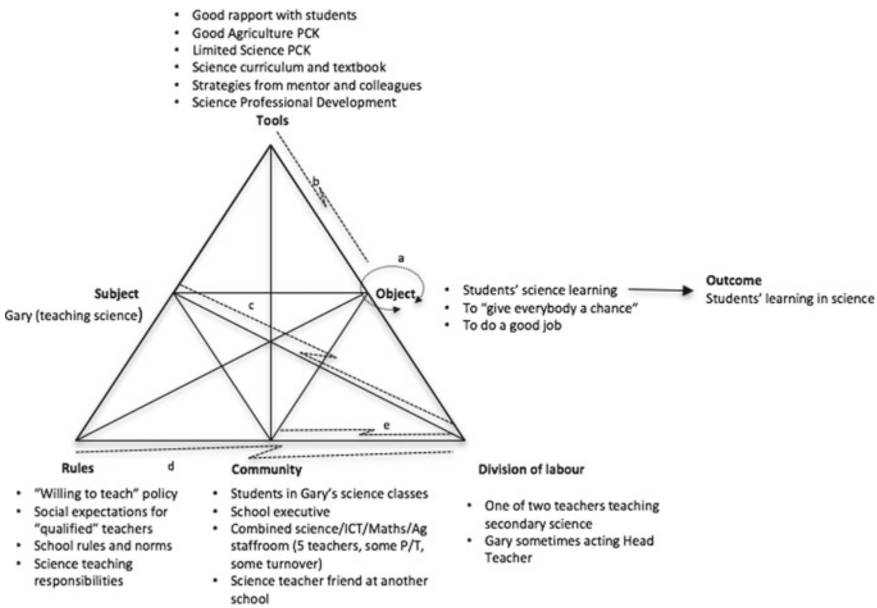

Fig. 4.3 Activity system of Gary teaching science out-of-field

> being taught being someone who's not qualified." And then I can say, "Well actually yes, yes I am….So I think just, having that behind me gives me a bit of a safety net.

Gary experienced considerable tension (d) because of the division of labour that allocated him to science classes, which contradicted with his passion and preference to be teaching agriculture, especially in his first 2 years:

> because Ag really is my true love, and so I think that if I was to give away all of my Ag, then in actual fact, I'd say that I probably would not be a teacher.

This division of labour was also problematic (Tension e) given there was only one other science teacher position in the relevant community, which had been filled by a series of part-time or casual appointments. This meant that for some of the time Gary did not have ready access to a critical friend in science within the school community—a tension which he partially resolved by recourse to a close friend outside the school.

Teaching science was only one of Gary's activities at school, as he was also involved in the parallel activity system of teaching his in-field area of agriculture. This situation is not uncommon for out-of-field teachers or in schools more generally and, as argued by Engeström, Engeström and Kärkkäinen (1995, p. 319), people at work move between parallel activity contexts that require ' different, complementary but also conflicting cognitive tools, rules, and patterns of social interaction. The criteria of expert knowledge and skill are different in various contexts'. This was certainly the case across Gary's in field and out-of-field teaching activities, where some of his knowledge and skill in agriculture was not relevant to the science teaching context. Moreover, the object of student learning in science was partially shared by the school executive and by the students, in a network of linked activity systems that brings further contradictions that can be explored from a third generation CHAT perspective, to further facilitate resolution of tensions and learning.

4.3.3 Critical Analysis of CHAT

CHAT has attracted criticism from scholars who are working within CHAT, or in related theoretical agendas, and those who object to the dilution of CHATs Marxist and dialectical legacy. Some of the grounds for criticism (reviewed by Engeström and Sannino 2010) include neglect of the cultural impact of digital technologies, disconnection to knowledge from practice, and its neglect of the individual subjective as opposed to collective activity. Roth (2009; 2012) points out that the triangle representation connotes stasis and emphasises the structure of activity, obscuring the dynamism of the inner contradictions, and agentic aspects of activity such as identity, emotion and other constructs. As acknowledged by the Center for Activity Theory and Developmental Work Research (n.d.), Activity Theory needs to develop conceptual tools to better understand dialogue, cultural diversity, multiple perspectives and voices, and networks of interacting activity systems.

One of the main affordances of CHAT in research into teaching out-of-field appears to be the power of the framework to integrate a range of other educational concepts commonly applied to research into teaching out-of-field. Roth and Lee (2007, p. 188), describe CHAT as ‘an integrative road map for educational research and practice’. Three areas of integration are outlined below as examples.

First is the conceptualisation of mediational tools in CHAT to include teachers’ PCK, teaching and learning models and other aspects of teacher professional knowledge often invoked in discussions of the out-of-field phenomenon. Integrating these important aspects of teaching out-of-field within a framework that conceptually and systematically links them to other elements of teaching out-of-field such as support from the *community*, and the *rules* and policies that surround the *division of labour* leading to teaching out-of-field can facilitate the analysis of the complexities and contradictions, and resolution of tensions involved in teaching out-of-field.

The second potentially useful aspect of integration afforded by CHAT relates to identity—one of the key ideas in research into teaching out-of-field as outlined earlier this chapter. Researchers in identity theory (Holland and Reeves 1994) argued that CHAT could be enhanced by the incorporation of the notion of the ‘perspective’ of subjects, while Penuel and Wertsch (1995) suggested that identity research should be conducted within local activity systems, taking into account the cultural and historical tools mediating the formation of participants’ identities. Research by Roth and colleagues, in particular, has explored and utilised the nexus between identity and CHAT in educational contexts. Roth (2004, p. 6) argues that ‘participation in activity entails change in life conditions and identity of the acting subject and its associated object, and this change is coextensive with changing participation and learning'. He subsequently (2007, p. 83) theorises identity in relation to an expanded articulation of CHAT, in which engagement in actions is central to developing identity. Roth and Tobin (2004) use CHAT to frame an exploration of the changing identities of beginning science teacher, an experienced science teacher after moving to a new school and a student. In this account, he argues that:

> To understand identity, we must consider the tools, object, community, rules, and division of labor associated with the primary activity system. We also must consider other activity systems the individual is and has been involved in and take into account those activity systems (distributed over space and time) in which others from the primary activity system are involved. (Roth and Tobin 2004, p. 68).

The interplay between Gary's identity as a teacher of agriculture and committed professional, and elements of his out-of-field science teaching activity were apparent in our analysis. Gary's confidence and enjoyment teaching science increased markedly in subsequent years, partly because of interactions with the community associated with his science teaching activity, including some mentorship and passion sparked by a new Head Teacher. He was also impacted by the professional satisfaction of seeing his object being achieved: observing students appreciating and benefiting from his teaching. His identity shifted, and he came to see himself not as an agriculture teacher teaching science, but as an agriculture/science teacher. The third affordance of CHAT, as alluded to above, is in its relationship to the concepts of boundaries and boundary crossing, which are both explicit components of CHAT (Akkerman and Bakker 2011), and have informed the Boundaries Between Fields Model of Hobbs (2012, 2013a) in theorising and responding to the out-of-field phenomenon. More detailed discussion of boundary crossing is provided in the following section, but in CHAT, boundaries have been conceived of as contradictions between activity systems (Akkerman and Bakker 2011, p. 136; Roth and Lee 2007), which carry strong potential for learning. Gary brought with him tools such as tried and true pedagogical strategies from his agriculture teaching activity that have facilitated his crossing into the unfamiliar territory of science teaching. Third generation CHAT explores boundary crossings by multiple subjects and between multiple interacting activity systems (e.g. Engeström, Engeström, and Kärkkäinen 1995), enhancing coordination and communication in workplaces through resolution of contradictions between activity systems (Engeström 2001).

Finally, one of the strengths of CHAT resulting from these affordances is its potential in generating solutions to problems in practice. CHAT acts as a 'conceptual map' (Cole and Engeström 1993, p. 8) that can be used to trace and facilitate learning and change (expansion) by analysing the formation and resolution of contradictions (Engeström et al. 1999, p. 33; see e.g. Roth and Tobin 2004). Joint systematic analysis of problems in practice can help practitioners master the learning demands of workplaces (e.g. Engeström 1999), and this has been an explicit focus of much CHAT research activity (Center for Activity Theory and Developmental Work Research, n.d.). CHAT can potentially frame professional discussions among the school community around the complexities of out-of-field teaching, helping teachers to identify and work towards resolution of contradictions and tensions as they learn to teach in their out-of-field areas.

4.4 Boundary Crossing[3]

Boundaries are the unit of analysis for a number of sociocultural theories used in educational research, in particular, communities of practice (Wenger 1998) and Activity Theory (Engström et al. 1995). The first focuses on the shared practices of individuals within communities and the learning required for a newcomer as they increase their participation within the community. The second focuses on complexities within systems, or fields, and interaction between different systems as people cross the boundaries between systems, as discussed above. Researchers interested in boundary spaces and practices often draw from these theories to inform their research (see Akkerman and Bakker 2011).

The boundary crossing lens is concerned with the learning that occurs as people move between different institutionalised and social practices. This theory shifts the focus from learning within a discipline or domain to the potential for learning 'when people interact with, move across or participate in different practices' (Akkerman and Bakker 2011, p. 1). Akkerman and Van Eijck (2013, p. 62) highlight that there has been a move towards exploring movements of people and practice across multiple social systems, that is, 'a movement from focusing on learning as a vertical process within a single social system, to learning as a horizontal process between multiple social systems'.

Akkerman and Bakker (2011) define boundaries as 'sociocultural differences leading to discontinuities in action and interaction' (p. 21), rather than any move between different practices. The emphasis here is on the resultant discontinuity that arises for the individual 'rather than sociocultural diversity per se' (p. 21). Such discontinuities can be overcome through a process of 'reestablishing action or interaction' (p. 5), leading to learning, and which ultimately leads to identity development (Akkerman and Bakker 2011). The utility of the boundary crossing lens lies in its focus on learning. Learning according to this theory ultimately means re-establishing practice despite differences in practices: 'boundary crossing should not be seen as a process of moving from initial diversity and multiplicity to homogeneity and unity but rather as a process of establishing continuity in a situation of sociocultural difference' (Kumpulainen and Sefton-Green 2014, p. 13). Boundaries reach a state of porosity, or permeability, when continuity is reached. Based on their review of 187 studies, Akkerman and Bakker (2011) described four learning mechanisms that arise at the boundary: *identification* of discontinuities; *coordination* of boundary objects; *reflection* on practice and identity; and *transformation* of practice and identity.

Boundaries can be crossed by people, objects and interactions. People can be boundary crossers, that is people who introduce practices from one field to another

[3]Section 4.4 by Linda Hobbs.

such as pre-service teachers becoming in-service teachers (see for example, Goos 2015; Gunckel 2013), or people who move from one field to another and are expected to understand and assume the practices of the new field, such as out-of-field teachers (Hobbs 2013b). Objects can act as boundary objects, that is objects that inhabit and are recognised as coming from different cultural worlds, for example, objects or artefacts that move between professional development sessions and teachers' classrooms (Kazemi and Hubbard 2008), or that can enable groups to negotiate a shared vision (Shimizu 2002). Interactions can be established between people who bring different practices together, for example, where there is sustained collaboration by people from different fields, such as interdisciplinary work (Akkerman and Bakker 2011), through interconnected communities of practice (Kislov 2013), where connected learning is promoted as students move between different contexts (Kumpulainen and Sefton-Green 2014), or exploring the implementation of computer-supported learning activities to link the language of school subjects with out of school practices (Lantz-Andersson et al. 2013a, b).

4.4.1 Boundary Crossing Lens Applied to Out-of-Field Research

The boundary crossing lens is particularly relevant for contexts where people are specialised but may find themselves working in interdisciplinary teams or having to take on new roles within diversified work environments, such as having to teach new subjects. Interactions within these spaces can result in discontinuities for an individual, that is, recognising that a new practice does not match current or known practice. The boundary crossing lens provides a model for conceptualising the process of change, or the learning involved in moving across the boundary from one 'field' to another. Out-of-field teaching can be considered from the perspective of teachers moving from the familiar in-field subject where a background in the subject provides the knowledge, attitudes and appreciations that can inform their practice, to an out-of-field subject where there is limited background or experience to understand what and how to teach and represent the new subject. The language of boundary crossing, discontinuities, porosity or permeability of the boundaries, and the learning mechanisms are useful for examining the learning associated with crossing boundaries between in-field and out-of-field teaching practices.

According to this theory, a boundary exists only when the differences between the practices and perspectives required to teach the subject are 'discontinuous', meaning that unless a teacher identifies differences in practices, they are unlikely to benefit from the learning that might occur as a result of crossing the boundary. While the 'field' of a teacher is determined by their qualifications, 'field-*ness*' is determined by experience of these factors as discontinuities, that is, whether a teacher 'feels' out-of-field or not. Identification of these discontinuities can assist with identifying where learning can take place (Hobbs 2013b), and therefore what support is needed. According to Akkerman and Bakker (2011), and elucidated further by Hobbs (2013b), the boundary can lead to learning in a number of ways:

- Identifying discontinuities enables recognition of the differing practices in both fields and the issues that can arise as a result of being unfamiliar with the new practices. Learning arises when there is recognition and appreciation for the differing practices and identities that each involves. An out-of-field teacher might be prompted to identify the differences between the subject-specific demands of each subject.
- Coordination of boundary objects can assist in negotiating boundaries. Boundary objects are people (also called boundary spanners), artefacts or processes that have elements of both fields and so intersect both worlds, acting as bridges or anchors (Star 1989; Wenger 1998). They provide support while re-establishing practice. Learning involves coordinating or finding and applying these boundary objects to facilitate easy movement between sites. An out-of-field teacher might be prompted to find boundary objects, such as specific educational theories, support materials, or other teachers, to help them build confidence and competence in teaching the new subject.
- Reflection on practice and identity can be enhanced by encountering a boundary. When a teacher takes up an out-of-field subject, it offers the opportunity to encounter and negotiate differences in practice, and reconcile the unfamiliar with the familiar. Learning arises out of seeing things from a different perspective and 'coming to realise and explicate differences between practices and thus to learning something new about their own and others' practices' (Akkerman and Bakker 2011).
- Transformation of identity and practice occurs when confrontation from the intersection between social worlds leads to a reconsideration of practice and identity. Learning arises out of a recognised need for change. Professional identity expands by re-conceptualising: the task of teaching, relationships, their understanding of and respect for learners, and a belief in a capacity to adapt. Importation of practices across fields can be generative, for instance, for language teachers running discussion and debate in science, or economics teachers bringing context to mathematics.

Discontinuity may negatively impact on a teacher's efficiency in teaching or confidence to effect positive learning outcomes. Despite the obvious discontinuity relating to lack of content knowledge, there are many personal and contextual factors that disrupt the rhythm of a teacher when teaching out-of-field. Drawing on Akkerman and Bakker's (2011) theory, Hobbs (2013a) developed the Boundary Between Fields (BBF) Model (Fig. 4.4) to describe a number of factors that influence the identity construction for out-of-field mathematics and science teachers: 'the context of the teacher, support they received, or the personal resources of the teacher' (p. 285).

These factors can act as boundary objects, or they can exacerbate the effect of the boundary. For example, rurality can inhibit teachers' access to professional development that might help in the re-establishment of practice in the new subject. The BBF model can inform the learning mechanisms that support teachers' re-establishment

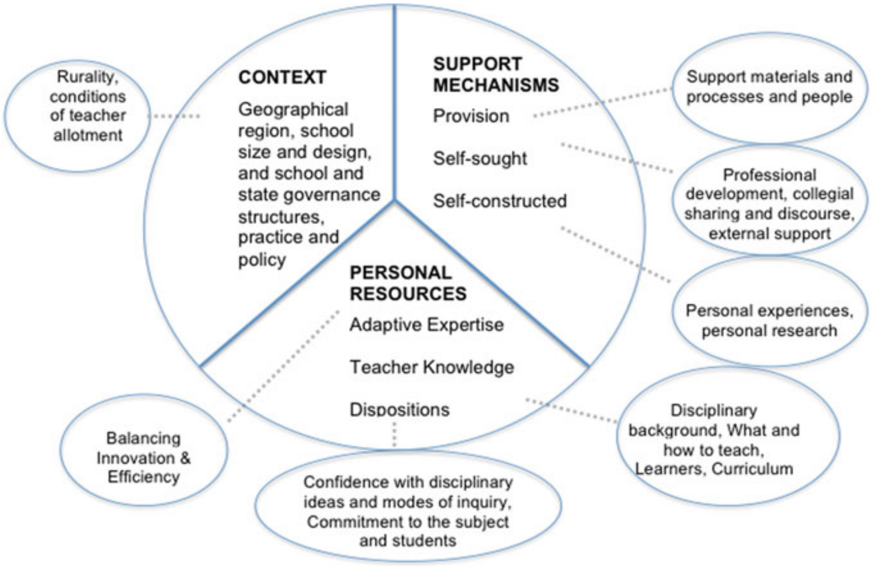

Fig. 4.4 Boundary Between Fields model (Hobbs 2013a)

of practice through helping them to identify where the discontinuity lies (personal resources and content), what boundary objects may be useful (personal resources and supports), where reflection can lead to reconsideration and transformation of practice and identity (personal resources).

4.4.2 Boundary Crossing Lens as Applied to Our Research into Learning to Teach Out-of-Field

To illustrate the analytical power of the boundary crossing lens, I refer to data for one teacher involved in a current study examining the learning and identity changes that occurs for out-of-field teachers, and the effect of context in shaping this. Eliza was a General Science, Physics and Information Technology (IT) teacher, who was asked to teach Year 8 Textiles. Eliza was interviewed individually (four times) and with her mentor or critical friend (twice) during her second and third year of teaching.

As a new teacher, Eliza had a strong relationship with the disciplines associated with her previous career as a mechanical engineer, and she found this translated well into her Physics teaching and some of the General Science units. She also had an IT background. Textiles was technically out-of-field except that she designed and sewed her own clothes, so had the necessary sewing and design skills needed to teach the subject.

In her first year of teaching Textiles, Eliza encountered difficulties in knowing how complicated to make the design challenges and underestimated the degree of support that students would need. Discontinuity caused from this was overcome by identifying what was common across her teaching. In her first year of teaching Textiles, she found that ‘there’s a lot of similarities between the practical work they do for textiles and practical work in either science or IT classes. Not the performing of it but the set up and how you manage a class and how you do that side of things’. Also, she mentioned that her ‘passion for finding out and problem solving’ was translatable across all of her subjects. In Eliza’s reflections on her process of learning to teach Textiles, she felt that the design process helped her to make links with the science inquiry process in science and the technology systems design process in IT:

> when someone says in a whole lot of science classes, what happens when? Well, how can we find out? We could google it or we could…get out the things and investigate and when you investigate, really paying attention to what you can see and what’s going wrong and how we can make it better. In textiles, it’s more going, well what’s our need?… something to keep you warm. What sort of materials are going to do that? What sort of design shape are we going to need to have? What sort of aspects is it going to have? Then you make it and it’s pretty ugly. Well, how can we now make it aesthetically pleasing as well, how can we improve the fit… That is part of the design process… Same process but VCE IT is built around the problem solving methodology so the analysis, design, development, evaluation which is exactly the same, I’ve got a situation, here’s my plan for what I’m going to do to solve it, here’s the thing I have built…

In inviting her to take on the textiles teacher role, Eliza’s principal encouraged her to use conductive thread as a way to bring science into the design process. In her first year she saw this as something for the future, but by her second year she had redesigned the students’ tasks to include conductive thread, LEDs, and little button batteries as part of the design and construction. She was also working with the art teacher to

> start up a subject that is going to incorporate… modern or digital and analogue techniques, so, say, incorporating leatherwork and the new laser cutter… Coming from my textile stuff we’ll be looking at things like felting, and some simple electronics…

By identifying the differences between practices, Eliza has questioned her assumptions about the nature of teaching a technology subject like Textiles, now realising that students need ‘the spatial awareness and being able to work out how things fit together is… looking at how something 2D changes into 3D’. Re-establishing practice has involved identifying what was common, therefore bridging the gap between potentially distinct sets of pedagogical practices. This process was dialogical such that her practices in both subjects benefited, that is, were informed by and were informing of what it meant to be a STEM teacher. This required an expansion of her role and identity as a science/IT teacher. She was able to imagine and re-design curriculum in a way that integrated her science background into textiles tasks, but also through meaningful and innovative collaborations with another teacher to develop a new STEM unit.

The process of learning to teach out-of-field she likened to a ‘dimmer light’ used to make a light brighter or more dull:

> it starts off, and it's a bit dark. Like you walk in and it's like, where the hell is everything… You don't know what – you can sort of make out where things are, but over time it gets brighter and clearer, and you can see exactly what you should be aiming for, or more exactly, because someone still might move stuff around, but you know, and it just gets clearer. So, from the start, you have an idea, it's just that it gets more identifiable as the light gets turned up and you get more information.

For Eliza, continuity is a process of understanding how to best teach textiles, and how to re-conceptulise curriculum and learning in ways that are congruent with her passion for design, creativity and problem-solving. Drawing on Akkerman and Bakker's (2011) learning mechanisms, evident in this example is learning enabled by the following:

- recognising differences in practices differentiating the teaching and learning of textiles and science;
- finding what was common, in particular, the application of science objects (such as conductive thread) and the design process which then act as boundary objects, enabling her to establish continuity between the subjects;
- reflecting on her assumptions of the learning demands associated with sewing, and developing a new appreciation for the focus on skill-building in contexts that are meaningful for students; and
- transforming practice and identity as her identity expanded to incorporate a STEM-way of teaching.

Boundary crossing has enabled Eliza to be creative when working with materials and be flexible with the design/ problem-solving processes, she has embraced new roles and identities as STEM teacher and developed confidence in her ability to work through difficult situations, and transformed textiles pedagogy and activities to embrace twenty-first-century technologies. As she integrated science and textiles a hybridised version of textiles was developed, inspired and informed by her physics background, resulting in a boundary practice that extended her identity and enriched her teaching career.

4.4.3 Critical Analysis of the Boundary Crossing Lens

The boundary crossing lens has currency when exploring out-of-field teaching as it shifts the focus from what teachers are missing, to what they can bring to the interaction and what can be learned; key to the theory is that learning is dialogical. While out-of-field teaching has the potential to be devastating for teachers, rather than assuming a deficit position, this lens recognises the possibilities for identity expansion and a re-conceptualisation of practice if teachers are supported at their point of need. This exploration of awareness and discontinuities associated with boundary crossings has the potential to highlight the blackspots (problematic areas) and blindspots (unknowns) in teacher education and in-school support mechanisms, by informing curriculum and program structures in initial teacher education, or mentoring and initiation programs for new teachers. The theory also helps to understand why even experienced teachers can feel like novice teachers, or 're-noviced' (Blazar 2015), when teaching out-of-field (Hobbs 2013a) and therefore need additional time and support.

In preparing pre-service teachers to be adaptable, or in supporting out-of-field teachers through continuing professional development, the dialogical learning mechanisms of boundaries can be a useful learning framework to highlight differences in practices and how these differences can act as discontinuities, the types of boundary objects that can support re-establishment of practice, how reflection is needed to notice differences and learn something new, and recognise the need for change in practice and how they see themselves as pedagogues and subject specialists.

Two constraints may be associated with this theory when using it to understand the complexity of teaching out-of-field. First, while the boundary metaphor is useful for conceptualising specialists moving into new fields where the practices are different, the assumption that an out-of-field teacher has well-formed specialist practice of an in-field space may be tenuous when the out-of-field teacher has never actually taught in-field, as can be the case for novice teachers. Also, novice teachers face a number of boundaries that can blur the landscape and make learning more complex, i.e. boundaries between student and teacher, career changes, as well as in-field and out-of-field subject boundaries. For these teachers, a temporal idea of navigating through the landscape over time (like turning on a dimmer light) might be more representative of the learning processes involved.

Second, to some extent the boundary crossing lens glosses over power relations and conflicts that arise at, or that have caused the boundary. In criticism of communities of practice, Ramsten and Säljö (2012, p.34) state that

> the seductive metaphors of communities of practice with productive relationships between experts and newcomers engaged in shared practices serving a common good may gloss over an everyday world of conflicts, diverging interests and competition in and between communities and organisations.

Where the unit of analysis is on the out-of-field teacher, there is less focus on the effect of context in creating tensions between providing agency to teachers in perusing interests and teachers being placed without regard for interest, self-efficacy, or even capability. Shifting the focus to the practices within the fields within those contexts, rather simply on the teacher and their learning, may give due attention to problems that can occur within this boundary space. It also helps to shift the locus of responsibility for responding to out-of-field teaching away from just the teacher to include other key players involved, such as the school leaders and policymakers.

Despite these limitations, the boundary crossing lens is useful for articulating learning that arises because of the boundaries, and for supporting teachers to identify the boundary objects that might be useful and identifying the professional development needs of the teachers. 'Thinking about boundary crossing leads to questions about how and to what extend continuity is maintained despite sociocultural differences' (Akkerman and Bakker 2012, p. 156), that is 'finding productive ways of relating intersecting dissimilar practices' (p. 155). The dialogical nature of boundary crossing recognises the ongoing, two-sided actions and interactions between practice (Säljö 2003) if indeed the context is supportive and enabling of change and innovation.

4.5 Epistemological Perspective: The Lived Experience Theoretical Framing[4]

The search to understand the meaning that this phenomenon has for teachers is directed through Gadamer's (1975) hermeneutic philosophy to 'understand the whole in terms of the detail and the detail in terms of the whole' (p. 258) and to explain the culture that underpins the out-of-field 'thing' (p. 414) as out-of-field teachers' truths. The hermeneutic circle explained by Gadamer (1975) encourages observation of the culture, beliefs and history surrounding out-of-field teaching practices in schools in its totality. It, however, underlines specific 'parts' of the whole experience to develop a clearer and deeper understanding of lived experiences. A hermeneutic mindfulness is attentive to the 'newness' that is offered through reflections on personal perceptions and understandings (Gadamer 1975, p. 238). Gadamer's theory (1975) directs the search for 'what' needs to be understood about the out-of-field experience while Van Manen (1977, 1990) guides understanding in terms of 'how' the phenomenon impacts teachers.

The Vygotskian theory (1978) of the knowledgeable other effectively aligns the impact teachers' content knowledge (CK), pedagogical content knowledge (PCK) and pedagogical knowledge (PK) play in prior and new concepts, described as the 'zone of proximal development' (ZPD). Reflecting on this theory will clarify 'why' there should be an urgency to understand the implications of the out-of-field phenomenon for quality education and quality teaching. A discussion of the phenomenological philosophy of Gadamer (1976) explains how different lenses and the use of specific verbal and non-verbal language supports researchers in looking deeper into the hermeneutic experiences, which greatly impact the teaching and learning space, in relation to out-of-field teaching. Gadamer's hermeneutic philosophy emphasises how language supports an understanding of the complex human 'life-world' (Regan 2012) and is fundamental in understanding the implications of the out-of-field phenomenon. Understanding depends on verbal and non-verbal communication; these linguistics reveal what there is to understand. Interpreting participants' 'language' about their lived experience makes this communication hermeneutical. Hermeneutics is a real-world philosophy that defends the view that truth is not reliant on scientific approaches for it to be discovered and that information is positioned in the history of the specific phenomenon.

[4]Section 4.5 by Anna E. du Plessis.

4.5.1 Application of Lived Experience to the Out-of-Field Phenomenon

Epistemological investigations of the lived experiences that underpin the out-of-field phenomenon frame a deeper understanding of the phenomenon. This nature of knowledge about out-of-field teachers' lived experiences are closely linked to Vygotsky's socio-cultural learning theory and Gadamer's hermeneutic philosophy of deep understanding. Awareness of various theoretical assumptions and the need to developing a theory that supports in-depth investigations of lived experiences linked to the long tradition, culture and common practice of assigning teachers to out-of-field positions calls for bold innovative theoretical framing of this research. Critical analysis of the 'life-world' of people necessitates discretion, compassion and understanding. The need to have a theoretical frame that appreciates and acknowledges the impact of context-conscious understanding motivates a bold and innovative stance to create a theory that will provide support and access to a Context-Conscious Understanding Development theory (C-CUD theory) (Du Plessis 2018). This theory conceptualises deeper levels of understanding with strong alignment between contextual factors and epistemological awareness. The Context-Conscious Understanding Development theory (C-CUD theory) acknowledges the impact contextual factors have on lived experiences and is deeply embedded in Vygotsky's (1978) sociocultural learning theory, Gadamer's (1975, 1976) hermeneutic philosophy of deep understanding through linguistic expressions and Van Manen's (1977, 1990) lived experience and reflexivity theory. The C-CUD theory supports development of an in-depth understanding of 'real-life' experiences and the influence these experiences have on individuals who are expected to manage, use initiative and lead in the specific space they function.

The innovative theoretical framework, C-CUD theory (Du Plessis 2018) opens possibilities for focusing on the human experiences in order to unveil their truths within a specific context (Du Plessis 2018). Teachers in out-of-field positions have to manage their lived experiences that link to their feelings and experiences of incapacity to act with confidence as the knowledgeable other in the teaching and learning space. These lived experiences and what it means for the teaching and learning space have been, up to now, overlooked by educational and school leaders. The C-CUD theoretical approach is a suitable method to uncover the 'life-world' of teachers assigned to out-of-field positions (Du Plessis 2018).

This theoretical framework discloses misunderstandings and misconceptions about the implications out-of-field teaching practices have for quality education. The innovative theoretical framing aims to investigate the meaning of the out-of-field phenomenon at a deeper level while it underscores why it needs to be investigated and how we could construct a better understanding of the impact this multilayered phenomenon has on quality teaching and learning. Three powerful theories, the social-constructivist theory of Vygotsky (1978) to argue the complex learning and teaching environment that develops as a consequence of out-of-field teaching, and Gadamer's (1975, 1976) hermeneutic philosophy to support a deeper understanding of Van Manen's (1990, 1977) complex lived experience theory, are linked to the out-of-field phenomenon. The multilayered complexities of the out-of-field phenomenon cannot be investigated in isolation as they are intertwined with contextual factors, epistemological experiences and expectations for quality teaching in classrooms. The theoretical framing provides an underpinning to search for the 'truth' in relation to out-of-field teaching practices and the 'lived meaning that out-of-field teaching has for the teaching and learning environment' (Du Plessis 2014, p. 15–16). Combining Vygotsky, Gadamer and Van Manen in a bold frame underlines the extreme care researchers need to take when investigating a phenomenon that involves sensitive lived experiences with implications for the environment in which individuals function. The C-CUD theoretical framing makes it possible to acknowledge the human experience while staying focused on the fundamentals and core issues that develop as a result of this specific phenomenon (Du Plessis 2018).

Participants need to explain how the nature of 'the thing', in this case the out-of-field phenomenon, and how it impacts the essence of life-world and understanding (Regan 2012). Gadamer's hermeneutic philosophy further claims that 'Someone who understands is always already drawn into an event through which meaning asserts itself' (Gadamer 1975, p. 446). The C-CUD theory adopted Gadamer's (1975, 1976) interpretation of understanding embedded in listening with a difference, observing, testing through different lenses, reflecting and searching from different positions to express meaning through the language offered by participants. This theoretical account of concerned understanding through language involves a 'fusion of horizons' (Gadamer 1976, p. xix), an ontological focus and a pre-understanding of the phenomenon under investigation (Vessey 2007).

Gadamer's view of 'being-in-the-world' with others stimulates the development of an in-depth understanding of out-of-field teachers' specific needs and how they experience collaboration (Brewer 2005). Ontological consideration, focusing on the life experiences within a participant's world, draws Gadamer's attention because of the 'capacity to not only interpret human understanding but misunderstanding as a mechanism for effective communication' (Regan 2012, p. 288). The philosophical belief in ontological understanding leads to the innovative and bold development of the Context-Conscious Understanding Development theory (C-CUD theory), a theoretical framework that emphasises discovery of meaning in context (Fig. 4.5).

'How' is the impact of the out-of-field issue linked to specific situations? Lave and Wenger

Critical reflection on specific context, experiences and situations is often absent. The connectedness to specific context as a fundamental theoretical stance allows for the exploration of a wide range of perspectives and interpretations in the field (Boudah 2011). Specific context in the search for out-of-field teachers' truths acknowledges the social interdependence of teachers and their students in classrooms while at the same time realising the impact that these teachers have on the actions of their students (Johnson and Johnson 2003).

The C-CUD theoretical approach supports an in-depth understanding of the situated influence of the out-of-field phenomenon and how it impacts teachers lived

Fig. 4.5 An epistemological approach: C-CUD Theoretical framing to understand out-of-field teaching experiences (Du Plessis 2018)

meaning of being a teacher. The issue of out-of-field teaching practices is not isolated from the specific situation or circumstances in which it occurs. A clear understanding of the link between the out-of-field phenomenon and its situatedness will improve the effective management of the phenomenon through targeted support. Analysis of the phenomenon and its embeddedness in teachers' specific situations and context offers a theoretical framing for deeper understanding of these teachers' life-world, unique situations, contexts, and needs teachers themselves might not be conscious of or notice (Van Manen 1990; Laverty 2003; Lave and Wenger 1990, 1991). Noteworthy, an in-depth reflection on teachers' specific contexts, experiences and situations is often absent when decisions are made about teachers' placements, support or teacher performance assessment processes.

'Where' do the implications of the out-of-field phenomenon impact teachers and therefore effective teaching? Van Manen

A hermeneutic philosophy aims 'to let things speak for themselves' through a descriptive approach and accepts that 'lived experiences are always already meaningfully experienced' when they are interpreted (Van Manen 1990, p. 180–181). The C-CUD theoretical approach sought to understand the lived meaning of 'being part of the out-of-field situation' in such depth that it reveals what participants themselves might not be aware of (Van Manen 1990; Laverty 2003). The themes that emerged through a C-CUD theoretical framed investigation form 'insightful invention, discovery and disclosure' while supporting the construction of new meaning (Van Manen 1990, p. 88). Identification of recurring themes unwraps the 'needfulness and desire' (p. 88) within the teaching and learning context to make sense of lived experiences in relation to out-of-field teaching practices. The specific theoretical framework supports in-depth conversations through which information emerges about the 'life-world' of out-of-field teachers 'as we immediately experience it pre-reflectively' (Van Manen 1990, p. 9).

'Why' is Understanding Important? Vygotsky

Conceptualising the theoretical framework to address question about 'why' it is necessary to develop a deeper understanding support the construction of knowledge in relation to the out-of-field phenomenon. Focus on Vygotsky's (1978) theories about the more knowledgeable other (MKO) and the zone of proximal development (ZPD) accentuates the impact of CK, PCK and PK as well as the impact its absence has on the teaching and learning environment. Vygotsky's social-cultural constructivist theory provides an instrument that facilitates an in-depth understanding of why out-of-field experiences impact the teaching and learning environment.

The significance of confident social interaction in the teaching and learning space is underlined in the C-CUD theoretical framing (Du Plessis 2018). The implications of experiences within the learning and teaching community for the development of students and how effectively they construct meaning (Vygotsky 1978) should not be underestimated. The culture within the learning environment effects cognitive progress (Vygotsky 1978). The sociocultural interface of students with a knowledgeable other guides and grows healthy learning dispositions and habits (Vygotsky 1978). Vygotsky's theory underlines the impact of expertise in guiding the construction of new knowledge while accentuating the scaffolding of prior and new knowledge. The 'why' in understanding the phenomenon involves acknowledgement of the place that expertise has in ensuring that students internalise new, unfamiliar knowledge and what happens in the teaching and learning environment when the teacher is not the knowledgeable other. The language of what happens in the classroom impacts internalisation of new knowledge. The culture, atmosphere, traditions and beliefs practiced in classrooms influences the smooth transitions between prior acquired knowledge and newly constructed knowledge to internalise new concepts.

'What' is there to Understand? Gadamer

Hermeneutic phenomenology as a philosophy evolved from the theories of Husserl (Zahavi 2003) on the essence of consciousness and Heidegger's (1962) theories which involve the ontological principle. Haring (1962) defined ontological principles as a focus on 'actual entities' (p. 4). The philosophical beliefs for the development of the C-CUD theory are to open the field for an in-depth connection with the participants in their 'real life-world', in their context and in the 'space' where their lived experiences take place (Du Plessis 2018), based on Gadamer's hermeneutics (1976). The C-CUD theory frames an investigation as ontological, making use of close conversations and continuous interaction, formal and informal, with participants to develop a fuller understanding as 'in linguistic communication, the world is disclosed' (Gadamer 1975, p. 404). Husserl's notion of the 'life-world' defines object and subject as interconnected through the subject's lived experience, while Heidegger (1962) explained that 'the being-there' (p. 182) of Dasein (the truth) is 'being in the world' (p. 174). The argument then focuses on how being assigned to out-of-field teaching practices impact teachers' sense of belongingness, not only in these specific fields but also in the teaching profession.

Out-of-field teachers influence the life-world of the people they encounter—parents, students, colleagues and the wider community—but, in turn, are influenced by the 'world' in which they live (Schutz and Luckmann 1973). Bourdieu (1979) records that habitus encompasses embodied dispositions that define how an individual perceives their world, performs in this space and adjusts to it according to specific challenges. The C-CUD theoretical framing underlines the influence of embodied experiences and specific context on dispositions within the teaching and learning environment. Sharing their understanding during interviews, participants reflect on the relationship between 'being' and 'their truth' in terms of their out-of-field context. Bourdieu (1990) emphasised how meaning-making and 'habitus' influence social viewpoints. Out-of-field teachers' experiences of 'belongingness' (Gadamer 1975, p. 416) to the specific context in which they function informs a better understanding of the phenomenon.

The embodied knowing that binds the experience and the person in union (Dall'Alba and Barnacle 2005) has relevant meaning for investigating a multilayered phenomenon such as the out-of-field situation. Targeted dialogue develops and mediates understanding through stimulating interest to conceptualise 'taken for granted' experiences of everyday life (Barnacle 2001) and what underpins these 'taken-for-granted' dispositions. In agreement with Gadamer's (1975) philosophy, respondents are perceived as a part of a larger community, culture, history and context. Respondents do not function in isolation. Gadamer constructed his notion of the individual, drawn from Heidegger's view, as always being a person-in-community with a past or tradition. He further suggested that analysis of the human experience should take this into consideration: 'There are no eternal truths. Truth is the revealedness of being that is given with the historical nature of there-being' (p. 479). The development of the C-CUD theoretical frame is deeply embedded in a Gadamerian notion that practical wisdom involves self-understanding within the situation of practice while the distance from the practice 'can induce a distortion' (Grondin's 2002, p. 5). Gadamer further defines practical wisdom as the understanding that develops through the fusion of different horizons (Gadamer 1975). Vested in Husserl's theories (Zahavi 2003) of the 'horizon' of experiences that hovers between what is real or concrete and what is seen as the ideal or the abstract ideas of people, the C-CUD theoretical framework finds validity in Gadamer's theory of 'the fusion of horizons' (Gadamer 1975, 1976, p. xix). His 'fusion of horizons' theory (1975) claimed 'to interpret means precisely to use one's own preconceptions so that the meaning of the text can really be made to speak for us' (p. 358).

The 'fusion of horizons' philosophy uncovers the voice and agency of different participants to offer a deep understanding of 'being' (Gadamer 1975, p. 432). The mediation of understanding is interwoven with specific circumstances and 'the self' (Gadamer 1976). Gadamer's (1975) hermeneutic approach is a cognizant fusion of the position of the interpreter and the data being inferred.

4.5.2 Lived Experience Theory Applied to Our Research on the Out-of-Field Phenomenon

The C-CUD theoretical framework offers explanation, understanding and several acts of clarification (‘fusion of horizons’) as described by Gadamer (1975). The interpretation of the verbal and non-verbal interaction and communication reveals rich clusters of meaning identified from data to expose the essential nature of the lived experience (Van Manen 1990). A beginning teacher shared how the specific situation, circumstances and context in which she finds herself assigned to teach a subject outside her field of qualification and expertise impacted her lived experience as a teacher as well as her self-esteem beyond the classroom walls:

> I am a disaster, I am pathetic, I sit behind my desk the whole day, I have no friends and no time for my family. I feel worthless in everything I do.

An in-depth understanding of the lived experiences teachers in out-of-field teaching positions have to manage only develops through appreciation of the context in which the out-of-field phenomenon occurs (Du Plessis 2018).

4.5.3 Critical Analysis of Lived Experience

A context-conscious understanding of data depends on a trust relationship between the interpreter and the interpreted, displaying awareness of preconceptions within a specific historical time and context in order to expose beliefs and build new knowledge about the meanings of specific actions (Maggs-Rapport 2001). Awareness of tradition and historical time advances an in-depth understanding of the meaning of diverse contexts and validates the data gathered.

Gadamer’s hermeneutic circle, where the whole can be clarified by smaller, specific incidences against the background of cultural, historical and literary context, supports looking beyond common practices and taken-for-granted attitudes. Interpretive and reflexive analysis acknowledges that personal context conditions have implications for the research approach. Gadamer (1975, p. 238) described interpretive analysis, in agreement with Heidegger (1999) as ‘A hermeneutical trained mind must be, from the start, sensitive to the text’s quality of newness—sensitivity involves neither neutrality—nor the extinction of one’s self but the conscious assimilation of one’s own fore-meanings and prejudices’. The analysis process includes investigating and re-examining accounts to find discernments through analysis of the participants’ accounts, while the context of the participants’ story is the emphasis of the hermeneutic circle (Annells 2006; Crist and Tanner 2003).

Focusing on the whole and respecting the parts (Gadamer 1975) underpins the value of Vygotsky’s (1978) social constructivist theory for understanding the meaning that the out-of-field phenomenon has for classroom context. The theoretical framing allows for a holistic view of the out-of-field experience while affording researchers opportunities to 'get close' to valuable data in the field (Berg 2004; Cohen et al. 2011; Ladson-Billings and Donnor 2005). The theoretical framing stimulates a view of the phenomenon as 'the thing' to be understood through different participants. The conceptual framework imparts new understanding about the interrelation between out-of-field experiences and effectiveness in classrooms and schools in contextual factors.

4.6 Synthesis and Key Insights

The four theories and what they can illuminate about the out-of-field teacher are summarised in Table 4.3. Positioning theory, Activity Theory and Boundary Crossing are distinguishable, although there is common ancestry of Activity Theory and Boundary Crossing meaning that there is agreeance in the underlying theorization of boundaries between social practices and the learning that such boundaries can prompt. For fourth theory, the three contributing theories—Vygotsky, Gadamer and van Manen—are expanded on to illustrate what each can contribute to an analysis of teaching out-of-field and what each contributes to the C-CUD Theory proposed by du Plessis (2018).

So what can be gained from this juxtaposition of theory? There are two parts to this question: first, what can be learned about theory; and secondly, what can be learned about the phenomenon of teaching out-of-field?

In response to the first question, the four lenses showcased here have been shown to foreground different aspects of the phenomenon, thus highlighting the value of drawing on multiple theories, either across studies or within a study. The third and fourth lenses illustrate also how new theory or models can be derived from or at least informed by existing theory in ways that more keenly focus researcher attention on the research problem. The C-CUD theory from du Plessis, in particular, is rigorously informed by multiple theories, illustrating also the explanatory power gained from taking a kaleidoscopic approach to research. Denzin and Lincoln (1999) proposed the notion of interpretive researcher as bricoluer, giving permission for researchers to draw on whichever theoretical frameworks or research methods are needed to solve the researcher question and gain insight into the problem. Indeed, the work of du Plessis might be seen from this perspective as experiences are interpreted both from the individual teacher perspective while also recognising the social nature of learning as teachers interact within the social setting of the classroom and school. There is also great benefit in using a single theoretical lens to interrogate closely some aspects, for example, positioning theory enables close analysis of the ways the respondent articulates, shares, and puts into narrative their experiences, and can highlight through this articulation that what ways in which teachers might feel marginalised by having to teach something new but also the agency they feel they have over their allocation, learning and teaching. Activity theory has particular power in providing a framework for identifying various parts of the systems within which the teachers operate and can be valuable in highlighting disjunctures, discontinuities and challenges that teachers

Table 4.3 Summary of theories and their application to researching teachers who teach out-of-field

Theory:	Positioning theory	Activity theory (third generation)	Boundary crossing	Sociocultural learning theory	Philosophical hermeneutics	Lived experience
Key theorists:	Harré and van Langenhove (1999)	Engeström (1990, 1998, 2015)	Akkerman and Bakker (2011)	Vygotsky (1978)	Gadamer (1975, 1976)	Van Manen (1977, 1990)
Focus of theory:	Reality is conceived of as dynamic, changing moment-to-moment in conversational acts. Positioning triad describes an individual's perceptions and interpretations (Storylines) of the social, cultural and historical facets of the moral order (Discursive practices), and the system of rights and duties within which intentional acts are done (Positions)	Collective human behaviour is object-oriented and involves dialectical relationship between a subject, object, culturally mediated artefacts, patterns of division of labour and the wider community	Learning occurs as people cross boundaries between different social practices Discontinuities can be overcome by re-establishing continuity and increasing the porosity of the boundary	The impact of expertise from more knowledge able others, through the zone of proximal development, in guiding the construction of new knowledge while accentuating the scaffolding of prior and new knowledge	Practical wisdom is understanding that develops through the fusion of different horizons: horizon of experiences between what is real or concrete and what is considered the ideal or abstract. Uncovers the voice and agency of different participants to offer a deep understanding of 'Being'	Lived experiences are always already meaningfully experienced as they are interpreted

(continued)

Table 4.3 (continued)

Theory:	Positioning theory	Activity theory (third generation)	Boundary crossing	Sociocultural learning theory	Philosophical hermeneutics	Lived experience
Applicability to out-of-field						
Usefulness:	Focuses on identity formation, socialisation practices, habitus and capacities. Provides alternative to static concept of ‘role’ Understand and track changes in teacher identity formation and perceptions of personal agency as they negotiate unfamiliar curricular contexts	Focuses on how activity systems are interlinked, interact with and influenced by other related systems. Shared objects are the unit of analysis Contradictions and tensions can be sources of conflict but can also drive learning and change	Focuses on what teachers bring to the boundary rather than what teachers are missing Learning mechanisms of the boundary allow teachers to move from in-field to out-of-field spaces	Focuses on the complexity of the learning and teaching context Expertise of the teacher ensures that they are the more knowledgeable other. The culture, atmosphere, traditions and beliefs brought to classrooms influence student learning	Focuses on what needs to be under-stood—culture, beliefs, history. Analysis focuses on how the teacher’s experience of belonging to a specific context informs a better understanding of what is means to be an out-of-field teacher	Focuses on the meaning of experience and the impact on the individual. Anecdotal narratives constructed from in-depth conversations give insight in toe life-worlds of out-of-field teachers

(continued)

Table 4.3 (continued)

Theory:	Positioning theory	Activity theory (third generation)	Boundary crossing	Sociocultural learning theory	Philosophical hermeneutics	Lived experience
Limitations:	Linguistic uncertainties as described by Herbel-Eisenmann et al. (2015) may cause misunderstandings of the seminal terms used to better understand the complexity of social situations	Nexus between CHAT and identity not immediately apparent. This link was extended by Roth (2004)	Assumes knowledge and practice of in-field area well understood May gloss over power relations that arise at or cause the boundary crossing	The uniqueness of the individual can be overlooked while the socio-cultural aspects can be over emphasised	Articulation of perceptions, thoughts and feelings requires deep and challenging reflection and consciousness of a specific phenomenon	A focus on the individual meaning of an experience may misrepresent or only partially describe the broader situation or context
Emergent theories/advances:	Fine-grained analysis of interpersonal encounters may inform models of professional development to build the capacities of out-of-field teachers		Boundary Between Fields Model (Hobbs 2013a) identifies the factors that make a teacher 'feel' out-of-field	Context-Conscious Understanding Development Theory (du Plessis 2018) Draws together these theorists as a framework for developing an in-depth understanding of the situated influence of the out-of-field phenomenon and how it impacts the teacher's lived meaning of being a teacher		

can face, thus informing where support might be provided. Similarly, the boundary crossing lens has this effect of identifying discontinuities, but also the boundary crossing construct is useful as a metaphor of the movement of teachers across specialisations or subject boundaries. Also, the learning mechanisms can provide a useful language for shifting discussion from a deficit view of teaching out-of-field to highlighting the potential for learning and what is needed to support learning, identity expansion and transformed practice.

In response to the second question, and summarising the arguments from each theory in preceding sections, we can see that teachers' work is comprised of multiple systems and that moving between these systems, that is crossing boundaries, can result in discontinuities, which relates to their 'at home-ness', and which can in turn lead to learning if the conditions are right. Common ground, or boundary objects can assist within this crossing so that with experience and overtime there is permeability across sites as teachers learn what is needed to operate successfully in the new subject. Teachers experience these boundary crossings in different ways, and their degree of at-homeness influences the meaning that teachers attach to these experiences. This meaning is a product of, or at least contributed to or shaped by, the teacher's personal qualities (such as disposition to learning) but also and perhaps more significantly by the nature of the context they are in. Crossing the boundary between subjects, therefore, can provide opportunities for learning as long as the personal and contextual factors afford, support and embrace teaching out-of-field as a complex, potentially destabilising, potentially enriching processes that take time, space and understanding to overcome. Teachers may position themselves in relation to the tasks as pedagogues and subject specialists, the associated rights and duties, which can morph and take shape contextually and temporally, and issues of power and agency arise in relation to the control they perceived they have in their allocation and as they attend to their professional duties negotiating new content and pedagogies.

4.7 Conclusion and Implications for Practice and Policy

This chapter has showcased four theoretical lenses that have been used to analyse the phenomenon of teaching out-of-field. As a complex phenomenon, we have shown that even when focusing specifically on the teacher as the unit of analysis, different theoretical lenses are needed to highlight different aspects of this experience and its effects. We acknowledge that other lenses might just as well have been showcased here, such as identity theory, which is becoming a well-used and appropriate lens for examining the effects of out-of-field on the teacher (see for example, Bosse and Torner 2015). Even more so, when the focus of analysis moves beyond the teacher, other theoretical lenses can be fruitful in highlighting, for example, how different stakeholder groups represent out-of-field teaching as might be shown by the use of 'problem representations' (Bacchi 1999); such 'representations' (such as how out-of-field teaching is represented) are created and shaped as we speak about them and as we propose how to ‘address’ them.

Theory enables the researcher to find and tell the story they want to tell. Therefore, researchers need to be thoughtful when selecting theory so as not to twist the story to unfairly paint a deficit position of what it means to, and the effects of, teaching out-of-field. After all, appointing teachers to teach subjects for which they have no specialisation is often a remedy to a lack of appropriately specialised teachers, often a last resort, and often an accepted response within education systems that are often under-resourced. Public understanding of and trust in the teaching profession can be seriously undermined when only the negative story is told. Similarly, only focusing on positive experiences of professional learning and identity expansion can downplay the power dynamics that can be pivotal in determining the quality of the experience of teacher learning and feelings of survival and failures that can sometimes be experienced by teachers. An over-emphasis on the individual can neglect the influence of context, while over-emphasising the sociocultural context may not account for the range of experiences of individual teachers within and across different contexts and education systems. Research into this phenomenon that is informed by theory should be honest in how the theory provides a constructive constraint to the examination of the phenomenon, that is, which aspects of the phenomenon fall within its gaze at the exclusion of others. What a researcher hopes to achieve through the research should also be clearly indicated as the theory one uses will bring to the fore different aspects of the phenomenon that have different implications for policy and practice.

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Chapter 5
Teacher Professional Competence: What Can Be Learned About the Knowledge and Practices Needed for Teaching?

Máire Ní Ríordáin, Catherine Paolucci and Terry Lyons

Abstract As teacher educators face the challenge of supporting out-of-field teachers, it is essential to maintain a focus on the development of both specialised content knowledge and the essential skills and practices required for competent teaching. It is well established that teachers' knowledge base plays a critical role in determining what is done in classrooms, and accordingly, how and what students learn. Similarly, research relating to the professional work of teachers emphasise the importance of developing teachers' core practices. Utilising the example of mathematics and science teacher education, this chapter examines both teacher knowledge and teacher practices, with a focus on key considerations for 'out-of-field' teacher education. We discuss the importance of both knowledge and practices being incorporated into professional learning opportunities for teachers entering an out-of-field subject. We suggest that this involves identifying core practices as specific to subject areas, identifying key knowledge as underpinning and connected to these practices, and to provide out-of-field teachers with the appropriate opportunities to acquire such knowledge and practices. Accordingly, key considerations and reference points for researching out-of-field teachers are identified, as well as policy implications for the design and implementation of suitable professional learning opportunities.

Keywords Teacher knowledge · Core practices · Mathematics/science
Out-of-field teacher education

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5.1 Introduction

As teacher educators face the challenge of supporting out-of-field teachers, it is essential to maintain a focus on the development of both specialised content knowledge and the essential skills and practices required for competent teaching. Given that out-of-field teachers are already certified teachers with various levels of teaching experience both in and out of their subject area, this requires flexible, multi-dimensional approaches to professional development that are both strategically planned and emerge in response to teachers' individual and evolving needs.

This chapter examines the constructs of teacher knowledge and core practices within a mathematics and science teacher competency focus. We recognise and appreciate that these constructs apply to other subject areas also but for the purpose of this chapter we focus on mathematics and science. Ensuring high-quality teaching requires both high-quality knowledge and high-quality practice. To perceive that such knowledge and practices can be obtained without formal preparation undermines and underestimates the complexity of the teaching profession (Cochran-Smith and Zeichner 2005). Of concern to us is what knowledge mathematics and science teachers need, how knowledge and practice relate, and how can we interconnect the two in order to support teachers within an out-of-field context.

Rather than seeing this as an issue to do with qualification, we suggest that there is a need to build a professional learning infrastructure to support out-of-field teachers in developing the knowledge and practices required for professional competence (Ball and Forzani 2011). We suggest that there is a need to develop a professional curriculum focused on the knowledge utilised most in teacher practice and to provide teachers with an opportunity to practice and receive feedback in a variety of learning contexts such as in the classroom, universities, summer workshops, communities of practice and virtual learning environments. However, agreeing on such knowledge, skills, and practices is one of our greatest challenges in teacher education (Ball and Forzani 2011).

A core focus must be on developing models of professional learning for out-of-field mathematics and science teachers that enhance teachers' relationship to the subject and to the teaching of the subject, in due course contributing to learning gains for students. Currently, the field lacks a deep understanding of the knowledge and practices that out-of-field teachers bring with them and how these may impact on student learning. Accordingly, professional learning programs need to be considered in a deliberate manner with a focus on their conceptualization, design and implementation (Pournara et al. 2015). In particular, professional learning programs need to provide out-of-field teachers with an opportunity to develop and refine their knowledge and practices for teaching. However, understanding in what ways out-of-field teachers can best learn, be supported and develop knowledge and practices still remains an open issue and one needing addressing. This chapter provides a discussion on moving towards an understanding of this issue.

5.2 Teacher Professional Competence: The Knowledge Turn, the Practice Turn

Teacher professional competence is a complex, multi-dimensional construct. It is inclusive of both professional knowledge and affective-motivational characteristics (Weinert 2001). We examine research relating to the professional knowledge dimension of professional competence and provide a discussion on the need to consider both the knowledge dimension and its connection to the professional work and practice of teachers. The foci of many theoretical and empirical studies examining teacher professional knowledge have primarily focused on in-service or pre-service teachers (e.g. Ball et al. 2008). Examining professional knowledge and practices within an out-of-field context is under-researched (Ní Ríordáin et al. 2017). However, such studies with pre-service and in-service teachers can provide valuable theoretical, methodological and practical implications for consideration within an out-of-field context.

5.2.1 *The Role of Teacher Knowledge*

It is widely understood that teacher knowledge has an impact on pedagogy and student learning in mathematics and science (Abell 2007; Arzi and White 2008; Ball et al. 2008; Nixon et al. 2016). Interest by researchers in teachers' professional knowledge has developed over the past number of decades, stimulated by the work of Shulman (1986, 1987). Within the mathematics education context, a range of theoretical frameworks relating to knowledge required for teaching mathematics have been developed (e.g. Adler and Davis 2006; Ball et al. 2008; Davis and Renert 2013; Rowland and Ruthven 2011; Tatto et al. 2012). Although such models are diverse in underpinnings and approaches, there are similarities that provide rich insights in relation to the knowledge required of mathematics teachers that impacts on teaching and learning in classrooms (Charalambous 2016).

Essentially, Shulman (1986) specified three core dimensions relating to teacher knowledge. These are subject matter knowledge (SMK), pedagogical content knowledge (PCK) and curriculum knowledge, which form a critical theory for understanding and improving subject-specific teaching. Over the years, several researchers have augmented and elaborated on these core dimensions (Baumert et al. 2010). For example, in mathematics education, there is agreement that strong SMK is a core component of teacher professional competence in order to make mathematics comprehensible for students (e.g. Ball et al. 2008; Grossman and Schoenfeld 2005; National Mathematics Advisory Panel 2008). Nevertheless, there is not a consensus on what level and depth of mathematics content teachers must understand to be effective teachers in the classroom. However, in general, it is expected that 'teachers must know in detail and from a more advanced perspective the mathematical content they are responsible for teaching…both prior to and beyond the level they are assigned to teach' (National Mathematics Advisory Panel 2008, p. 37).

In an empirical study examining the professional development needs of out-of-field mathematics teachers in the Irish context, data was gathered in relation to teachers' cognitive and conceptual proficiency with curriculum aligned mathematical content, as well as self-reported confidence in relation to teaching mathematics (Ní Ríordáin et al. 2017). Out-of-field teachers ($n = 202$) in this study were commencing a professional development program linked to a qualification to teach mathematics at secondary level. Low achievement levels on the mathematics test and high occurrence of conceptual errors point towards inadequate SMK and difficulties with the curriculum that they are teaching. Furthermore, these out-of-field teachers described themselves as either somewhat or very confident in teaching mathematics. This is of significance given that many studies have established that SMK impacts on teacher instruction and student achievement (Nixon et al. 2017b). This discrepancy and lack of awareness of the significance of SMK highlight the importance of developing professional learning opportunities for out-of-field teachers that are situated and practice-based (Ní Ríordáin et al. 2017).

However, 'there still have been relatively few studies on the development of SMK in the context of teaching' (van Driel et al. 2014, p. 854), and a paucity in the out-of-field science and mathematics education context. An argument can be made that a teacher's SMK develops with experience in the classroom and over a long period of time (cf. Arzi and White 2008). This 17-year-long study concluded that secondary science teachers' SMK tends to consolidate around the content they are teaching, with unused knowledge fading from memory. The authors found that accretion of new SMK was limited, and linked mainly to new syllabus content. More recently, Nixon et al. (2017a) found that SMK did not change significantly from the first to the fifth year of teaching for secondary science teachers, and argue that it may take a very long period of time for SMK to develop through experience, and being receptive to learning opportunities. Additionally, some researchers suggest that teachers, inclusive of out-of-field, can draw upon other SMK (for example, another subject that they are certified to teach) to support teaching and learning in the classroom (Nixon and Luft 2015). This new research focus in out-of-field teacher education is conceptualised as a 'boundary crossing' (Hobbs 2013), with an increased attention on how science teachers transfer content knowledge through focusing on crosscutting concepts that bridge subject areas (e.g. chemistry and biology; Nixon and Luft 2015). In particular, this study found that out-of-field teachers relied on their area of specialisation to support the teaching of the out-of-field subject and were more likely to utilise crosscutting concepts to support their teaching. However, this research was undertaken within science subjects, there is a need for further research in relation boundary crossings and SMK in other subject areas.

More notably, research has demonstrated the importance of teachers having a conceptual understanding of the content to be taught, rather than just having studied the content to a higher level (Baumert et al. 2010). In particular, conceptual understanding in the form of PCK is important for classroom practices and the ability to teach a given subject effectively. Shulman (1987) distinguishes PCK from SMK, as 'a form of content knowledge that embodies the aspects of content most germane to its teachability' (p. 9). Accordingly, it refers to a distinct combination of content and pedagogy, essential to the teaching of a given subject. A number of studies have found that a teacher's SMK is essential for the development of their PCK (cf. Abell 2007). It is a requirement that teachers understand the subject matter themselves before, for example, they can comprehend student difficulties with content or select appropriate pedagogical approaches to support student learning (Nixon et al. 2017a). Du Plessis (2015) undertook an in-depth examination of the lived experiences of out-of-field teachers. This qualitative, multiple perspective study found that practices in the classroom were very much influenced by out-of-field teachers' content knowledge, pedagogical knowledge and pedagogical content knowledge. In particular, she found that a lack of PCK impacted on the quality of teaching observed with out-of-field teachers struggling when students asked questions relating to subject knowledge, teaching to the 'middle' group of students, lack of development of connection of key concepts and engagement with challenging subject matter, memorization of key concepts and a lack of understanding of the curriculum to be taught and applied (Du Plessis 2015, p. 95). Furthermore, out-of-field teachers' lack of PCK impacts on affective aspects such as confidence and anxiousness relating to effective teaching.

Research relating to PCK in mathematics education has largely focused on conceptualising PCK (e.g. Ball et al. 2008), measuring pre-service or in-service teachers' PCK (e.g. Hill et al. 2005), and development of teacher professional learning programs connected to PCK constructs (e.g. Rowland and Ruthven 2011). Although differences exist in relation to conceptualization and impact on practice, research on PCK continues to develop (e.g. Askew et al. 2012). Perhaps of importance for progressing research in the out-of-field context is the connection between SMK and PCK. Ball and her colleagues (2008) in mathematics education refer to the combination of both as mathematical knowledge for teaching (MKT), a professional knowledge base required for teaching mathematics. As acknowledged by Hobbs (2013), due to a lack of subject knowledge, out-of-field teachers do not possess the confidence to engage with more advanced subject content and it impacts on their identity as teachers. Previous research has demonstrated that more experienced teachers draw on PCK to scaffold restricted SMK when teaching out-of-field (Sanders et al. 1993). However, Nixon and Luft (2015) raise concerns around newly qualified science teachers teaching out-of-field given their limited PCK and experience. We suggest that there is a need to examine the professional knowledge base of out-of-field teachers when developing professional learning opportunities in order to support and progress competence.

The research on teacher knowledge in secondary science has much in common with the mathematics education context, along with some points of difference. With respect to commonalities, it grapples with similar questions around what constitutes competence in SMK and PCK, and how this competence can best be achieved by pre-service and in-service teachers (e.g. Kind 2009; Lee and Luft 2008; Loughran et al. 2008). Accreditation bodies and professional associations in several countries have attempted to specify the knowledge competence expected of beginning science teachers, with varying levels of success. Experiences in the US and Australia are illustrative. In the former, the National Science Teachers Association (NSTA) articulated a set of standards for pre-service teachers that included expectations about 'content knowledge', 'content pedagogy' and 'professional knowledge', among others (NSTA 2012). The Council for the Accreditation of Educator Preparation (CAEP) has adopted these standards as part of its protocol for accrediting the science teacher courses of colleges applying for national recognition. While the NTSA standards with respect to SMK are not of the same level of detail as the Next Generation Science Standards (NGSS), for instance, the inclusion of subject-specific standards in course accreditation ensures SMK is well represented in course curricula and assessments, and demonstrates respect for the expertise of professional associations (Veal and Allen 2014).

Like its US counterpart, the Australian Science Teachers Association (ASTA) developed a set of science teacher standards—in this case for 'highly accomplished' rather than beginning teachers—with the intention of expanding these to address a range of career levels (ASTA 2009). ASTA was hopeful that the newly minted Australian Institute for Teaching and School Leadership (AITSL) would adopt their standards with respect to science teachers. However, AITSL chose not to develop subject-specific standards, and the considerable efforts of subject associations like ASTA and the Australian Association of Mathematics Teachers (AAMT) are not recognised in the official teacher standards or in course accreditation. While AITSL (2011) provides exemplars or 'snapshots' to illustrate typical practices of subject teachers at various levels, this compromise has been criticised since generic standards are of limited use to designers of science or mathematics teacher education programs (Ingvarson et al. 2014).

One important point of difference between mathematics and science education with respect to required knowledge and skills relates to the way the science curriculum in many countries encompasses integrated or 'multi-strand' science teaching in junior secondary classes and separate disciplines for senior classes. Science teachers in these systems have dual identities—the multi-discipline generalist and the single-discipline expert—a characteristic that policymakers often overlook (Arzi and White 2008). In such systems, it is in the role of generalist that early-career science teachers often feel least competent. Whereas it is expected that pre-service mathematics teachers with a degree or major in mathematics will have a sound understanding of the SMK required to teach junior mathematics, the same cannot necessarily be assumed for pre-service science teachers with a science degree. A major in chemistry, for example, may not prepare a teacher adequately for teaching physics or biology concepts to junior secondary students.

A UK study by Kind (2014) found that many graduate-entry teacher education students with 'good Bachelor of Science degrees' had insufficient knowledge of some basic chemistry concepts taught in lower secondary classes. Kind reported that many of those with non-chemistry majors held similar misconceptions to 15-year-old students. Similarly, in the US, a study of Year 8 teachers of integrated science by Harrell (2010) found low levels of teacher understanding across a range of science discipline areas. She concluded that even among qualified science teachers, teaching an integrated curriculum can conflict with their sense of content expertise.

The problem is not simply a lack of SMK within topics; there is also the challenge of connecting knowledge, skills and themes across topics (Lock et al. 2011). According to Sun et al. (2014), integrated science in junior secondary classes in China has met with limited success due in part to the compartmentalised, discipline-specific pre-service training received by many science teachers, who struggle with cross-subject knowledge and integrative content.

Such examples suggest the need for a greater focus on the development of PCK in pre-service science teacher education as a means of increasing both SMK and confidence in teaching outside of specialisations. This contention is supported by a study of experienced science teachers by Sanders et al. (1993), who concluded that regardless of whether they were teaching in-field or out-of-field topics, the teachers' 'wealth of pedagogical knowledge, and pedagogical content knowledge for general science topics, seemed to sustain them in whatever content they were teaching' (p. 723).

Of important consideration within the out-of-field teacher education context is that research examining SMK and PCK (with pre-service and in-service teachers) has demonstrated a significant connection between both elements. For example, Baumert et al. (2010) conclude that key studies have demonstrated 'that the repertoire of teaching strategies and the pool of alternative mathematical representations and explanations available to teachers in the classroom are largely dependent on the breadth and depth of their conceptual understanding of the subject' (2010, p. 138). Similarly, research focused on the improvement of teachers' SMK demonstrate that it can contribute to enhanced classroom instruction (e.g. Swafford et al. 1997). However, SMK is not solely the key determinant for quality teaching and learning. For example, findings from Baumert et al. (2010) suggest that a teacher's PCK has a greater influence on student achievement than their content knowledge. Nevertheless, a common conclusion can be drawn from various studies undertaken: given that a relationship exists between SMK and PCK and can be viewed as a required foundation for professional knowledge (e.g. Ball et al. 2008), then both impact on teaching quality and student learning (Campbell et al. 2014).

Theoretical constructs of knowledge required for teaching are useful and help us to think about teachers (Chapman 2013), particularly in this context to help us think about out-of-field mathematics and science teachers and their work. Naturally, there are limitations to such theoretical constructs, such as the variety of curricula that exists worldwide and related classroom implementation (Ball et al. 2008). Similarly, cultural aspects such as teachers, students and contexts need to be taken into consideration. In particular, focusing solely on a perceived 'set of knowledge' (Chapman 2013, p. 238) will limit the opportunity of examining and understanding what happens in out-of-field teachers' classrooms in order to help develop their professional competence. Specifically, teacher knowledge should be perceived as developing and changing throughout a career (Arzi and White 2008; Charalambous 2016). Accordingly, these forms of knowledge should be incorporated into professional learning opportunities for out-of-field teachers, not left to chance. Additionally, Charalambous recommends 'moving beyond the different types of knowledge to also identifying the practices entailed in these knowledge conceptualizations' (2016, p. 221).

5.2.2 The Practice Turn: Frames and Advocates

In addition to the emphasis that research has placed on knowledge development in teacher education, researchers have built a compelling argument for the importance of specialised skill development and a practice-based approach to teacher training and professional development (Ball and Forzani 2009; Burn and Mutton 2015; Janssen et al. 2015; McDonald et al. 2013). Those who have advocated for the value of mastering key professional practices have discussed that it is not sufficient to focus support throughout various stages to teacher education solely on knowledge, beliefs, and dispositions. Instead, setting teachers up for success in the classroom requires opportunities to explicitly practice the skills, judgements, and behaviours that are essential components of effective mathematics and science teaching in contexts that offer consistent feedback and support from well-trained mentors (Grossman 2010).

The critical practices required for effective teaching are discussed in the literature under categorisations such as core practices and high-leverage practices (Janssen et al. 2015; Lampert 2010; McDonald et al. 2013). They include skills that require strategically constructed opportunities for practice that should be in line with the performance-based training requirements of other highly skilled professionals such as surgeons, airline pilots, or hairdressers (Ball and Forzani 2011). In fact, the term 'clinical practice' has become commonly used to describe this critical component of both initial teacher education and the continuing professional development of practicing teachers (Burn and Mutton 2015).

Despite widespread discussion of the importance of such practices, the literature also reflects a struggle to define, and in some cases, a strategic effort not to define, a common set of specific practices that are considered core practices (McDonald et al. 2013). While some attribute this to the necessity for improvisation in the classroom, others cite the varying nature of critical subject-specific practices that are not common across all disciplines (Ball and Forzani 2009). This critique is particularly important to consider when examining the development needs of out-of-field teachers, as it implies that proficiency with core practices in one subject area does not necessarily translate to proficiency with what are considered to be core practices in another subject area.

In the context of mathematics education, viewing teaching as a highly skilled practice is seen as critical to designing teacher education that can consistently ensure teachers have the ability to reach all students in their classrooms (Ball and Forzani 2009). International research, policy documents, and professional standards offer further evidence of a shift in teacher education that places significant value on practice and skill development (Grossman 2010). For example, in the United States, standards for the preparation of mathematics teachers published by the Association of Mathematics Teacher Educators (AMTE) place a strong focus on the development of skills and practices in conjunction with knowledge and dispositions (AMTE 2017). This is similar to the work undertaken by the NSTA in developing standards for science teachers. In addition, many states have adopted assessments and certification requirements, such as the EdTPA, which evaluate teacher practice through required video submissions. However, these tend to be used across subject areas, and thus are more general in their assessment of teaching practices.

While studying theories of learning is an important foundation for understanding students, teachers must be able to interpret these theories in ways that enable them to understand the varying needs of their students (Burn and Mutton 2015). This is not to say that a strong theoretical foundation is not also essential for mathematics teaching, but instead to say that the study of theory must be accompanied by opportunities to learn how the theory is specifically applied in the mathematics classroom while working with students (Ball and Forzani 2011; Burn and Mutton 2015). This supports the argument that teachers who are qualified to teach in one particular subject area should not be expected to transfer that knowledge and experience to other subject areas without targeted professional development that focuses specifically on the essential practices of teaching mathematics.

While the use of classroom videos and strategic modelling can be powerful tools for helping mathematics teachers to see examples of both effective and ineffective skills and practices (Ball and Forzani 2009; Borko 2004), teachers should not be expected to learn entirely from watching others (Burn and Mutton 2015). By nature, skills such as facilitating group work, cultivating a safe and empowering classroom environment, and creating a culture of student participation and active learning require practice. It can also not be assumed that an out-of-field mathematics teacher who has developed these skills in one particular content area will be able to easily transfer them to teaching mathematics. Some general aspects of these practices will be the same, but integrating an understanding of students' individual mathematical knowledge and dispositions becomes an essential component of these practices, particularly in a subject area where students may have previously developed negative dispositions toward mathematics or a fear of embarrassment from giving a wrong answer.

Teachers must also master subject-specific skills that require them to flexibly adapt their knowledge of the subject in ways that are not required in any other context. Ball et al. (2008) illustrated this need for a practice-based approach to mathematics teacher education in their list of Mathematical Tasks for Teaching. These tasks require teachers to apply specialised mathematical knowledge to routine practices ranging from selecting representations for the purpose of illustrating a particular idea to evaluating student explanations and understanding why a student may have arrived at a particular answer. Mathematics teachers must be able to strategically ask sequences of questions to scaffold students' mathematical learning and differentiate activities to suit the varying needs of the learners in their classroom. Their use of technology must also be strategic and skillful, ensuring that it enhances learning rather than distracting from it (Ball and Forzani 2009, 2011). These skills require teachers to constantly change and adapt the way in which they are applying their subject knowledge, which makes it nearly impossible to develop such skills without working directly with students.

When considering this in the context of out-of-field teacher development, it becomes even more critical for teachers to have the opportunity for well-supported learning in context. Ball et al. (2008) stress that the tasks required for effective mathematics teaching not only require teachers to understand mathematics in a way that is different from how they would have learned it as a student, it also requires them to apply that knowledge in a way that is not expected in any other context. This means that out-of-field teachers must not only be supported in their development of specialised mathematical knowledge, they must also be supported and mentored through the process of developing specific skills that involve flexible application of this knowledge to recognise and effectively address the diverse mathematical needs of their learners.

Calls for a stronger focus on a practice-based approach to development of SMK and PCK have also resonated strongly in the science education literature (e.g. Childs and McNicholl 2007; Arzi and White 2008; Kind 2014). A study of novice chemistry teachers by Nixon et al. (2016) concluded that coherence and sophistication of a teacher's SMK was not simply a function of having a degree in the discipline area, but also of practical classroom experience. Classroom practice helps pre-service and early-career teachers develop their SMK, but perhaps more importantly, it builds their sense of identity and confidence as a teacher. A science degree alone does not necessarily provide beginning teachers with adequate confidence in their SMK. Analysing data from a national survey of novice science teachers in the US, Banilower et al. (2015) noted that whereas 60% of high school science teachers had degrees in science and/or engineering, less than half felt very well prepared for teaching topics such as Earth science, astronomy, ecology, waves, electricity and magnetism in their assigned classes. The sense of preparedness was even lower among middle school science teachers.

So, what should practice-based professional development for out-of-field teachers look like? Grossman (2010) advocates for a range of carefully constructed clinical experiences that can provide strong mentorship from trained mentors and offer specific feedback on instructional practice. These experiences can range from simulations or microteaching experiences outside of the classroom to well-established in-school mentoring structures, with the common critical components of both types of experience being observation and feedback. Ball and Forzani (2009) agree that not all practice-based experiences have to take place in the classroom and provide examples of effective approaches to both strategically designed modelling by a facilitator and simulated skill practice by the teacher. The key in both of these approaches is that the teachers' learning is situated in subject-specific practice, the experiences are highly interactive, and they engage teachers in a structured and ideally collaborative process of critiquing the practice with a facilitator or a mentor and their colleagues or peers.

5.2.3 A Place for Both in Out-of-Field Teacher Professional Learning?

Variation in type, standards, and duration of teacher education exists internationally. There is no doubt that teachers require expert knowledge and skills in order to undertake the work of teaching and to ensure student understanding (Kind 2014). We discuss that ensuring competent teaching requires both high-quality knowledge and high-quality practice. Research on teacher knowledge has demonstrated that it is an important predictor of student achievement, largely due to it being central to decision making processes in classroom interactions (Schoenfeld 2010). Similarly, the day-to-day practices of teachers in schools have been established as a powerful influencer on student learning (Clotfelter et al. 2007). Accordingly, the two perspectives together, provide an appropriate view on the relationship between teacher education and what is accomplished in schools, while acknowledging other significant complex factors also exist. As knowledge for teaching tends to be a practice-based theory and teaching practices are culturally influenced (Stigler and Hiebert 1999), it is understandable that differences exist internationally.

Given that the specialised knowledge, skills, and orientations that underpin and facilitate effective teaching are not acquired consequentially, there is a need to view teaching as intricate work and requiring well-designed teacher education curricula (Ball and Forzani 2009). This is compounded when working with out-of-field teachers and out-of-field teacher education where complexity is derived in terms of contexts, qualifications, subjects, identity, and experiences of teaching. We claim that both knowledge and practice must be core to supporting out-of-field teacher education and close attention must be given to developing appropriate professional learning opportunities for supporting out-of-field teachers in undertaking their work effectively. A focus should be on identifying core teaching practices that teachers employ, as connected to knowledge conceptualisations (Charalambous 2016).

It is also important to consider knowledge and practice development of out-of-field teachers as a continuum of lifelong learning (Musset 2010), not necessarily as a one-off initiative. Accordingly, a first objective would be to examine professional learning opportunities, how they are designed, and how best to facilitate out-of-field teacher development and learning, with a focus on quality knowledge and practice (Ball and Forzani 2009). For teacher education, this perhaps requires a reconceptualization of the standards and licensure requirements essential for entering the teaching profession in a given context. The challenge is to prepare out-of-field teachers for the specialised work of teaching subjects such as mathematics and science, which cannot be acquired through experience alone. We suggest that this involves identifying core practices as specific to subject areas (for example, see Windschitl et al. 2012), identifying key knowledge as underpinning (for example, see Ball et al. 2008) and connected to these practices (for example, see Charalambous 2016), and to provide out-of-field teachers with the appropriate opportunities to acquire such knowledge and practices.

However, such a focus in out-of-field teacher education would require a shift in curriculum design and approaches as it requires identification of key professional knowledge connected to the specific subject area, as well as the demands of using such knowledge in practice. Such knowledge and practice requirements have been shown to be difficult and complex (Ball and Forzani 2009). Accordingly, such a challenge needs to be addressed by the field of teacher education, rather than just at the individual programme level (Windschitl et al. 2012).

Addressing this challenge requires continued work towards the development of a research-based broad set of knowledge and core practices for out-of-field teachers that can be developed over time and that support student learning. For example, we have an indication of how teacher knowledge develops, its connection to teacher education and impact on student achievement within a mathematics education context (Blomeke and Delaney 2012). However, much more work needs to be undertaken to understand how providing opportunities for learning and acquiring such knowledge is accomplished through teacher education (Blomeke and Delaney 2012), as well as how it is connected to practice (Charalambous 2016).

Such conclusions in relation to knowledge and core practices will be different in an out-of-field teacher education professional learning context and research in this area is of paramount importance. This is particularly true given conclusions such as that of Hobbs (2012) which acknowledge that the professional development needs of out-of-field teachers vary significantly and consequently, require a range of different support structures. Developing a broad set of knowledge and core practices for out-of-field teachers would function as a framework to guide professional learning design, with the opportunity for other relevant components to be integrated as required, for example, by the specific subject area, the cultural context, mandated curricula, and so on. The development of such a framework could serve as a basis to be built upon throughout a teacher's career (Windschitl et al. 2012). We do not propose to have the answer to such a framework, but rather a conceptualization of how to approach the challenge of out-of-field teacher education in our systems.

5.3 Key Insights for Out-of-Field Teacher Professional Learning

Formal, strategically constructed approaches to professional learning can take place both in and out of the classroom (Ball and Forzani 2009; Borko 2004). Knowledge development can be supported and measured through formal coursework and assessments offered through institutions of higher education, learning centres, online learning, or other formal learning contexts. While the nature and amount of the mathematics or science content may be influenced by standards set by professional associations or governing policies and agencies, the literature makes the case that this knowledge development must extend beyond basic acquisition of new mathematics or science knowledge to include the specialised knowledge of mathematics and science that is required to be able to carry out the critical tasks for effective teaching (Ball et al. 2008; Vale 2010).

To help out-of-field teachers position this specialised, subject-specific knowledge at the centre of their teaching, they must also have strategic and well-mentored opportunities to transform this knowledge into effective practice. In addition, these opportunities must enable them to practice the application of knowledge and skills in a mathematics or science-specific context (Vale 2010). Outside of the classroom context, this can take the form of mathematics and science teaching simulations or 'approximations of practice', which can vary both in structure and in the nature of the out-of-field teachers' engagement (Grossman 2010; Janssen et al. 2015). One example could involve effective and ineffective practices being modelled by a mentor or teacher educator, with out-of-field teachers engaging in critical analysis of the practice. Another may involve the out-of-field teacher practicing a particular instructional technique and receiving constructive feedback from mentors and peers (Ball and Forzani 2009).

Practice-based learning can also take place while working with their students in a classroom context or in other informal learning contexts, such as after-school or summer programs. These alternative learning contexts often allow for more flexibility in curriculum and instruction which is more conducive to opportunities for pedagogy and skill development. In either context, researchers identify the most critical components to be observation and feedback (Burn and Mutton 2015; Grossman 2010).

The role of colleagues and peers in teacher development is emphasised by McDonald et al. (2013), who model the process of learning to enact core practices as a cycle with no specific starting point. The use of a cycle means that opportunities for development can occur at any stage of enactment. This highlights the critical need for sustained structures to support professional learning that can become embedded in teachers' practice within their schools. Hobbs (2012) also advocates for sustained support over time through a range of mechanisms that can be teacher initiated and are driven or informed by a specific interest or need.

In this context, researchers discuss the value of communities of practice or professional learning teams for teachers who are already teaching in schools (Burn and Mutton 2015; Vangrieken et al. 2017). A community of practice or professional learning team is a teacher-led model of professional development that forms and evolves based on the individual or shared needs of colleagues. They can provide practicing teachers with continued support from others who share their development goals and provide a mechanism that can extend professional development for out-of-field teachers into their own school contexts.

Whereas mandating teacher education curriculum with a focus on practice seems consistent with research recommendations, these recommendations are typically made in reference to initial teacher education (Ball and Forzani 2011). Out-of-field teachers require more flexible structures and models of teacher education. Formation of a community of practice or professional learning team can be motivated by teachers' needs throughout all stages of their careers (Vangrieken et al. 2017). This is particularly valuable given the need for professional development to account for out-of-field teachers' diverse range of experience, teaching contexts, and development needs (Du Plessis et al. 2014; Hobbs 2012; Vale 2010).

The specific focus of these groups can change based on challenges that are immediately relevant or based on longer term goals that may be shared by a group of colleagues (McDonald et al. 2013). For example, in the context of out-of-field teaching, the focus of a community of practice or professional learning team may be on mastering a particular classroom strategy or content-specific skill, such as promoting robust mathematical discourse in the classroom. Members of the community of practice or professional learning team can identify strategies for doing this, observe each other's efforts to integrate these strategies into their mathematics classroom and offer feedback for continued improvement of their integration of these strategies.

While these models of professional learning typically function outside of the context of formal professional development courses or programs, the teacher educators that run formal professional development can help out-of-field teachers to build communities with both their out-of-field peers and more experienced colleagues to reinforce and expand on the content of a professional development experience in a routine and sustainable way. In conjunction with this, Grossman (2010) advocates for formal professional development programs to also offer mentorship training to ensure that experienced teachers are better prepared to serve as mentors either within a community of practice or through formal mentoring relationships with their colleagues.

Ideally, a community of practice or professional learning team would include colleagues within a teacher's own school, but in cases where out-of-field teachers may not have others in their school to work with, professional development programs can help them to set up virtual communities that can still offer this type of support through means such as online discussions, resource sharing, and classroom video analysis (Borko 2004; Vale 2010). These communities can meet regularly outside of school to discuss and reflect on the teachers' work, monitor their progress toward their professional learning goals, and identify new directions for learning as they evolve.

In suggesting a role for virtual communities of practice as structures for developing teacher knowledge and skills, we are keenly aware that the potential of online formats for this type of teacher professional development has yet to overcome a range of 'wicked problems' (Kelly et al. 2016) which hamper their effectiveness as real communities of practice. Nevertheless, there is emerging evidence that teaching practice (i.e. modelling practice, supporting reflection and providing feedback) can be supported by private, stable and trusted relationships within small groups (Kelly et al. 2018).

While the promise of effective social interactivity within virtual professional development is still to be realised, existing technology already provides a wealth of opportunities for individual out-of-field teachers to develop science and mathematics SMK far more conveniently and effectively than at any time in the past (Mawn and Davis 2015). Resources such as PhET, the Khan Academy, and university short courses available through Coursera and MIT Open Courseware not only allow out-of-field teachers to understand new concepts quickly but encourage them to use these technologies in their own classrooms. The usefulness of these resources for out-of-field teachers will be compounded significantly once the technical and social challenges of online mentoring, modelling and reflecting have been addressed, helping teachers to transform new knowledge and skills into good classroom practice.

Essentially, it is important that we situate out-of-field teachers' learning experiences in meaningful contexts (Borko 2004). In particular, teachers need to experience and participate in similar learning activities that they expect of their students. For example, if out-of-field teachers are expecting their students to use technology, then teachers need to experience this themselves as learners also. Similarly, if out-of-field teachers are provided with opportunities to learn about instructional practices then a meaningful context is an actual classroom with importance placed on supporting out-of-field teacher learning by a tutor, colleague, etc. (Borko 2004). Clearly, there are a number of ways to situate out-of-field teachers' professional learning in both formal and informal contexts. The purpose of a given professional learning opportunity (e.g. subject knowledge development, instructional approaches) will drive the selection of the most appropriate approach (Putnam and Borko 2000). We suggest that a combination of approaches and situated in a variety of contexts will help facilitate the development of out-of-field teachers' knowledge and practice.

5.4 Implications and Recommendations for Research and Policy

Of course, any recommendation about professional development models for out-of-field teachers is contingent upon the broader context of professional development efficacy in different countries. Where a culture of effective, well-integrated teacher professional development already exists, programs for out-of-field teachers can be developed and implemented with reasonable confidence that they will be well subscribed. Unfortunately, however, the quality and uptake of teacher professional development in many countries are less than ideal (OECD 2014). Little research exists in terms of evaluating the effectiveness of professional development programs. There also tend to be fewer opportunities in rural areas, where out-of-field teaching is more prevalent (Lyons 2008; Maher and Prescott 2017). In such circumstances, out-of-field teachers must be supported and encouraged to make the most of professional development opportunities. There is a need to build a system of professional learning that can reliably prepare out-of-field teachers for the demands of teaching subjects such as mathematics and science. We discuss that this needs to be underpinned by research and policy, as appropriate to the education system and context.

The process of researching professional learning initiatives needs to be carefully conceptualised and supported by robust data collection (Pournara et al. 2015). In particular, methodologies and approaches employed for examining knowledge and practices needed for teaching (Charalambous 2016), mathematics and science in this instance, in out-of-field contexts require consideration. Charalambous (2016) proposes that research examining teacher knowledge and practices should be longitudinal in design, mixed-methods and examine a variety of knowledge constructs and practices. Accordingly, there is a need for empirical studies to be undertaken, focused specifically on the validation of types of knowledge and core practices required by out-of-field teachers, in various subjects, levels of education, and educational contexts. Consistent with Luft et al. (2015) we would suggest that there is a threshold level of SMK required by out-of-field teachers in order to support student learning in the classroom. Similarly, efforts need to move beyond theoretically constructing PCK in identifying key practices that translate specific content knowledge into learning that is meaningful for students.

However, further research is required in relation to examining SMK/PCK relating to out-of-field teachers and the work of Ball et al. (2008) provides a starting point for this work. In particular, their work has focused on empirically refining the characteristics of SMK and PCK, based on the practices of classroom teachers. Within their framework, common content knowledge (CCK), specialised content knowledge (SCK) and horizon knowledge (HK) constitute SMK; knowledge of content and students (KCS), knowledge of content and teaching (KCT) and knowledge of curriculum (KC) constitute PCK (Ball et al. 2008). We advocate that this work provides a strong base to draw upon in order to examine teacher knowledge, as connected to practices, in out-of-field teaching contexts. However, we propose that there needs to be a greater emphasis on generating theory and evidence about knowledge and practices within out-of-field contexts, which can accordingly inform the development of policy and research specifically relating to this cohort of teachers (Du Plessis 2015).

In particular, we suggest that a greater research focus needs to be placed on examining learning opportunities within schools such as communities of practice (Hobbs 2013). There is a need to move from traditional approaches to investigating teachers' knowledge to a more learner (out-of-field teacher)-focus and examining collaborative learning opportunities among teachers to improve their knowledge and practice (Chapman 2013). For example, research exists around the use of lesson-study and mathematics teachers collaborating together in school to improve SMK, PCK and curricular knowledge (cf. Ní Shuilleabháin and Clivaz 2017). We propose that there is a need to examine collaborative professional learning opportunities, such as a community of practice, with out-of-field teachers in their school contexts. Specifically, we suggest that if improving knowledge and practice is a focus of the professional learning opportunity, then there is a need to move beyond formal levels of development to better understand how out-of-field teachers utilise their experiences, their expertise and their colleagues to become more competent teachers. And accordingly, examining the quality of the knowledge and practice ensuing from it. This connects with the concept of boundary crossings developed by Hobbs (2013) and enabling out-of-field teachers to develop their professional identities.

To be both evidence-based and useful in practice, policy relating to out-of-field teacher education and professional learning must balance the strengths and limitations of all relevant research evidence with the practical realities of the teaching and learning setting. This is a problematic step because of limitations in both the evidence that is available and in policy-making relating to out-of-field teacher education (Ní Ríordáin et al. 2017). Also, most countries have mandated curricula, and this very much focuses any research and discussion on knowledge and practices for teaching in a given context. Teacher registration requirements, licensure requirements, subject specialist guidelines developed by national associations, etc. may help individual practitioners and researchers. We do not propose the need to develop a specific set of knowledge and practices for out-of-field teachers, but rather the need to develop a theoretical framework that can facilitate investigation of knowledge and practices within an out-of-field context.

5.5 Conclusion

Regardless of the cause, out-of-field teaching appears to be something of an occupational hazard for science and mathematics teachers in many countries. In Australia, for example, the experience is almost inevitable for science teachers (Arzi and White 2008). Whereas teachers who are prepared by their pre-service education may be less affected by, or even relish, this dual-identity, for others it can be a source of professional and personal dissonance. We purport that appropriate professional learning opportunities need to be developed to support out-of-field teachers in our systems given their valuable contribution to teaching in schools around the globe. In particular, we suggest the need for developing models of professional learning for out-of-field mathematics and science teachers that enhance teachers' relationship to the subject and to the teaching of the subject, which will in due course contribute to developing their knowledge and practices. It is important for future research and program development to investigate how out-of-field teachers apply and transform SMK/PCK in practice. However, there is also awareness of needing to move beyond this to understanding in what ways out-of-field teachers can best learn and be supported to develop as competent teachers in their out-of-field subject areas.

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Chapter 6
Subject-Specific Demands of Teaching: Implications for Out-of-Field Teachers

Cosette Crisan and Linda Hobbs

Abstract This chapter provides a framework for thinking about the subject-specific nature of teaching in terms of the knowledge, modes of inquiry and discursive practices that delineate one subject from another in the traditional school curriculum. The chapter will explore how these disciplinary traits are translated into teaching as curriculum, knowledge and pedagogy, and how this subject-specificity of teaching is juxtaposed against the more generic aspects of teaching. The chapter explores the idea that if a teacher's expertise can be situated within a field, then they can also be positioned out-of-field. Implications for teaching out-of-field are discussed in terms of the subject-specific knowledge, processes and skills, and the difficulties associated with teacher practice. English and Australian illustrations of teacher practices from in-field and out-of-field situations are provided, in particular highlighting the demands of moving across subject boundaries. Cross-fertilisation is especially evident when subjects are integrated, therefore, the issues associated with integrated curriculum are discussed where the traditional subject boundaries are being challenged as schools are reorganised to integrate subjects through, for example, STEM teaching, or holistic curriculum designs.

Keywords Subject-specific knowledge for teaching · Modes of inquiry
Subject boundaries · Generic descriptions of pedagogy

6.1 Introduction

This chapter entices the reader into thinking about the subject-specific nature of teaching in terms of the knowledge, modes of inquiry and disciplinary practices

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_6

that delineate one subject from another in traditional school curriculum, and the implications that this traditional carving up of the curriculum (and therefore the task of teaching) can have for teachers teaching subjects without the associated specialisation. This analysis of how qualification matches teaching allocated becomes imperative to consider when the traditional subject-oriented approach to school curriculum is challenged by alternative models of curricular and pedagogical design. Such a challenge comes from the science, technology, engineering and mathematics (STEM) phenomenon, where the economic and political pressure to align educational outcomes with a changing workforce is positioning interdisciplinary thinking, and 'soft skills' (Australian Government 2011; West 2012) such as team work, communication, critical and flexible thinking and creativity, as central to a skill set for the twenty-first century. Utilitarian purposes of schooling take precedence under such regimes, and as a result, teachers face a potential breaking down of the STEM subject boundaries; subjects which have thus far created a 'space' for teachers to situate themselves in and a 'culture' to belong to, in accordance with their disciplinary background and training. Interdisciplinary groups of subjects, such as STEM, and with the arts as STEAM, are emerging and being privileged though curriculum innovation (e.g. Kipperman and Sanders 2007), new teacher qualifications, and even new school infrastructure, such as STEM education centres or facilities in schools. Integration of subjects, as echoes of the integration of the 1960s and other eras (LaPorte and Sanders 1995; Yager 1996), is breaking with traditional curriculum and giving voice to more marginalised subjects such as technology (design and computer technologies) and engineering (which in many countries, such as Australia, is not even included in the mainstream school curriculum). This proliferation of STEM globally, as well as other non-traditional ways of packaging the curriculum, such as through the phenomenon-based approach described in Finland's national curriculum framework, challenge the idea that school is about learning within distinct knowledge and skill sets as defined by the discipline and then translated into the school subjects.

The implication of these changes is that teachers are likely to be faced with developing and implementing new curriculums that may fall outside of their areas of specialisation. The notion of teacher as 'out-of-field' may in fact become a natural part of what it means to be a teacher. A danger associated with this move is that teachers who are teaching content that they are not familiar with can fail to give rigorous attention to the disciplinary knowledge and skills. Before relinquishing the notion of subject teacher, it is important to give serious attention to the subject-specific nature of teaching, both in terms of how the subjects provide meaningful focal points around which teachers develop a sense of identity, belonging, support and collaboration, as well as meaningful teaching and learning practices that are identifiably associated with that subject. For the out-of-field teacher, coming to understand the subjects' content and teaching approaches is only part of their journey of learning to teach the subject.

In this chapter, we examine the subject-specific nature of teaching, beginning with a brief historical account of how school subjects evolved over time. While contemporary schools may still teach through subjects, there remains some debate over what should constitute school content and teaching approaches and the relationship of the subject to its corresponding disciplines. Such debates are illustrated through the case of mathematics as a school subject, where we discuss the relationship between school mathematics and the corresponding academic disciplines.

The evolution of the school subjects imposes demands on teachers and the subject-specific knowledge base for teaching needed by specialist teachers. The implicit assumption is that preparation of teachers as subject specialists is a way of ensuring that school-based curriculum development and delivery is informed by a background of knowledge of disciplinary practices and an appreciation for how the disciplines can be used in answering important societal, political, personal, economic and philosophical questions of life. The basic assumptions underpinning mathematics and science subjects (Hobbs 2012) are discussed in order to explore how the nature of curriculum and activity place subject-specific demands on teachers. Despite this subject-specificity, scholarly debates have lead to a number of trends in education that frame education and teaching in generic terms, thereby at times sidelining the role of the subject in shaping pedagogy.

But what are the implications of having a subject-oriented approach for the preparation and support of 'out-of-field' teachers? Can teachers learn to teach the subject despite not being formally specialised in an area? Research has shown that learning to teach a subject without the necessary background in either the content or the teaching approaches is not unproblematic and therefore requires focused re-training (Crisan and Rodd 2014) and an appreciation of the fact that it can actually be quite difficult to teach out-of-field (du Plessis et al. 2015; Hobbs 2013). This chapter therefore also explores how enculturation into the disciplinary practices and subject culture of out-of-field teachers is possible over time, while considering the challenges associated with crossing boundaries for out-of-field mathematics and science teachers.

6.2 A Brief Historical Account of School Subjects: What Is the 'Field' of a Subject Teacher

Secondary schooling in Australia and England, for example is based on a departmental model. Teaching occurs through subjects, and teachers usually refer to themselves as teachers of specific subject areas. Historically, subject specialisation developed in American education system between the late 1800s and early 1900 (Hargreaves 1994), resulting in the 'emergence and institutionalisation of the academic department' (Siskin 1994, p. 38) in high schools. Siskin suggests that this ready acceptance was because high schools were a relatively recent phenomenon during these discussions and the form they would take was still unclear. Departmentalisation remains one of the main differences between primary and secondary education in Australia and England.

By the 1930s, subjects were firmly grounded in high schools, established through a top-down approach from academic institutions (Siskin 1994). According to Goodson (1993), the subject begins with the creation of an intellectual discipline by scholars, normally working in a university, which is then 'translated' for use as a subject in schools. An academic school subject thus emerges out of a field of knowledge that provides for the subject inputs and general direction. This intrinsic relationship between academia and the development of school curriculum persists today to the extent that 'upper secondary requirements are largely determined by the requirements for university entry with inevitable consequences for the lower secondary curriculum' (Dorfler and McLone 1986).

Teaching became increasingly professionalised as teacher training gradually moved from the school to the universities where the subject specialists were located. Disciplinary boundaries became linked to state certificates of college degrees (Siskin 1994). With the establishment of specialised subject areas, secondary teachers increasingly came to see themselves as part of a 'subject community', and tended to separate themselves from each other (Goodson 1993). Curriculum development became overtly subject-centred to the extent that, in America, concerns were expressed through The Norwood Report of 1943 (quoted in Goodson 1993) that 'subjects seem to have built themselves vested interests and rights of their own' (Goodson 1993, p. 31).

Over the years, the term 'subject' has been applied at a number of levels: as a school examination category, a title for a degree or training course, and as a department within a school. Goodson (1993), claims that the

> "subject" is the major reference point in the work of the contemporary secondary school: the information and knowledge transmitted in schools is formally selected and organised through subjects. The teacher is identified by the pupils and relates to them mainly through her or his subject specialisation. (p. 31)

Departments act as more than administrative units (Siskin 1994); they also serve as the primary site for social interaction, professional identity and community, they represent strong boundaries dividing the school and they influence decisions and shape the actions of individual teachers. According to Siskin, these departments are distinguishable and determined by 'realms of knowledge' (p. 5). These realms of knowledge are more than just adjectives or labels for organising the school, 'these subjects give departments their very reason for being' (p. 153). The knowledge is recognisable so that understood differences between realms of knowledge construct boundaries that draw people together around a common interest. Therefore, subject departments

> are not just smaller pieces of the same social environment or bureaucratic labels, but worlds of their own with their own "ethnocentric way of looking at" things. They are sites where a distinct group of people come together, and together share in and reinforce the distinctive agreements on perspectives, rules, and norms which make up subject cultures and communities. (Siskin 1994 p. 181)

A teacher's identity and work, according to van Manen (1982), are organically bound up in what teachers know about their subject. Teachers describe themselves as teachers according to what they know:

> to know a particular subject means that I know something in this domain of human knowledge. But to know something does not mean to just know just anything about something. To know

> something is to know what that something is in the way that it is and speaks to us. (van Manen 1982, p. 295)

The subject, the subject matter and personal histories in relation to the subject are defining elements for teachers. This was demonstrated through Little's (1993) research into schools that challenged the traditional school structure around subject departments, where it was found that subject allegiance remained high as teachers used subject expertise for maintaining the status of the subject.

Siskin (1994) also found that teachers tended to talk not only about themselves but also about others in terms of their specific subject area as a way of conveying information about their work. What mattered for teachers involved in Siskin's study was 'not simply *that* they teach, but *what* they teach' (p. 155, emphasis in original). Disciplinary background is revealed through a teacher's choice of words, how they structure an argument and their goals for teaching and learning, and this aspect is developed further in the next section.

6.3 Disciplinary Underpinnings of a Subject: The Case of Mathematics as a School Subject

The academic disciplines of mathematics and science are represented as school subjects; however, the nature of what is represented as the subject does not, and perhaps cannot, necessarily mirror that of the academic version of the discipline. The foundational knowledge of mathematics and science are translated and organised for the purpose of meeting the outcomes of education (Beane 1995), hence the school subject will be a simplified form of the discipline, according to how curriculum designers see fit to present a discipline to pupils.

In mathematics, Siskin (1994) claims that teachers in her US study developed general agreement about 'what counts as knowledge, and how it is organised and produced' (p. 170). Counter to such claims of general agreement, Schoenfeld (2004) states that, as with other subject areas, controversies exist about the epistemological foundations of the mathematics discipline, particularly 'what constitutes "thinking mathematically", which is presumably the goal of mathematics instruction' (p. 243). Variation in the conceptualisation of what should be learned and how it should be taught has sparked curriculum reform and different views of the content and purpose of a curriculum have been put forward. For example, Cuoco et al. (1996) proposed a 'habits of minds curriculum' where 'Much more important than specific mathematical results are the habits of mind used by the people who create those results' (Cuoco et al. 1996, p. 1). Through such a curriculum, pupils would have opportunities to learn how to bring together different aspects of their knowledge and how to apply their mathematical skills in tackling a variety of mathematics situations (routine and non-routine, within and outside mathematics). However, this calls for teaching mathematics for its disciplinary and intellectual value, aimed at providing training to the mind of the learners and developing intellectual habits in them.

Despite these controversies, mathematics has often been and continues to be characterised by incremental learning, 'a slow systematic and progressive movement from the simple to the complex' (Hargreaves 1994, p. 139). Mathematics activities are, therefore, often seen as 'a sequential progression through a series of topics, each of which is a prerequisite to what follows' (Sherin et al. 2004, p. 208). With this as a teaching model, Siskin claims that 'math teachers value testing, placement, and tracking as the means of assigning students to the right rungs during their progress up the ladder' (p. 170). In her US study, Siskin found that tracking was a distinguishing feature of mathematics teachers: where tracking was viewed by mathematics teachers as a means of meeting student learning needs, tracking was viewed by teachers from other subjects as simply 'convoluted' and extraneous.

One of the consequences of having widespread agreement on the content and sequence—what Siskin (1994) calls 'the tight paradigm of mathematics'—is that teachers are able to learn the routines, and thereby follow the same curriculum. In 1986, Dorfler and McLone expressed views congruent with Reys (2001) and Siskin (1994) stating that 'the material content of school mathematics is to a high degree internationally standardised. Deviations from this standard are only minor and depend on the educational system, local traditions and influences and perhaps special local demands' (p. 58). This view to some extent dominates accounts of how subject matter is organised as 'coherent sets of topics' worldwide (National Curriculum Board 2008, p. 2). In the Australian context, the framing paper for the proposed *National Mathematics Curriculum* (National Curriculum Board 2008) acknowledges content variations across the Australian states and territories, but proposed a content structure that is based on 'the most common categorisations of the basic content strands…in the compulsory years: Number, Measurement, Space, Chance and data, and Algebra' (p. 2). While it is only realistic to expect that pupils in schools learn about relatively simpler mathematical concepts and principles than those of the discipline of mathematics, curriculum-related controversies raised by this framing paper relate not to what is taught, but to the nature of the proficiency strand incorporating processes involved in 'working mathematically' (p.8), which is about learning and adopting some of the ways mathematicians do mathematics through discovering patterns, formulating conjectures, making links, abstracting, generalising, presenting convincing arguments, justifying and proving, thus helping students develop a conception of mathematics as an intellectually rewarding discipline.

In the next section, the subject-specific nature of teaching in terms of the knowledge, modes of inquiry and disciplinary practices that delineate one subject from another in traditional school curriculum are considered.

6.4 Becoming and Being a Subject Specialist Teacher: What Does It Entail?

Historically, there has been an implicit assumption that a body of specialised knowledge of academic mathematics and science (usually studied beyond the age of 18 years old) is necessary or useful in order to account for the specific demands of school teaching practice. For example, until recently, in England, prospective mathematics teachers who enrol on a teacher training course were required to have studied a mathematics degree or a degree with some considerable amount of mathematics content. However, what of and in which ways this body of specialised knowledge of academic mathematics is necessary or useful to functioning effectively as a teacher of mathematics at a school level is still under much debate (see Chap. 5). There is strong evidence instead which shows that teachers' ideas about mathematics, mathematics teaching and mathematics learning directly influence their notions about what to teach and how to teach it. Such research shows that teachers' goals for instruction are, to a large extent, a reflection of what they think is important in mathematics and how they think students best learn it (Bransford et al. 2000).

As such, those teachers who perceive mathematics as being about computations are likely to emphasise its place in the school curriculum and likely to argue for traditional methods of instructing children in computation. When taught in this manner, Office for Standards in Education (OfStEd) (2008) found that mathematics appears disjointed and meaningless to many pupils, who tend to 'refer frequently to prompts provided by the teacher about how to carry out a technique, but such methods, memorised without understanding, often later become confused or forgotten, and subsequent learning becomes insecure. Moreover, such an approach fragments the mathematics curriculum' (p. 37).

In contrast, those teachers who have been enculturated into mathematics are more likely (not a certainty) to see their discipline as a web of meanings with ideas that unify arithmetic, algebra, geometry and thus more likely to expect pupils 'to remember methods, rules and facts as well as grasping the underpinning concepts, making connections with earlier learning and other topics, and making sense of the mathematics so that they can use it independently' (OfStEd 2008, p. 5).

The OfStEd report (2008) produced detailed evidence and analysis from inspections of mathematics teaching and put forward a number essential ingredients of effective mathematics teaching: teachers' good mathematical expertise (subject knowledge and subject-specific pedagogy) and teaching that focuses on developing conceptual understanding, while the American National Council of Teachers of Mathematics (2000) identified that one of the distinguishing features of an effective mathematics teacher is having an understanding of the 'big ideas of mathematics and [being] able to represent mathematics as a coherent and connected enterprise' (p. 17).

Many of these issues about appreciation for the complexity and connectedness of mathematics ideas are also evident in science teachers. The case for science teacher preparation is more complex, however, in that the science subject consists of multiple science disciplines in which a science teacher might be trained, or enculturated, into one or two. This limited exposure to the broad spectrum of science disciplines has a number of implications for teachers.

One implication relates to what counts as the ‘science’ subject. In the lower to middle levels of secondary schooling (ages 12–15), science is taught as a generalist science subject in many countries (such as Australia), while in other countries (such as China), science at this level is taught as the separate disciplines, that is, chemistry, biology, physics and earth sciences. This means that in one country, a biology teacher, for example, may actually be considered out-of-field if they are actually trained in physics; while in another country where a ‘generalist’ science approach is the norm, the same teacher would be considered in-field. This distinguishing feature of science renders international comparisons difficult.

Another implication is that, because of these differences, the ‘subject-specific’ nature of teaching is delineated by different criteria. The case could be made that a grounding in any science discipline is adequate preparation to teach any science discipline because of a ‘common’ scientific method, or at least an appreciation for the role of evidence-based claims when seeking answers to questions of a scientific nature. However, it is worth noting that the modes of inquiry of physics and biology, for example, are sufficiently different to be daunting, at least at first, for a teacher trained in one to be expected to teach the other.

The generalist science teacher, if considered in-field, will have background in one or more science disciplines, and possibly not others; this teacher might be considered a ‘native’ science teacher who is considered in-field but may feel out-of-field in the science disciplines for which they have limited background, or may even be classified as out-of-field in education systems where science disciplines are taught separately. This is particularly the case for teachers at the senior levels where, in most countries, science is taught as a discipline-based model with specialised science discipline teachers, i.e. the chemistry or physics teacher. Teaching out-of-field at the senior level, even as a ‘native’ science teacher, can be very difficult because of the depth and complexity of content knowledge required. An example of the ‘native’ science teacher is Donna, an Australian science (in-field) and mathematics (out-of-field) teacher, who explained that a stronger grounding in biological science due to personal experiences with the subject matter, the discipline and the type of thinking required, manifested as a more intuitive approach to teaching science than mathematics or physics. Donna’s coherent and unified picture of the biological sciences stemmed from her experiences of learning biology and working with these science concepts in whale research. Physics, however, was considered as foreign for her as any other subject that had not been encountered in any meaningful way. It was for this reason that her teaching of biology required less planning and research compared to her teaching of physics or mathematics, as stated below:

> I don’t have a big mathematics background, so I have to spend a bit of time thinking about what could be available and what I could do; whereas with a science background, I think of things just because I’m experienced in that area. So I suppose it might depend on how much mathematics you’ve done or what resources you’ve been exposed to, what you might know of… I do a lot more prep for a topic like physics than I would for chemistry or biology. I’m

> teaching a 9/10 combined class in biology, and I'm finding that, like I do my normal prep but I can just go off in class and say, I did this and I've got this example, and we've been having great class discussions and fun activities. I wouldn't have the confidence doing that with a physics topic. So I might spend a lot more time researching it, I might check a few things with another teacher. But I wouldn't have that flamboyance in a topic that, because I haven't done physics at all, apart from bits and pieces of it.

Of course, enculturation into the disciplinary practices and subject culture is possible over time. This is the case of Sara, a computer science specialist teacher and an 'out-of-field' mathematics teacher who participated on an in-service course aimed at addressing the shortage of mathematics teachers in England, UK (Crisan and Rodd 2017). On such a course Sara had opportunities to revisit and teach the subject matter (school mathematics), leading to the development of her technical fluency of some of the more challenging topics taught at different levels of school education (11–16-year-old pupils). Evidence gathered throughout the course showed that Sara was very determined to improve her subject knowledge and familiarity with the school mathematics topics. As the course progressed, Sara became more focused on the learning and doing of mathematics compared with her initial central concern on how to teach a specific mathematical topic. Her lesson planning provided evidence of her consideration for the interconnectedness of the mathematics topics and links with previously taught topics, just as modelled and promoted by the in-service course, providing a strong evidence of her enculturation into the mathematics teacher community.

However, enculturation of the out-of-field teacher often reflects school versions of the discipline; teacher beliefs associated with these versions of mathematics can be very varied (Beswick 2007). This enculturation, therefore, centres on the school subject culture; the subject-specific nature of teaching becomes consolidated, recognisable and describable when exploring the basic assumptions underpinning teaching practices common to the subject culture.

6.5 Subject Pedagogies, Basic Assumptions and Subject Culture: A Case Study from Australia

'Subject culture' refers to the traditions of practice, beliefs, purposes and behaviours associated with a subject. Schwab (1969) states that a complex culture, such as a subject culture, requires both *diversity* and *unity* when conceiving of the tasks of teaching and learning. Unity as common goals amongst teachers within the subject area is important in establishing 'shared traditions, shared experience, shared problems, values and idiom' (p. 198). This unity makes the subject identifiable. Drawing from Organisational Theory, subject culture is underpinned by patterns of 'shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration' (Schein 1992, p. 12). Basic assumptions are derived from the previous experiences of the individual and consist of perceptions of the nature of people and objects in the work environment. According to Schein (1992), the essence of a group's culture is its pattern of shared taken-for-granted basic assumptions. Schein likens these basic assumptions to Argyris and Schön's (1974) theories-in-use that prescribe how to act, think and feel about things, and that operate as 'unwritten scripts' for members of the group. These scripts internalise a routinised approach to performance on the job: 'Potential courses of action are evaluated in terms of internalized socially constructed theories-in-use' (Schein 1992). Like theories-in-use, basic assumptions are internalised perceptions of the world, objects, ideas and how to relate with others.

In the teaching context, enculturation involves a lifetime of experiences of learning, practising and teaching the subject. If the 'group' refers to all science and mathematics teachers across all schools, then subject culture refers to those shared basic assumptions that govern the dominance of certain 'subject paradigms' (what should be taught) and 'subject pedagogies' (how this should be taught) (Ball and Lacey 1980). These basic assumptions act as signposts and guidelines for teaching and learning the subject.

A study by Darby (2010) explored the basic assumptions of two aspects of the subject cultures of mathematics and science in Australia that appeared to be central for the participating teachers in shaping pedagogy: content organisation and hands-on activities. In this study, six teachers from three schools were interviewed and their teaching observed during two teaching sequences. A thematic analysis showed that, while the nature of the subject matter and its organisation may be unique to any subject and likely to determine teaching practices (Stodolsky 1988; Stodolsky and Grossman 1995), the nature of the curriculum organisation had implications for mathematics teachers in ways that were more significant in shaping pedagogy than for the science teachers. Student support was a central pedagogical imperative that arose out of a highly sequential curriculum where mathematics anxiety and 'filling the gaps' is part of the teaching imperative; for example, one teacher quoted 'I want them to enjoy mathematics. Because mathematics is a threatening subject, it is so threatening because it is so sequential'. Curriculum content organisation was seen to have an immediate and critical role in shaping the practices of the mathematics teacher because of the demand that the nature of the content, the progressive nature of student learning and the traditions of status and importance, place on student learning. The shaping effect of the curriculum organisation appeared less central in the minds of the science teachers, who were guided by an imperative to plan units 'that work', that is, units that are age appropriate and that provide opportunities for students to engage with science concepts at various levels. This comparison arises out of differences in the degree of specificity and sequencing of the subject matter—mathematics to a higher degree than in science.

By comparison, Darby found that in science, teachers showed a firmer commitment to students experiencing natural phenomena. The teachers relied on such experiences to engage students at an aesthetic and motivational level, as well as at a deeper conceptual level. In mathematics, while teachers considered practical experiences to be beneficial for learning, teachers were resistant to their use to some degree due to practical issues that arose as a result of their experience of a traditional commitment within the subject culture to a skills and process based, tightly structured curriculum. Whether a teacher incorporated practical or activity-based experiences in mathematics and science was not simply a matter of having a filing cabinet full of activities, but required an awareness of the purpose and nature of the types of activities appropriate for the subject. It also requires a particular epistemological stance, which is underpinned by a web of beliefs, knowledge and experiences that provides some logic to the pedagogical decisions that are made by a teacher.

The basic assumptions underpinning these positions on these aspects of teaching are outlined in Tables 6.1 and 6.2. Darby used Schwab's (1969) commonplaces of schooling—subject matter, student, teacher and milieu—as the framework for constructing these basic assumptions. These basic assumptions were developed to expound the relationship between the structure of the subject matter and the pedagogy of these teachers, as well as the epistemological, pedagogical and cultural demands associated with curriculum content organisation (Table 6.1) and hands-on activity (Table 6.2). The perceived learning needs of their students and other broader influences from the cultural milieu factor into these aspects of the subject cultures. The basic assumptions listed in Table 6.1 represent the enacted curriculum as it emerges out of the interface of the students' learning needs in the classroom, teachers' beliefs about what needs to be learned and how this is best made available for students, the imposition of a school system and its expectations and demands associated with different subjects and the nature of the school version of the disciplinary knowledge.

The basic assumptions in Table 6.2 represent teachers' experiences of using hands-on activities when teaching mathematics and science: demands imposed by the subject matter, teachers acting within a context that enables or constrains the use of hands-on activities, and expectations of students and teachers to incorporate such activities in supporting conceptual development.

The cultural expectations captured through the basic assumptions above appear to have a strong influence on practice, and in some senses teachers' pedagogical responses are clear. They represent, at least with respect to these teachers, what was considered central and specific to teaching the subject. Darby describes these common responses subject pedagogies (Ball and Lacey 1980) because there was general agreement about what was central to the teaching task.

In mathematics, a 'pedagogy of support' was seen to predominate: the curriculum was seen to be more sequential than in science and moving to increasing degrees of complexity, and this appears to result in a particular response by the teacher—to make it less threatening for students, and to take the responsibility for student progression as a central part of their role. Of fundamental importance is that students are given the best opportunity to be successful in the subject, therefore, support for learning dominated these teachers' approach to teaching and learning. A pedagogical imperative to support students in their learning is, therefore, fundamental to mathematics teachers, both at the relational level where teachers make themselves available, and at a cognitive level where teachers support the development of optimism (Williams 2005) by judiciously offering support for problem solving.

In science, Darby (2010) described a reliance on a 'pedagogy of engagement' where the artefacts of science and natural phenomena are used to engage students with science ideas and ways of thinking. In order to understand how a Pedagogy of Engagement emerges in science, it is important to understand the relative importance

Table 6.1 Subject differences in the basic assumptions relating to curriculum content organisation

	Science	Mathematics
Subject matter	Basic Assumption 1: Junior school science subject matter is organised in topics that are relatively discrete, but there is some sequencing of ideas within the disciplines of science. Topics tend to be iterative	Basic Assumption 1: Junior school mathematics subject matter is organised as a carefully sculpted sequence of skills/processes and concepts, moving to greater degrees of abstraction and complexity
Students	Basic Assumption 2: Missing science content at the junior level has limited bearing on future success with science learning. Students' willingness to engage with future learning experiences, however, is dependent on coherent and suitably targeted content	Basic Assumption 2: Poor skill development can result in insecure foundational understandings, posing a threat to future success. This can result in students feeling threatened by the learning demands of school mathematics
Teacher	Basic Assumption 3: The imperative for the science teacher is to add more pieces to the puzzle for students so that they develop a coherent picture of the knowledge and skills of science, and move them on to more complex concepts	Basic Assumption 3: The imperative for the mathematics teachers is to support students in developing firm foundations to allow them to move successfully to the next level of complexity and abstraction
Milieu	Basic Assumption 4: Science curriculum content is subject to reshuffling, reflecting an acceptance that there is no single trajectory through the subject matter required for students to achieve success in their learning	Basic Assumption 4: Mathematics curriculum content is relatively stable because there is general acceptance about the steps that students should take as they move to greater degrees of complexity. The imperative to ensure student success comes from the importance given to mathematics for school, university and life

Source Darby (2010)

Table 6.2 Subject differences in the basic assumptions relating to hands-on activities

	Science	Mathematics
Subject matter	Basic Assumption 1: Science is seen to be an empirical way of knowing that seeks to explain phenomena and objects that can be readily observed and explained. Often the theory is about the natural phenomena that are being observed and manipulated	Basic Assumption 1: Mathematics is seen as an abstract discipline because the focus is on mathematical objects, structures and relationships that are independent of context rather than tangible objects that can be readily observed. These concepts can be applied to real-life contexts, and understood through real, or concrete, objects
Students	Basic Assumption 2: Students expect to have practical-based learning experiences in science. Such experiences give students the opportunity to think about how theory relates to natural phenomena. The immediacy of the object in science demands engagement with objects so that the provision of hands-on experiences is essential to the learning process	Basic Assumption 2: Students do not necessarily expect to be engaged in hands-on activities in mathematics. An abstract epistemology does not immediately demand concrete representations, although such representations are considered valuable because they can assist in understanding an abstract concept
Teacher	Basic Assumption 3: Teachers are expected to be proficient in planning for, executing and making the most of practical work as part of their teaching repertoire. Teachers rely on these experiences to engage students at multiple levels	Basic Assumption 3: Teachers feel encouraged but not expected to be proficient in providing hands-on experiences. The use of such activities is negotiable and peripheral to the main business of mathematics teaching
Milieu	Basic Assumption 4: Since the objects of science are the focus of instruction, these objects need to be central to the learning experience. Consequently, science is afforded the necessary resources, infrastructure, and personnel to support teaching and learning	Basic Assumption 4: A tradition of commitment to a skills-based curriculum has not prioritised hands-on experiences as part of the learning experience. Infrastructure has been built around teaching approaches that move students through the curriculum, with the textbook as the defining resource

Source Darby (2010)

afforded to the 'cultural artefacts' (from Becher's [1989] theory of academic tribes) of the subject and discipline. For the science teacher and learner, the laboratory, the scientific equipment and the phenomena explored during science lessons are science cultural artefacts. Also, the specialist scientific language, the scientific processes and methods experienced through practical activities are characteristic of science. The defining artefacts represent multiple meanings that are associated with traditional practices of science and science education. Certain expectations are perpetuated. Students expect to do experiments, teachers expect to include practical work as part of their teaching repertoire, and schools expect to have to provide the appropriate cultural grounds and artefacts to enable this practice to take place. The artefacts, both as objects (phenomena and equipment) and practice (practical work), are central to this cultural view of what defines and differentiates science teaching and learning.

The use of the term pedagogy here implies not just an adoption of methods of teaching but a rationale and certain philosophical assumptions. They represent strong discourses that characterised the pedagogical imperatives of the participating teachers. As subject pedagogies, they are recognisable as particular pedagogical practices, underpinned by certain assumptions, and they have a moral dimension in that they are driven by certain pedagogical imperatives that elevate particular beliefs about what constitutes the teaching of one subject above others. These subject pedagogies make the subject teaching identifiably mathematics or science.

What are the consequences of having general agreement about these aspects of teaching? What happens when the prevailing pedagogies resist moves towards alternatives that are underpinned by other basic assumptions? How do these general agreements on what it means to teach the subject affect how teachers negotiate subject boundaries? For example, out-of-field teachers are expected to understand how the curriculum content is organised and how to engage students actively in their learning. Grundy (1994) suggests that in circumstances where teachers are expected to develop a curriculum that explores cross-curricular practices, 'it isn't sufficient that each learning area simply acknowledges the knowledge production processes of other learning areas, each learning area needs to be understood and respected' (p. 13). This need for respect for disciplinary integrity in integrated approaches to curriculum applies also to situations where teachers are teaching a subject with which they are unfamiliar. These teachers may not be as aware of the demands imposed by the subject culture. They may be ill-equipped to filter, respond to or seek alternatives to the subject pedagogies, that is, the 'Pedagogy of Support' and the 'Pedagogy of Engagement', which are underpinned by other basic assumptions about how the subject should be taught.

For example, while teachers in Darby's study identified practical work as critical to engagement, the individual teacher will determine whether practical work is used effectively by creating an environment that fosters deeper levels of engagement, or alternatively rely on the activity to 'hook' students and focus purely on an affective response. An alternative to this reliance on practical work might even be sought through more productive imaginings where students are able to 'make a link, to identify, to engage some part of themselves with something in science' (Lemke 2002, p. 33); this places the emphasis on the mysteries and possibilities that science produces, rather than on objects themselves, or the theory that arises out of scientific investigation.

Similarly, in mathematics, where there is an expectation to support learning in order to prepare students for future learning success, a danger is that this imperative may be interpreted in a way that restricts the learning experience to skills and processes as laid out in textbooks. Another danger is that teaching focuses on coverage rather than depth of understanding, resulting in superficial student learning, difficulties in translating mathematics to real-life contexts, and poor attitudes and self-concept in relation to mathematics. Stacey (2003), however, advocated for 'greater emphasis on explicit mathematical reasoning, deduction, connections and higher-order thinking' (Stacey 2003, p. 122). This agenda calls for teachers to 'create supportive learning environments, to utilise worthwhile mathematical tasks, to manage students' mathematical discourse, and to promote sense making' (Jones 2004).

While there is some flexibility within the traditions to accommodate variation, for a teacher to break away from those traditions to embrace emerging traditions emanating from the research literature requires an appreciation of what is possible within the epistemological and pedagogical constraints of the subject. A number of factors, such as teaching backgrounds, subject commitments and beliefs about teaching and learning, mediate a teacher's capacity to interpret the traditions, and degree of autonomy to challenge or move forward from those traditions.

6.6 Challenging the Role of Subjects and Subject Cultures in Determining Pedagogy: Subject-Specific Versus Generic Descriptions of Pedagogy

While a tradition of subject specialisation in secondary schools has contributed to a tendency to promote pedagogy appropriate for specific areas of content, in recent years, various curriculum models underpinning education systems reflect a rethinking of the purpose and role of the 'subject'. These models are informed by research focused on a contemporary view of the purpose of schooling that has generated, and reported on, a shift in the way pedagogy is conceived, particularly in the middle years of schooling. This section outlines some of the arguments and counterarguments involved in this debate about the integrity of 'the disciplines' as conceptualisations of pedagogy is distanced from the context of the subject.

In 2004, Gardner stated that disciplines are 'the best answers that human beings have been able to give to fundamental questions about who we are, physically, biologically, and socially' (p. 233). They are distinctive in terms of mores, genres, syntax and content, the mastery of which takes time. However, historically, research in teaching and learning has regarded subject matter disciplines in varied ways: 'as the organizing framework for investigation and implementation' (Shulman and Sherin 2004, p. 135); or as secondary to 'generic principles of instruction that could transcend disciplinary boundaries' (Shulman and Sherin 2004, p. 135). The result was that content areas nearly disappeared from research at various points in history.

Since the mid-1980s, research on teacher thinking and teacher knowledge, which recognises the importance of teacher cognition as a means of understanding the teaching process, focused on the complex relationship between subject knowledge and pedagogy (Shulman 1986; Wilson et al. 1987; McNamara 1991; Banks et al. 1999). Shulman (1986) argued that researchers neglected to ask questions about the content of the lessons taught, the questions asked and the explanations offered.

> Where do teachers' explanations come from? How do teachers decide what to teach, how to represent it, how to question students about it, and how to deal with problems of misunderstanding? […] Research on teaching has tended to ignore those issues with respect to teachers. (Shulman 1986, p. 8)

Shulman (1987) attempted to outline the categories of knowledge that teachers must master in order to teach their subject matter. Among the categories, he includes both general pedagogical knowledge and discipline-specific pedagogical knowledge, referred to in literature as 'pedagogical content knowledge' (PCK). Shulman conceptualised this term (PCK) as being an amalgam between content and pedagogy necessary to an understanding of how particular topics, problems and issues are organised, represented and adapted to the diverse interests and abilities of learners. For example, PCK enables teachers to come up with examples, authentic problems and rich applications that enable pupils to see the usefulness of mathematics, the links to other disciplines and the interconnectedness of ideas in mathematics. It also encompasses an understanding of the learning process itself, including an awareness of the conceptions or misconceptions which students may bring to their learning. Shulman (1986, 1987) suggested that discipline-specific pedagogical knowledge is particularly important for teachers who specialise in teaching a particular subject matter, differentiating as such the expert teacher from the content expert. (See Chap. 5 for a deeper discussion of knowledge in relation to teaching out-of-field.)

In the early 2000s in the US, Gardner (2004) saw disciplines as being threatened by 'facts, which are discipline-neutral subject matter, and which serve as just a textbook convenience' (p. 233), and by 'interdisciplinarity, which often ignores and obscures disciplinary differences' (p. 233). These pressures were evident worldwide where interdisciplinary approaches to broad scale and localised curriculum development were being explored through integrated and alternative middle years programmes in the early 2000s, and more recently through the schools' response to the STEM agenda.

What does this shift from tradition mean for science and mathematics education? In a review of subject matter, Shulman and Quinlan (1996) predicted that subject matter would again take prominence in determining school curriculum as the work of scholars in creating the knowledge and of citizens and professional practitioners who use and enjoy the knowledge in the real world play a significant role in defining what counts as subject matter. The social contexts or communities within which the knowledge is discovered and used will become part of the definition of how classrooms are organised for its study. And epistemological questions will finally reach parity with questions of substance in characterising the curriculum. (p. 421)

Shulman and Quinlan's (1996) predictions were not unfounded. There was considerable evidence leading up to 1996 of student dissatisfaction with school, especially with what was being offered in the middle years (Anderman and Maehr 1994; Beane 1990; Sizer 1994). For example, Hill et al. (1993) noted a decline in the engagement of young adolescents in secondary school compared with their engagement at primary school. There was mounting evidence to support a change in direction of curricula and syllabi to recognise the unique needs of middle years students.

The reform in the middle years of schooling in the early 2000s reflected a modified emphasis on subjects where the purpose of the subject matter was as context for delivering an alternative curriculum concerned with 'many of the communicative, expressive, thinking, affective, moral and social experiences which can provide students with impetus to their holistic development as young adults' (Arnold 2000). Arnold stated that middle school curricula and syllabi should 'reflect integrated approaches emanating from collaboration between teachers of different subjects and between the teachers with their students' (p. 4). The New Basics curriculum model trialled in Australian state of Queensland represented such an integrated framework for curriculum, pedagogy and assessment (see Matters [2001] for a review of the New Basics trial), and signalled a move towards generic description of pedagogy. The framework incorporated Productive Pedagogies, derived from Newman's construct of Authentic Pedagogy, and Rich Tasks that allowed students to 'display their understandings, knowledge and skills through performance on trans-disciplinary activities that have an obvious connection to the real world' (Matters 2001, p. 2).

Gardner's (2001) argument for more purposeful education did not promote the integration of subjects but advocated that disciplines should provide the context for in-depth study of an area of content. The pressure to get through the curriculum, he proposed, should be replaced with opportunities to develop a 'rounded, three-dimensional familiarity with a subject' (Gardner 2001, p. 5). The subject matter, therefore, remains the context for teachers' knowledge about teaching and learning, and a tool for drawing out pedagogical knowledge.

According to Shulman and Quinlan's 1996 prediction, 'Much of the educational psychologists' work will involve inquiries into the advantages of different strategies for transforming subject into subject matter' (p. 421). Indeed, Stodolsky (1988) noticed striking differences in patterns of instruction in upper primary classrooms that she considered to be a function of the subject matter. In challenging the assumption that teaching and learning were seen as uniform and consistent, Stodolosky highlighted that teachers arrange instruction differently depending on what they are teaching, and that students respond to instruction differently depending on the structure and demands of the lesson.

Indeed, subject-specific descriptions of pedagogy take into account a subject-specific awareness of content that informs pedagogical decisions. Building on Shulman's (1986) two domains of knowledge, namely SMK and PCK, Ball and her colleagues developed the mathematical knowledge (MKT) framework, where MKT is 'the mathematical knowledge needed to carry out the work of teaching mathematics'(Ball et al. 2008). The MKT framework provides a framework for the discussion of teachers' mathematical knowledge and has been used extensively in informing the development of teacher education programmes and the design of support materials for teachers. Subject-specific teaching strategies are described in terms of when to use them and the degree to which they are deemed useful (Ball et al. 2005). Where pedagogical frameworks or educational policy are described in generic terms, the focus shifts from the knowledge structures, skills, processes and stories of the subject to more general issues, such as student learning, developing relationships and personal development. Also, the teacher's identity shifts from subject specialist to pedagogue. While these shifts in themselves are not necessarily negative outcomes for teachers with strong understanding and content appreciation, for teachers who do not have those passions and positive background experiences to inform their teaching, the aesthetic of the subject can be lost.

Stodolsky and Grossman (1995) claim that the content provides the context for the secondary teacher, not just in terms of the subject matter to be taught, but in the ways teachers think about learning, assessment and their roles as teachers (see also Grossman and Stodolsky 1995; Siskin 1994; Stodolsky 1988). Research has shown that the content places contextual demands on teachers' interpretation and response to a 'generic' imperative to make schooling relevant (Darby-Hobbs 2013). Teachers' beliefs about the value of the subject are bound up in the perceived potential purposes that the content could have for students and themselves.

The specificity of subject teaching is delineated on the basis of content, but the teacher's understanding of how to teach the subject is based on more than content knowledge.

Sullivan (2003) recognises the importance of an aesthetic dimension of teachers' mathematical knowledge, asserting that:

> this knowledge is not just about the formal processes that have traditionally formed the basis of mathematics curriculums in school and universities but the capacity to adapt to new ways of thinking, the curiosity to explore new tools, the orientation to identify and describe patterns and commonalities, the desire to examine global and local issues from a mathematical perspective, and the passion to communicate a mathematical analysis and world view. (p. 3)

Research by Hobbs showed that a teacher's pedagogy is informed by subject matter and passion (Hobbs 2012). A teacher's multiple identities arise out of the interaction between their perceptions of themselves as subject specialist and pedagogue. Their identity can, therefore, be deeply seated in the subject that they teach and have been enculturated into. A mathematics teacher from Hobbs' study, for example, indicated that she thought of herself as a teacher of students rather than a subject specialist; however, her dealings with students were bound up in her awareness of the learning needs of her students that were specific to that subject, that is, a need to support their mathematics learning. Although the welfare of her students was foremost in her mind, the subject-specificity of her pedagogical purpose lies in her awareness of the reasons for these approaches, and what aspects of mathematics she values and expects to expose for her students to respond to (see Ball et al. 2005).

It was, therefore, not possible to think of her teacher identity in a non-subject-related way.

6.7 The Challenges of Crossing Boundaries for Non-specialist Mathematics Teachers: A Case Study of an In-service Course from England

The need to conceptualise pedagogy in subject-informed ways extends to how we conceptualise professional development for in-service teachers. Generic-based professional learning opportunities cater for only part of the teacher's professional needs. Research has shown that teachers in rural or regional settings can feel disenfranchised by professional learning programmes that cater for the needs of the whole school at the expense of subject-related needs (Tytler et al. 2008). Other research shows that the subject matters with regard to teacher support. Subject-specific mentors have been shown to be more effective in US science teacher induction programmes due to the specific support they can give in the areas of instruction, running practical activities, and planning, as well as support to incorporate 'science as inquiry' and the 'nature of science' into their teaching (Luft 2008). Grossman et al. (2004) further highlight the importance of providing external sources of subject-matter expertise when supporting reform efforts. They assert that the extent, and availability, of subject-specific instructional leadership has an effect on the degree to which teachers incorporate reform ideals into their practice: 'how teachers and administrators respond to and implement subject-specific policies will vary considerably, depending largely on their own knowledge of and beliefs about the subject in question' (p. 12).

Negotiating the boundaries between subjects can be difficult for the out-of-field teacher who has limited background and appreciation of what it means to teach the subject. Unfortunately, for some of these out-of-field teachers, there is limited access to people who might be seen as *culture brokers* (Stanley and Brickhouse 2001) who could play an important role in assisting them with their border crossing. The head of department and other subject teachers may assume this role, but some teachers receive little support, particularly in small schools in rural and remote locations where there are no other teachers to participate in subject-specific professional dialogue or where professional development is not readily available or only deals with generic teaching and learning issues (see Tytler et al. 2008).

However, in some countries government policies are responding to the lack of subject-related expertise of some teachers, calling for the provision of subject-related professional development, delivered by highly specialised teacher educators (see Chap. 11 for further analysis of professional development of out-of-field teachers). For example, a recent UK government call requires that all staff directly involved in the development and delivery of training are experienced in delivering high-quality professional development, have a deep understanding of the specialist subject required for high-quality teaching of the subject and understanding how teachers develop this knowledge.

To address the shortage of mathematics teachers in England, UK, serving teachers, qualified in subjects other than mathematics yet teaching secondary mathematics, were eligible to participate in post-initial teacher training subject knowledge enhancement courses commissioned and funded by the Teacher Development Agency (2011). Crisan and Rodd (2011, 2014) found that the participants on such courses (referred to as non-specialists mathematics teacher, the terminology for out-of-filed teachers used in England, UK), all of whom were aware of limitations in their own mathematics subject knowledge at the beginning of the course, towards the end of the course were able to articulate a wider view of the nature of mathematics.

While an understanding of subject matter content knowledge for teachers is necessary, Wilson et al. (1987, p. 105) advised that 'it is not a sufficient condition for being able to teach'. Given that the participants on the course were serving teachers, issues related to how to teach specific mathematics topics arose naturally in their questioning/enquiry and so a prominent feature of the course was also the participants' learning about mathematics pedagogical issues, which were taught by example and discussion of pedagogical implication of teaching specific mathematics topics. At the end of the course, the teachers still lacked fluency with mathematics and were far from having secure subject knowledge. However, the teachers overcame some difficulties they had with mathematics in the past and, by immersing themselves in learning mathematics, they felt more secure and confident in their mathematics and teaching of it. These teachers came to appreciate and understand mathematics, and related to it in a more personal manner. Familiarity with and learning of new mathematics topics on the course increased their confidence in themselves as learners of mathematics.

This experience of learning to teach mathematics out-of-field illustrates that there is no quick-fix re-training to become a mathematics teacher. Experiencing the joy and satisfaction of doing mathematics, beginning to see connecting themes in mathematics and experiencing being a mathematics learner on the course positioned the participants on the trajectory of learning towards a new identity, that of mathematics teachers (Crisan and Rodd 2014). For example, when visiting simplifying algebraic expressions, the participants surprised us with the questions they were asking. The questions were not just about how to get an answer; the teachers were enquiring about: the mathematics vocabulary specific to the topic and the appropriateness of using the mathematical words in other contexts (e.g. coefficient, term, equal, equivalent); the mathematical structure (e.g. in $a+3b-2c$, is the last term $-2c$ or $2c$?); and collection of terms (flexibility of interpretation of operations in an algebraic expression: from take away 2c to adding negative 2c). We also observed that these teachers were unpicking a mathematics topic to a greater degree than we observed in graduate or trainee (or pre-service) teachers who were already confident with simplifying algebraic expressions. It could be argued that our non-specialist mathematics teachers were asking these questions because they were lacking the necessary mathematical knowledge; however, their enquiries were evidence of their generic pedagogical knowledge in action where they had the ultimate aim of enhancing their mathematical subject-specific pedagogical knowledge, while at the same time facilitating an awareness of and a deepening of their own understanding of the subject matter under scrutiny. Our non-specialist teachers came on this course with weak subject knowledge, which they consolidated through thinking of questions of pedagogical nature (e.g. how would I teach this?, what if pupils would ask this?).

As the course progressed, we noticed that the non-specialist participants became less preoccupied with how to teach particular mathematical knowledge and more interested in the learning and doing of mathematics. They began to see mathematics in a new light, more than just a set body of knowledge and skills. For example, while on the course, Jessie, a Physical Education (PE) specialist teacher on the in-service course expressed a view of mathematics knowledge as reified items: ‘all of a sudden and everything that I’ve got from pockets of knowledge here and pockets of knowledge there, just all falls into place’ (Jessie, interview).

The teachers experienced joy and surprise at noticing connections between different topics, starting to see mathematics in a new light, more than just a set body of knowledge and skills. For example, when looking at the mathematics within the Pascal triangle, the teachers were amazed to discover many mathematics topics they had previously studied ‘in the triangle’. ‘It’s all in there!’ exclaimed Matthew in disbelief.

In interviews, in their assignments and in class presentations, the teachers talked about their changing of views of mathematics towards that of more useful or more real: for example, ‘Through completing this course I feel I’ve moved on from viewing mathematics as a pure subject that is learnt in classrooms to seeing mathematics as something that has endless applications’ (Nas, final assignment). Just like Nas, Crisan and Rodd (2014) found that by the end of the in-service course, most of the non-specialist mathematics teachers were ‘talking the talk’ about what it takes to be a mathematics teacher, influenced by the practices promoted by the in-service course. For example, they talked about the interconnectedness of the mathematics topics, links between topics, use of investigative approaches and group work.

Nevertheless, ‘talking the talk’ did not imply ‘walking the walk’ as they also found that teachers on an in-service course may seek to belong to a community of mathematics teachers, but lack of mathematical knowledge is reflected in less effective pedagogical choices. This was the case for Eva, a PE specialist and a non-specialist mathematics teacher on such an in-service course, who worked in a school as a teaching assistant. Eva was very well supported by the mathematics department and she used the resources this environment affords for her mathematical development: ‘all the mathematics teachers in my school help me get on with mathematics’ (post-lesson observation interview). However, when teaching her low prior-attaining 11- and 12-year-old students to work with fractions she restricted instruction to rehearsal of standard rules only. She did not exploit linguistic, diagrammatic or scenario representations, while the downloaded materials were used unadapted and were rather inappropriate, suggesting a restricted subject-specific pedagogical knowledge, hence making a less effective pedagogical choice in her lesson.

Generally, however, Crisan and Rodd (2014) found that the non-specialist mathematics teachers, all of whom enrolled on the in-service courses with an awareness of limitations in own mathematics subject knowledge, were able to articulate a wider view of what mathematics was about towards the end of the course. Ahmed, a non-specialist mathematics teacher with a specialist teaching background in computer science, was almost demanding to be shown how to answer 'types of mathematics questions' in an instrumental way: 'Show us: Step 1, step 2, and so on. Just like in programming'. Towards the end of the course, Ahmed became more adaptable and he too started to experience joy and satisfaction of seeing connecting themes in mathematics and experiencing being a mathematics learner on the course.

Research by Crisan and Rodd (2011, 2014) shows that being learners of mathematics and immersing themselves in doing mathematics have increased their confidence with the subject matter by revisiting and developing their fluency with the school mathematics topics they would be required to teach. Moreover, reflection on their own learning of and doing mathematics nurtured the non-specialists' mathematical awareness by noticing more mathematically and pedagogically, developing thus a subject-specific pedagogy.

Indeed, the need for extensive professional development and support illustrates that some teachers find it difficult to learn to teach a subject effectively. It also illustrates that generic skills are not enough for a subject teacher. How then, can a teacher be expected to teach difficult subjects effectively when they are out-of-field or unspecialised? This question takes on particular importance when the subject boundaries are removed, which appears to be a possible pathway for education into the future.

6.8 What Does the Future Hold?

In many parts of the world, there are shifts towards new ways of conceptualising schools and curriculum, leading to alternative teacher collaboration models, and challenges to the traditional siloed approach to curriculum knowledge. The virulent spread of STEM globally moves towards an automated and therefore changing workforce, and disruptions caused by international comparisons (such as PISA and TIMSS) all put pressure on schools to rethink and rebadge what they teach and how they teach it. As a result, the subject teachers as they currently exist is potentially going to be re-scoped, that is, the scope within which they are expected to operate is likely to expand or at least shift from individual subjects to a more amalgamated, problem-based space. This re-scoping may lead to a blurring of the boundaries that have traditionally delineated the knowledge considered important for education; it may also render some knowledge redundant. In the 1980s, the move towards integration (LaPorte and Sanders 1995), and the Science-Technology-Society (STS) focus of the 1960s and 1970s (Yager 1996), had a similar effect, although the longevity of this agenda was threatened by concerns that the subject disciplinary knowledge and practices were compromised, and pressure to reinstall the traditional subjects prevailed. The recent push for STEM in many countries (such as the United States, United Kingdom, and more recently in Australia) faces similar criticism, with concerns raised about interdisciplinary approaches to STEM leading to superficial treatment of some subjects. McGarr and Lynch (2015) for example raise concerns about the colonisation of technology and engineering spaces by mathematics and science, which have greater power and status because they have more defined subject boundaries, and there are strong rules governing what content is and is not part of the subject. However, other research has found that even mathematics teacher with excellent pedagogical skills and adequate mathematics knowledge actually found it quite difficult to integrate mathematics into STEM programmes (Mousa 2016). Superficiality can also arise because of the limited expertise of the teachers in some of the subjects that they are expected to integrate. To make this work, teacher collaboration models need to ensure specialist knowledge within the teaching team is pooled and out-of-field teachers are supported; also teaching spaces can be opened up and modified to allow for seamless interaction between the in-field and out-of-field teachers as needed. It is important to remember, however, that interdisciplinary teams are typical in the STEM disciplines and industries because of the need for complex solutions to complex real-world problems, so modelling of this type of shared expertise can potentially lead to quite innovative curriculum. For example, teachers of science can work with the mathematics, technology and arts teachers to develop a student project, e.g. a vehicle design that requires student learning in each of the four subjects during the same school term. This approach is quite different to a unit of work taught by one teacher who incorporates both mathematics and science outcomes; in this approach, unless the teacher has a full appreciation of the mathematical and scientific concepts involved they are at risk of giving inadequate treatment to both content areas.

Another example of this interdisciplinary approach comes from Finland, who, since 2016, are 'trading in teaching by subject (e.g. an hour of history followed by an hour of geometry) in favour of "phenomenon teaching," or teaching by topic' (Briggs 2016). The main goal of the reform was to 'create better prerequisites for successful teaching and for meaningful and enjoyable learning so that students would develop better competences for lifelong learning, active citizenship, and sustainable lifestyle' (Airaksinen et al. 2017, p. 2). While this reform was met with initial objections by teachers who have spent their careers developing subject-specific teaching expertise, reports show that there is some advancement in student learning outcomes (Briggs 2016). This type of systemic reform of the curriculum requires a reconceptualization of the role, commitments and expertise of the teacher, as well as a move towards learning that is more active and participatory in nature (Airaksinen et al. 2017). Proponents of the model state that 'At the level of disciplinary experts, there needs to be continuous involvement of real-world users of the disciplines, in addition to reform-minded academics' (Briggs 2016). Indeed, Airaksinen et al. (2017) highlight that crossing the boundaries within schools will require 'strengthening of the collaborative, multidisciplinary, and multiprofessional approach, developing the schools as a learning community' (p. 13), and that teaching competences would need to be re-conceptualised as transversal in nature rather than subject bound.

6.9 Conclusion

The argument in this chapter assumes that the expertise of a (secondary) teacher has, at least in some part, some alignment with the fields of knowledge, ways of knowing and modes of inquiry that they have encountered at university and in their initial teacher education. When 'in-field', their teaching allotment aligns with their specialisations, which, it is assumed, prepares them for teaching the subject content and pedagogy. When allotment does not match this background, the teacher is considered out-of-field. Of course, there are many aspects of a teacher's expertise which can be considered general to teaching and not specific to the subject. However, even seemingly generic knowledge can be understood through the lens of the subject.

Teachers teaching a number of different subjects are expected to understand pedagogical traditions in each subject, including basic assumptions that underpin these traditions and expectations. Out-of-field teachers may be less aware of the demands imposed by the subject culture and may be ill-equipped to appropriately filter, or respond to predominant pedagogies that may not necessarily align with reformist agendas in mathematics or science. Being aware of the demands of the subject can enhance a teacher's ability to seek appropriate alternative practices. This is significant for a number of reasons. First, subject pedagogies within the school have the potential to shape the practice of a novice or out-of-field teacher, particularly if those traditions and practices are deeply rooted in the school subject culture. Teachers who are flexible and embrace innovation and change are more likely to be successful in countering prevailing subject pedagogies that perpetuate traditional and ineffective teaching practices. Second, knowing what works and what does not, and an appreciation for how the subject both affords and limits change is required before a teacher can contribute meaningfully to conversations about curriculum development and innovation.

Having a background in a discipline is likely to equip teachers with the disciplinary knowledge to draw on in their teaching and an appreciation and enthusiasm for the subject that can be transmitted to students, qualities that are often used to define effective teachers (Darby 2005) and potentially lacking for teachers teaching out-of-field (Ingvarson et al. 2004). Other research shows that, while a teacher's practice is dependent on the experiences that the teacher has had with the subject or discipline, these experiences are not necessarily related to exposure at university level. For example, other factors, such as career trajectory (Siskin 1994) and professional development (Crisan and Rodd 2014; Tytler et al. 1999), have been found to be cogent in determining how teachers approach teaching and learning. These research outcomes highlight the importance of paying attention to teachers' experiences of the subject they are teaching. Evident also is an assumption that teachers can be enculturated, hence inducted into the culture of a subject through their experiences, and that, with further training, teachers can improve their competence and confidence in teaching a subject in which they have previously had limited background. Further research is needed that problematises the assumption that disciplinary training automatically and alone leads to effective teaching. Such research could explore those experiences that teachers teaching out-of-field believe are instrumental in developing confidence and competence in their teaching.

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Chapter 7
Out-of-Field Teaching Affecting Students and Learning: What Is Known and Unknown

Raphaela Porsch and Robert Whannell

Abstract This chapter presents a review of empirical literature which has investigated the research relating to the association between teacher qualification to teach a subject and the quality of student outcomes. The studies reported mixed findings when investigating the hypothesis that qualified, in-field teachers obtain better student outcomes then unqualified, out-of-field teachers. It is proposed that the research relating to the out-of-field phenomenon is not sufficiently mature for definitive conclusions to be made. It is considered that the differences in definitional and methodological approaches being used need to be overcome. To produce an empirical base of sound evidence, future research would require a more sophisticated approach to defining out-of-field membership, based perhaps on a construct such as identity, and methodological techniques such as multilevel regression modelling on an appropriately sized dataset.

Keywords Out-of-field teaching · Teaching across subject boundaries
Out-of-field research methodology

7.1 Introduction

Criticisms of education are often translated by governments as issues of teacher quality and teachers' ability to produce high-quality student outcomes. For example, country comparisons through international testing like PISA[1] or TIMSS[2] highlight international differences in student achievement. Such variability can then be asso-

[1] Programme for International Student Assessment.
[2] Trends in Mathematics and Science Study.

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ciated with the quality of the education system, and ultimately rests with the quality of a country's teachers. Greater and greater accountability is creeping into education systems where teachers are under pressure to raise student standards, producing greater stress through stringent reporting frameworks through more and more complex accountability processes. At times, the issue of teaching out-of-field enters into this discussion with the assumption being that when teachers are teaching areas outside their area of expertise they are likely to lack the content knowledge and pedagogical content knowledge to be able to teach effectively and support student difficulties with learning. Ultimately, the question that is asked is, are teachers who teach out of area likely to be able to achieve the same quality of outcomes for their students as teachers teaching in-field? Thus, the guiding question for this chapter is, to what extent do teachers' qualifications to teach in a specific field affect student educational outcomes.

A further interest for answering this question is the fact that studies investigating the association of teachers' formal qualifications or certification status on student's learning outcomes can be regarded as work on the effectiveness of (initial) teacher education (see Diez 2010). Other characteristics that can be looked at in terms of teachers' learning opportunities include, for example, teaching experience (occasionally operationalized as teachers' age) and professional development. However, 'it is difficult to examine the effects of teacher experience on student achievement, because sometimes more experienced teachers are assigned to students of higher ability and fewer discipline problems, and other times the more experienced teachers are assigned to the lower achieving students in need of more help' (Mullis et al. 2012, p. 292). Teaching experience, or other opportunities such as in-service training of teachers, is not the focus of this contribution. Instead, this chapter provides an overview of research on (formal) teacher qualifications and its association with student learning outcomes. After providing the theoretical background for this relation, this chapter will give an overview of studies that have looked at the association between teacher qualification to teach a subject and the quality of student outcomes. The generally mixed findings can be explained by differences in definitional and methodological approaches being used but might also hint at the relevance that teachers' subject identity might play in their professional development and in teaching effectively and enthusiastically.

7.2 Theoretical Background

The competence-oriented perspective that has a focus on teachers' knowledge and competencies, beliefs and characteristics such as motivational aspects necessary for effective teaching, can be regarded as the current dominant approach to the notion of 'professional development' and the 'professional teacher' in Germany and elsewhere. Proponents of this perspective often identify, classify and measure these characteristics and usually regard an increase of competences as an indicator of professional development (Baumert and Kunter 2013).

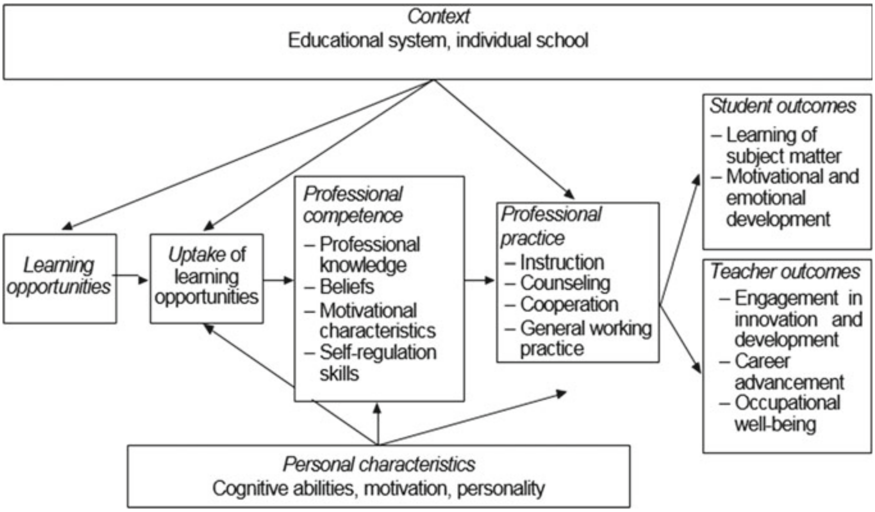

Fig. 7.1 Model of the determinants and consequences of teachers' professional competence. (From Kunter et al. 2013, p. 67)

According to the competence-oriented perspective, teacher professionalism and effective teaching are closely related, thus professional development aims at constantly increasing teachers' competencies or modifying other characteristics in a favourable way, such as enthusiasm for teaching. Initial education that provides various learning opportunities, such as attending courses at university or practical school experiences, can be seen as the basis for acquiring competencies that are needed for effective teaching which results in enhanced student learning. Kunter et al. (2013) provide a model of the determinants and consequences of teachers' professional competence that has its 'starting point' on learning opportunities by teachers (see Fig. 7.1).

The model assumes an effect on teachers' competences and integrates a number of additional factors (e.g. teacher's personality) as well as the general context of the educational system and the individual school. It illustrates that professional competencies lead to professional practice, such as teaching, but also acknowledges further tasks in the school context, such as cooperation or counselling. The model proposes that if learning opportunities are utilized by teachers, they conclusively have an effect on professional development of the teacher (e.g. career advancement) but also can affect students positively with their learning outcomes and their motivational and emotional development.

Derived from this model, it is proposed that teachers who teach a subject without having a subject-specific qualification obtained during initial teacher education (hereinafter referred to as out-of-field teachers) may have a substantial knowledge deficit in the subject as they may lack the requisite learning opportunities. It is also argued that the achievement of a formal qualification as certification to teach a subject that was completed many years in the past can be viewed as a rather distant variable of indicating teachers' professional competencies. Thus, in recent years, a growing number of studies have implemented tests to measure teachers' 'objective' professional (subject-/teaching-related) knowledge and link it to students' proficiency as well as lesson quality (e.g. Kunter et al. 2013). A prominent study that examined these associations is the COACTIV program (Cognitive Activation in the Classroom). The first main COACTIV study was a German national extension to the 2003 PISA-study testing mathematics teachers' and students' knowledge via tests. Results demonstrate, for example that teachers' content knowledge (CK) and pedagogical content knowledge (PCK) in mathematics depended on the type of teacher training program. Participation in a training program aiming at teaching in the academic track—so-called 'Gymnasium' in Germany where students can obtain their high school diploma—resulted in higher CK and PCK scores in comparison to those certified to teach in non-academic tracks (Baumert et al. 2010). German teachers who are educated to teach in non-academic tracks and in primary school have to attend in general more methods courses than courses aiming at developing CK in comparison to those who aim at teaching in the academic track. As teachers with different study requirements took part in COACTIV, these findings indicate that the number of learning opportunities were positively related to teachers' knowledge in one subject; the question remains, however, why teachers trained for the academic track also outscored their colleagues on PCK. A recently published study from the Irish context (Ní Ríordáin et al. 2017) that assessed the CK of out-of-field mathematics teachers points to the inadequate level of subject knowledge but also reveals the teachers' great diversity with regard to their competencies and further background. However, so far, studies testing teacher knowledge have not presented results of teachers with and without a subject qualification. In contrast, research on the effects of teachers' formal qualification has been conducted for more than fifty years (Darling-Hammond 2000). An overview will be given next.

7.3 Research Findings

7.3.1 Impact on Students' Proficiency

An increasing number of studies have been conducted investigating the question 'Does teacher certification matter?' (Goldhaber and Brewer 2000). These studies are generally based on the hypothesis that subject-related competencies acquired in initial teacher education are responsible for more effective teaching although some studies not only investigated the relevance of subject certification but also school certification (Goldhaber and Brewer 2000). A study of 1993–94 data across 50 states in the USA identified that 'teacher preparation and certification are by far the strongest correlates of student achievement in reading and mathematics' (Darling-Hammond 2000, p. 1). Historical research findings such as this have provided the basis for the assumption that students who are taught by subject-qualified and certified teachers are advantaged over those taught by out-of-field teachers. Several other studies have confirmed this hypothesis and have identified that a subject-specific qualification by teachers is associated with enhanced student learning outcomes in that subject (e.g. Goldhaber and Brewer 1996, 2000; Hoffmann and Richter 2016; Monk and King 1994). Although Kane et al. (2007) concluded that a certificate alone cannot explain student learning, several studies found correlations between indicators of teachers' qualification, such as licensure scores that were not subject-specific and students' achievement in various domains (e.g. Clotfelter et al. 2006, 2012). However, Goldhaber (2002) argues that 'most of the studies that find statistically significant relationships between teacher training and student achievement find that the effects of these characteristics are small and specific to certain contexts' (p. 54). Dee and Cohodes (2008) identified improved student outcomes based upon teacher certification, and only in subjects such as mathematics and social sciences but not in English and science. Conversely, they also identified that 'subject-certified teachers are not more effective at promoting the intellectual engagement of their students but are more likely to have negative opinions of a given student's performance' (p. 7). Furthermore, some researchers could not explain students' proficiency by indicators of teachers' qualification (e.g. Buddin and Zamarro 2009; Kyriakides et al. 2009; Tella 2008; Tsai and Yang 2015; Porsch and Wendt 2017; Zuzovsky 2009).

How can these mixed results be explained? In general, there are several constraints in the comparability of these studies. First of all, there are differences with regard to the criteria of how to define 'out-of-field' or what is regarded as a qualified/non-qualified teacher. This challenge has been described in the literature over many years (e.g. Ingersoll 2003; Schüler et al. 2015) with studies and official statistics using different indicators of the teachers' formal qualification. This can be explained due to the diverse educational systems that exist, even within one country, and by the availability of the data that may have been provided, for example, by a governmental institution for purposes different from evaluating the relationship between teacher qualification and student performance. Common indicators are, for example the certification status, especially a subject-specific teaching certificate, or the number of attended courses. This is not only relevant for comparing findings from different studies but also refers to the 'debate over the definition of a qualified teacher' (Ingersoll 2002, p. 8). For instance, Monk and King (1994) based their analyses on the type and number of courses teachers attended. They also attempted to cater for cases where this data was not available. Dee and Cohodes (2008) used two variables: differentiating between teachers who were state certified in the subject or not, and those with or without an undergraduate or graduate major in the subject. Brown et al. (2008) based their analysis on teachers' highest degree (bachelor's degree or no college degree), but did not include information on their professional training with regard to the different subjects. Buddin and Zamarro (2009) used a number of licensure scores (basic skills test, subject area tests and reading pedagogy) that are obtained during the teacher certification procedures in California (see also Clotfelter et al. 2006, 2012). Studies that utilized data from the Trends in International Mathematics and Science Study (TIMSS) take the variable 'Teacher's major' (major or main area of study) as implemented internationally in the teachers' questionnaire (e.g. Porsch and Wendt 2017). If relevant for the country situation the variable 'Teachers' (highest) levels of education' is also considered in the analyses (e.g. Zuzovsky 2009; Tsai and Yang 2015). What can be critical using the major as an indicator for the qualification of primary school teachers is that in some countries, as it is the case in Germany, for example, student teachers can choose to study a subject as a major, a minor or not at all. Thus, the different qualification background of teachers may not be taken fully into account.

Besides, the (normative and also practical) question of choosing criteria for distinguishing qualified and non-qualified teachers, studies on the effect teachers have on student achievement differ with regard to the applied design and type of analysis. Reviewing studies with regard to the design, one finds only a few longitudinal studies (e.g. Tiedemann and Billmann-Mahecha 2007). These studies estimated the impact of teachers (in this context their qualification status) on learning growth, rather than measuring student and teacher proficiency at a single point in time and attempting to infer an association. Burke (2006) describes a 'dynamic view of identities as always changing (though slowly) in response to the exigencies of the situation. Insofar as an identity cannot change the situation…it adapts slowly, gaining control where it can, and adapting where it must' (p. 93). Considering the length of time necessary for change to occur in identity, it is unlikely that short-term studies allow researchers the opportunity to understand the process of change involved in the transition into teaching out-of-field. It appears that most studies apply a cross-sectional, point in time design presumably for reasons of data availability as several works in this field used large-scale assessment data.

The methodology of the existing quantitative studies investigating the capacity for formal qualification of teachers to explain variance in the students' proficiency can be classified into three types. The first approach uses a comparison of mean scores for two or more groups of students that are based on the different qualifications of teachers (e.g. May 2006; Richter et al. 2013). The second approach involves regression analysis conducted without modelling the different levels and exclusively considering teacher variables (e.g. Goldhaber and Brewer 1996; Brown et al. 2008). Others have also controlled for student characteristics; these latter studies either include only indicators of the teachers' qualification (e.g. Dee and Cohodes 2008) or, in addition, further teacher characteristics like experience (e.g. Monk and King 1994), gender, or ethnic background (e.g. Clotfelter et al. 2006, 2012). The third, and most complicated, approach involves the application of multilevel regression modelling whereby teacher, student and class characteristics (e.g. Porsch and Wendt 2017) or teacher- (classroom level), student- and school-level factors are included to assess the influence of each level on students' performance (e.g. Tsai and Yang 2015).

In addition, some researchers provide interactions between student and teacher characteristics (e.g. Zuzovsky 2009) or between school and teacher characteristics (e.g. Hoffmann and Richter 2016). Multilevel analysis is recommended for nested data—if the number of participants on each level is sufficient. Failing to use this method would lead to an inaccurate picture of the results since the standard errors of the parameters would be underestimated and there would be no separation of the variance attributed to the levels (e.g. Hox 2010). Findings from the national assessment studies based on the national education standards in Germany conducted by the IQB (*Institute for Educational Quality Improvement*) suggest that teachers' qualification substantially impacts students' proficiency (e.g. Hoffmann and Richter 2016). In contrast, a number of studies that also use multilevel regression modelling controlling for variables on various levels, teacher characteristics like qualification do not play a significant role (e.g. Zuzovsky 2009; Tsai and Yang 2015; Porsch and Wendt 2017). One explanation for this is that student features explain most of the variance of students' proficiency. Blömeke et al. (2016), analysing TIMSS data from several countries, explain their findings as follows: 'Teachers' initial education is in this manner an example of a teacher characteristic which, at least for a large group of teachers, is distal to the other variables included in the model, and moreover, likely confounded with other omitted variables. Taken together this makes it difficult to identify a systematic relationship between features of mathematics teacher education and instructional quality or student achievement' (p. 42).

This review of the literature indicates there are several constraints with regard to comparability between studies in this field of research. The first issue identified was the difference between studies in the definition used for teacher qualification to teach a specific academic discipline. There were also substantial methodological differences that make a comparison of the results from different studies difficult. A further difficulty exists due to the assumption that teacher education programmes positively influence teachers' competences, and subsequently their professional practices, which in turn leads to more effective student learning. Furthermore, the context of each study needs to be carefully taken into account. Studies conducted on this issue in different countries (e.g. Germany, Taiwan, Israel) with varying sample sizes have had a focus on different subjects (e.g. Math, Science) or competencies like reading and have looked at students in various school levels (primary and secondary) and also at pre-schoolers (see Brown et al. 2008).

Besides methodological issues the professional development of out-of-field teachers as in-service teachers along with the heterogeneity of individual characteristics and contextual factors such as school support (see Hobbs 2012, 2013a, b) can be regarded as further explanation why some studies about the impact of teacher qualification on students' learning have not found any relation and many others could only detect small effects. Finally, some research suggests that out-of-field teachers are more likely to teach socially disadvantaged students (e.g. Ziegler and Richter 2017). That would mean that studies have overestimated the influence of out-of-field teaching on student achievement as students differ in their competencies even when entering (primary or secondary) school. However, results from longitudinal studies that would allow a comparison of the growth in learning in order to estimate the effectiveness of teachers' support and by looking at the teachers' qualification, are not known so far. In addition, Ingersoll (1999, p. 29) points out that interviews with out-of-field teachers suggest that they prefer using textbooks for planning and conducting lessons in math. As textbooks provide standardized tasks similar to those applied in large-scale assessment, students that are taught by out-of-field teachers might not have a disadvantage or, in other words, these tests might not be sufficient to show any difficulties students have in other areas (e.g. mathematical modelling).

7.3.2 Impact on Other Student Characteristics

If one considers different levels—society, institution and individuals—for classifying research on the possible effects of out-of-field teaching, one can state that besides a number of qualitative investigations (e.g. du Plessis 2015; Hobbs 2012, 2013a, b), studies testing indicators of teachers' formal qualification and their relation to students as individuals are by far the most frequently conducted. However, the main focus of these studies has been on the quality of learning outcomes and not on other student characteristics.

Tiedemann and Billmann-Mahecha (2007) researched the impact of teachers' qualification on students' testing results and the self-concept of the children in primary school. They hypothesized that higher competence belief of students taught by in-field teachers since these teachers 'are more familiar with the 'philosophy' of the subject and that affects the teaching practice. Thus, specialist teachers should be better able to succeed in enhancing students' joy of learning and to strengthen the academic self-concept' (p. 61, translated by authors). However, the results did not confirm this hypothesis as they found no significant differences in self-concept between students taught by in-field and out-of-field teachers. One explanation could be the use of a scale that measured the students' (general) academic self-concept. An investigation by Porsch and Wendt (2015) of the relation between the domain-specific self-concepts (mathematics and science) of students and their teachers' self-efficacy beliefs with regard to teaching these subjects and taking into account the teachers' qualifications (with and without a major) came to the same conclusion, that teachers' formal qualification could not explain students' competence beliefs.

The students' perspective is also evident in the work of du Plessis (2013, 2015). She analysed documents, made lesson observations and conducted interviews with specialist and out-of-field teachers as well as parents and school leaders. She identified that the parents and school leaders could provide insight into the children's perceptions. For example, a school leader stated: 'Children rebel. We had a situation in our music class where a kid said, "I'm not learning." We had children leave school saying, "I'm not learning in this person's classes"' (du Plessis 2015, p. 96). This view is shared by a parent of this class: 'They really do just get lost in the whole swarm of the classroom. It's a waste of a year for them because none of their needs are met' (du Plessis 2015, p. 96). The study concluded that students appeared to be dissatisfied with their lack of success in learning and the anxiety felt when taught by out-of-field teachers. The teachers reported feeling insecure and even anxious, which affected their students. One specialist teacher said: 'That sort of teacher is quite anxious and children in his or her class pick up on that anxiety and stress, and become anxious themselves' (du Plessis 2013, p. 78). A parent supported this view: 'My daughter is anxious; she tends to be fairly quiet. Her year 2 was unfortunately quite distractive and it upset her because she just desperately wanted to learn and get on with the activities and the fun side of learning—it was starting to bother her' (du Plessis 2013, p. 78.). Children reported the capacity to perceive a low level of confidence in their teachers: 'Kids were frustrated. The biggest thing was counselling the kids to understand that in life you'll get these situations happening, I was philosophical about it and said, you're still to do your best. (…) Teachers get discouraged in their skills and their ability in an area they are not competent—the children see the lack of confidence' (du Plessis 2013, p. 79). Consequences could be school anxiety or school reluctance as illustrated by the following quote: 'He doesn't want to go to school and that is my frustration because he loves school, he loves to learn but in these circumstances he is going to be left behind' (du Plessis 2013, p. 79).

In contrast to this rather negative view on the impact of out-of-field teaching on students, Olitsky (2007) reports from an ethnographic research project accompanying a female out-of-field chemistry teacher. In contrast what the researcher expected, many students expressed they enjoyment being taught by her. Interestingly, students also expressed the view that they liked that the teacher does not have full knowledge and makes mistakes. 'Observing their teacher in the "backstage" of learning may therefore be a particularly valuable experience for these students, as they may feel excluded from science as a high-status group but they value academics and are therefore open to the possibility of membership' (Olitsky 2007, p. 219).

Overall, it must be noted that effects on students' characteristics taught by out-of-field teachers have received little attention in research. That can be explained by the role of teachers as experts in the view of students, especially those at a young age, who probably seldom doubt the teachers' practices. So far no study is known that directly asked students about teachers' behaviour along with information on the teachers' qualification—perhaps because of ethical reasons or limitations in the objectivity from potential participants.

7.4 Conclusion

This chapter commenced with the presentation of a model relating the determinants and consequences of teachers' professional competence (Kunter et al. 2013). The model proposes that the precursor of professional competence is the availability and uptake of learning opportunities and that completion of these learning opportunities results in improved professional competence and practice. It is this change in professional practice that is hypothesized as resulting in improved outcomes for students in both the cognitive and affective domains. The model also hypothesized improved outcomes for the teacher, including being more engaged in innovation and gaining enhanced career advancement and general occupational well-being.

This review of the literature relating to out-of-field teaching has identified limited support for the Kunter et al. (2013) model, particularly in terms of improved student outcomes (e.g. Buddin and Zamarro 2009; Porsch and Wendt 2017; Tella 2008;

Tsai and Yang 2015; Zuzovsky 2009). Where improved student outcomes have been identified, the effect size in most studies has been relatively small (Goldhaber 2002).

It is not being argued here that there is no association between teacher qualification and learning and student outcomes. Rather, it is proposed that the research available in relation to out-of-field teaching and the possible association with student outcomes has not reached the level of maturity necessary to be able to provide the necessary robust empirical evidence to support any definitive stance. More evident is that out-of-field teaching affects different subjects in different ways. There appears to be several methodological challenges in the research conducted up to this point that have contributed to this situation that would need to be addressed before any conclusions are able to be made.

The first issue identified is the lack of a consistent definition to identify a teacher as being in- or out-of-field. The definition is usually based on the completion of the required tertiary study in either or both the academic discipline and teaching methods. It is questioned if such objective conditions are an appropriate benchmark for distinguishing the categories since it could be argued that all early career teachers are teaching out-of-field due to their lack of experience. It may be more appropriate to use an approach where teachers self-nominate if they are out-of-field in a subject. Such an approach would, perhaps, use a theoretical framework such as identity as the basis for researching the out-of-field phenomenon: an approach recommended by Bosse and Törner (2015). Recent work based on the lived experience of the out-of-field teacher (du Plessis 2013, 2015) may also be a more appropriate theoretical framework. Also, the factors that make a teacher 'feel' out-of-field from Hobbs (2013b) might be helpful.

The methodological differences between studies present a second substantial challenge. A primary shortcoming is the lack of longitudinal studies, with the large majority of studies conducted over timeframes that would not allow researchers to understand the change process for the out-of-field teacher. In quantitative studies methodological approaches such as a comparison of between-group means, regression analysis targeting the association between teacher and student variables, and multilevel regression modelling have been applied. Considering the complicated nature of the phenomenon being investigated, it appears that the use of multilevel regression modelling on an appropriately sized dataset involving longitudinal data would be necessary. The existing studies that have used multilevel regression analysis (e.g. Hoffmann and Richter 2016; Kyriakides et al. 2009) have identified that the differences in outcomes for students is largely dependent upon variables associated with the student, rather than the teacher. This finding would need to be further researched.

The primary implication for future research efforts based upon this review of the literature is that the out-of-field teaching phenomenon is still an under-researched area in order to derive practical implications on a solid basis. Additional work addressing the definitional and methodological challenges identified here is considered necessary to further develop the field to allow approaches to address the associated challenges to be done so on a sound empirical evidence base. Despite the mixed results, we still argue that subject qualifications are essential for high-quality student outcomes. Thus, there is a strong need for policymakers, school administrators and teacher educators for ensuring teachers out-of-field retrain or at least obtain the support needed to upskill and become proficient in the out-of-field subject, or increasing the supply of suitability specialized teachers and initiatives that increase teacher recruitment. Especially, initial teacher education that ensures teachers are adequately prepared for the subject-specific curriculum and pedagogies is vital.

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Part III
Confronting Dilemmas and Addressing the Issues of Teaching Out-of-Field

Chapter 8
Attending to Out-of-Field Teaching: Implications of and for Education Policy

Colleen Vale and Pat Drake

Abstract In this chapter, we argue that policy should take account of teaching out of field because it is systemic. Rather than being a product of poor teacher retention, we show that teachers teaching out of field has consequences for teacher retention. We illustrate opportunities for providing differentiated professional learning for people working in schools. Research, reports and commentary on education policy regarding the incidence of, perceptions of and responses to out-of-field teaching in secondary education with a particular focus on STEM disciplines are reviewed. Whilst education systems and policies differ between, and within countries, the review identifies policies and practices that impact incidence of and responses to out-of-field teaching. Scenarios taken from particular studies will be used to illustrate contexts, policies and practices. The review explores who takes responsibility within the education systems and jurisdictions for attending to the issue of teaching across specialisms, who is undertaking what actions, and what further steps are needed by the various policymakers and implementers to respond appropriately.

Keywords Retention · Recruitment · Teaching out-of-field policy

8.1 Introduction

Around the world teachers in secondary schools and in some countries, primary schools are required to teach subjects or year levels without the discipline knowledge or pedagogical content knowledge required or expected by the education and teacher registration policies for teaching that discipline (Adamson and Darling-Hammond 2012; Akiba et al. 2007; Ingersoll 1998, 2002; Marginson et al. 2013; Mullis et al.

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_8

2012; Törner and Törner 2012; UNESCO Institute of Statistics 2016). This phenomenon, called out-of-field teaching, occurs not only in developing nations but also in developed and advanced nations as reported in the Chap. 3. Whilst out-of-field teaching might be inevitable due to time delays in implementing education policies, such as raising the school leaving age, promoting participation in senior secondary school or introducing new discipline studies in curricula (Noyes et al. 2013), the continuing practice of appointing teachers to teach out of field is not a result of short-term shortfall in appropriately qualified teachers but a long-term problem of supply and allocation of qualified teachers (Darling-Hammond and Sykes 2003; Ingersoll 2011; Masters 2015).

We might expect there to be differences in the incidence of out-of-field teaching between developing and developed nations due to the increasing expectations for education systems in developing countries, but there is plenty of evidence to show that the differences in incidence of out-of-field teaching are higher within countries than between countries (Choi 2010; Ingersoll 2011; Weldon 2016; Zhou 2014). Studies in various developed nations show that out-of-field teaching occurs more often in low socio-economic communities and in some countries, such as Australia, in rural or remote communities. So, being a problem of growth and teacher shortfall, the practice of assigning teachers to teach out of field is an issue relating to equity and social justice (Adamson and Darling-Hammond 2012; Ingersoll 2011; Vale et al. 2016a, b).

Education policy around the world is focused on accountability and performativity, that is, systems and schools demonstrating that they are improving educational participation and achievement with policy directed towards increasing the autonomy of schools and improving the quality of teachers (Ball 2003; Ranson 2003; Skourdoumbis 2013). Yet, this agenda largely ignores the incidence of out-of-field teaching blaming so-called 'hard-to-staff' schools who employ less qualified teachers for failure to improve educational outcomes (Adamson and Darling-Hammond 2012; McKenzie et al. 2014; Vale et al. 2016a).

Zhou (2014) studied the incidence of out-of-field teaching across and within 47 countries to find that schools with greater autonomy reported lower incidence of out-of-field teaching. But these findings are contradicted by studies in Australia and the United States that show that when schools have autonomy in selecting and employing teaching staff, schools in low socio-economic, rural and remote schools struggle to recruit and retain teachers (Adamson and Darling-Hammond 2012; Baker and Weber 2016; du Plessis 2015; Handal et al. 2013; Ingersoll and May 2012; Lyons et al. 2006; Quartz et al. 2005; Tamir 2013). Studies also show that there is an increasing incidence of graduate and early career teachers teaching out of field (Mayer et al. 2014; Weldon 2016).

A number of researchers have drawn attention to the misalignment of education policies and funding of schools that occur within and across jurisdictions which enable the incidence and effects of out-of-field teaching to continue unabated (Adamson and Darling-Hammond 2012; Baker and Weber 2016; Vale et al. 2016b). For example, misalignment of education policy with respect to student outcomes, policies impacting on teacher working conditions and policy of teacher education contribute to problems with recruitment of people needed for specific subjects and to teach in particular communities and locations. Misalignment of policies regarding school autonomy, teacher specialist qualifications and funding for ongoing professional learning affects the incidence of out-of-field teaching and retention of these teachers.

In this chapter, we review research findings about the influence of educational policies on the incidence, practice and effects of out-of-field teaching and the ways in which systems and schools attend to out-of-field teaching to either reduce their reliance on less qualified teachers or to enhance their knowledge and experience of teaching across subjects to improve teachers' practice and well-being. We draw on cases from our research to illustrate issues of policy. We are keen to drill into the impact of out-of-field teaching and so are considering how teacher professional learning of subject specialist knowledge in secondary schools intersects with the specifics of teacher provision, that is, recruiting teachers and retaining them within the overarching performativity policy context.

Our discussion focuses mainly on the STEM disciplines, though we recognise that out-of-field teaching occurs in all discipline areas. The development of science, technology, engineering and mathematics (STEM) in schools has become of national focus in both Australia and the UK. Both countries engage with STEM policies as part of national economic growth. Without paying attention to teaching of STEM in schools, it is impossible to engage with the policy need for skilled STEM workers, and, conversely, the lack of flow of skilled STEM workers into schools in turn inhibits the preparation of these areas in the future.

8.2 Recruitment

Universally, to achieve primary education worldwide by 2030 there will be a need for 25.8 million more teachers (UNESCO 2016). Evidence shows that in successful education systems, teachers are high quality on entry and are provided with career structures that reward and support continued skills growth. These teachers in turn support new entrants (Marginson et al. 2013). Indeed, strong education systems do take account of the complexity of teacher recruitment, preparation, supply and distribution. Nonetheless, few jurisdictions achieve it. The European Commission (2012) states:

> High-performing systems build up their human resources by attracting, training, and supporting good teaching staff: research suggests that the world's best-performing education systems recruit all of their teaching staff from the top tier of graduates, with a mutually reinforcing balance between high selectivity and attractive working conditions. But few European countries achieve this. (European Commission 2012, p. 28)

How can this be achieved in areas of the world that are sparsely populated or in areas where there already is a shortage of teachers because universal basic primary education is not yet secured or where new graduates ignore teaching as a profession in favour of other labour market opportunities or where there are significant differences in citizens' access to high-quality schools? From these perspectives, the approaches a country takes to the preparation and education of teachers cannot simply be about preparing new entrants to the profession, because even if sufficient numbers of teachers are prepared, geographical, anthropological and socio-economic factors are known to disrupt their smooth and equitable distribution.

Capacity building of and for teachers at system level is apparent in strong systems as these recognise that whilst recruiting well-qualified teachers is of paramount importance and so is continuing to provide opportunities for professional learning. Circumstances on the ground can interrupt anticipated career trajectories and make it necessary also to prepare for and provide professional learning for altered and unexpected career paths. This is a difficult balance to achieve. In this section, we focus on approaches to the recruitment of high-quality teachers. We discuss how teacher recruitment might take account of the likelihood of teachers teaching 'out-of-field' and prepare for this eventuality at a system level by taking a pragmatic approach to identifying the potential for high-quality teaching when the teacher herself might be qualified originally in something else or indeed not qualified at all.

How teachers are recruited and the extent to which teacher recruitment is planned by forecasting the supply of teachers that are needed varies from country to country. In a few countries, such as France, for example, teachers are prepared professionally and then recruited to join the civil service through success in a national competitive examination. It is, thus, possible to match the success rate in the examination with the number of vacancies, and it is possible in such a system to match teachers with vacancies on a regional basis. This approach, whilst potentially resource intensive in so far as recruitment is selective from a larger pool of teachers who have trained, does address the inequities arising when qualified teachers choose to work in leafy and convenient metropolitan suburbs rather than the inner city or more remote rural areas. However, the approach is not common and even in countries that do adopt it, fewer teachers are part of this elite competitive pool because it is expensive and jurisdictions' education budgets are under increasing pressure. In England and Wales, attempts to match the number of new entrants to replace teachers who leave is done at the pre-service entry stage. The government sets targets for each teacher education institution based on these estimations and also based on the adjudged quality of the teacher education that is provided. Here in lies a large assumption, namely, that if entrants are selected appropriately and trained well, employing schools will be able to make reliable appointments at school level. All things being equal this would be a fair enough assumption, but all things are not equal. Some locations are more attractive to teachers and it is difficult to recruit in some subject areas, such as mathematics, science and modern languages.

In other countries, there are no attempts to govern the number of potential teachers taking pre-qualifying courses. In some, and Australia is in this category, courses are aligned with a set of professional standards, and so meeting the benchmark standard is not matched at all with the number of teaching vacancies in schools. There is little in the way of international system agreement about what professional standards should comprise. Despite there being no internationally agreed benchmarks for teachers' practice, it is assumed by jurisdictions who adopt professional standards that, provided a student completes a course, and meet the standards, then schools might reliably appoint teachers who are professionally prepared. It is up to schools to employ the teachers that provide the best fit for the vacancies. Some schools, typically, those located in areas of choice find it much easier to recruit teachers in this way. Other schools, such as those in remote rural areas with considerably less dense populations and also tending to be climatically inclement find it much more difficult.

Generally speaking, in European countries, potential secondary teachers would have a graduate qualification in a subject related to the school curriculum, with preparation in pedagogy coming at the latter stages of initial teacher education. Sometimes, as in England and Wales, a teacher is deemed qualified if and only if they meet professional standards prescribed by the government, with these standards being required at an individual rather than at a course level. Successful education systems are flexible in the ways that teachers are recruited according to demand and are able to respond quickly to the changing nature of the workforce and needs of schools. This tends to favour the degree plus postgraduate qualification approach because these approaches to teaching qualification, being shorter, are more flexible and more responsive to system variations. Where teaching qualifications are provided through longer degree programs, there are tensions between the needs of the system and the speed with which it can respond to these needs. There are also tensions between government and higher education, who, in order to alter their own approach to student teacher recruitment, need time to plan and adapt accordingly.

Jurisdictions vary and where there is a sophisticated grasp of the changing nature of the workforce to meet need, there may be shorter pre-service teacher preparation, recruitment of individuals with varied pre-qualification and greater opportunity for adaptation post-qualification. More stable systems are able to rely on making significant investment in initial teacher education.

A further dimension is the extent to which teachers are recruited ‘for life’. Ingersoll (2002, 2012) draws attention in the US to what is referred to as the ‘greening’ of the teaching profession that arises because of a combination of factors. First, the overall number of teachers in the USA has increased over time. Second, between 40% and half of new teachers have left the profession 5 years after entering it, with one in ten having left before the end of their first year. He points out that this makes the typical teacher, far from being a grey-haired old timer, more likely to be a newcomer to the profession with little experience. Reasons for teacher departures are serious and include poor salaries that increase very slowly over time. For instance, in most European countries it takes 15–25 years to reach the maximum basic statutory salary (European Commission 2012) longer in some, and fewer years in others. Other reasons for early departure include lack of support and professional development, lack of professional autonomy, poor working conditions, fragile job security and short-term contracts; these are discussed in detail later in this chapter as a set of retention issues. But from the point of view of teacher recruitment, teaching for a limited period of time could be identified as a means of providing skilled workers in areas of specific need, and to be framed as a valuable contribution to the career portfolio of a graduate. For example, scientists may become teachers of science for a limited period whilst bringing up their own families; such teachers may aspire to return to scientific careers. Are these teachers a loss to the profession or a gain? Likewise, there are teachers of mathematics who are ‘promoted out’ of the classroom, perhaps to work in the preparation of new teachers who then return to the classroom to refresh their teaching experience. In some countries, policy drivers are such as to facilitate people becoming teachers for a period of time in their career portfolio over a lifetime. Other systems leave these to chance.

Building capacity is not straightforward and furthermore lack of capacity tends to become more exacerbated more quickly in specific ways: shortage subjects such as mathematics, science and modern languages; areas where it is difficult to recruit teachers, such as rural areas, urban areas of social disadvantage and areas with challenging climates; and developing countries are increasing the teaching workforce in order to extend schooling to a broader population demographic. This makes the hot northern and central regions of Australia, the cold northern areas of Canada, poor areas of cities such as London and New York and developing countries, such as those in Africa, especially vulnerable.

The age of compulsory schooling varies across countries and systems also diverge in terms of what counts as ‘early years’, ‘primary’ and ‘secondary’. Traditionally, teachers of early years and primary phases are generalists, trained to teach all subjects. Some countries, for example, Hong Kong China, have initiated specialist teaching of some subjects such as mathematics and language, but this is difficult to achieve where there are inherent shortfalls in recruiting, into pre-service preparation, teachers with interest or relevant previous academic experience in these areas. Secondary teaching does have a specialist inclination with an expectation that teachers are subject specialists. For all the reasons discussed above, it is not surprising, especially at post-primary level, to find significant numbers of lessons being taught by teachers qualified in something other than the subject they are teaching. For instance, in England in 2016, about 1 in 5 teachers of mathematics did not have any qualifications in mathematics above the A level they gained themselves at school aged 18 (e.g. DfE England and Wales 2016). In some systems, teachers need not be qualified to teach at all. Exacerbated by school autonomy, recruitment, salary, tenure, allowances, workload of teachers varies within as well as between countries, and there are commensurate and associated status differences within and between countries as well.

We argue that, rather than teachers teaching out of field being ‘the problem’, ‘the problem’ is more precisely defined through lack of recognition of the inevitability of teachers teaching out of field, for the reasons discussed above. Strategic investment in professional development for these teachers could enable them to become more valuable in the resource set possessed by an educational jurisdiction. The problem of recruiting teachers certainly exists, as does the social inequity of school students’ experience of being taught by unqualified staff. Nonetheless, teachers teaching in schools, whatever the specific nature of their previous experience, have the potential to contribute significantly to the teaching force. In fact, teachers teaching out of field span all curriculum areas (see, e.g. UNESCO Institute of Statistics 2016) but we focus here on mathematics and science because of international policy imperatives to develop these.

8.2.1 *Teaching Out of Field: Annie, Rita and Jo*

The following scenarios are drawn from research cases (Drake 2009a) and are included to illustrate some of the circumstances in which ‘out-of-field’ teachers work.

Annie for some time did the books in her family catering business. The business folded after the family moved and her parents became frail. Annie rekindled her interest in school mathematics by helping her daughter with her homework and so she enrolled on an adult basic mathematics course, was successful and went on to an intermediate course in which she was also successful. She became a teachers’ aide in a low SES school near where she lives. Occasionally, she takes lessons on her own and would like to qualify to teach because she gets good feedback from students. She is doing a degree in Mathematics Education Studies part time because she cannot afford to give up her job. Annie said:

> I now understand more about what teachers are doing. Before, I was blindly following their lead, whereas now I know the pressures that are on them and I feel that I can make suggestions about how to do things, but I also see things from a student’s point of view as the students talk to us more than they talk to teachers. I feel more confident as a teaching assistant because I see the teaching from the classroom, so I see things as the students do, rather than as the teachers do, but at the same time, I am more aware of why teachers do certain things now.

Rita trained as a junior teacher. After a career break to have children she returned to teaching as a relief teacher. She wanted to establish herself as a special needs teacher so she retrained to teach mathematics intending to focus on special needs but she got hooked on mathematics. She wanted straightforward instruction in how to teach mathematics but instead found herself learning mathematics to a high level, which she enjoyed. Now in school again she is head of year and teaching mathematics but does not really feel ready to teach higher levels and so she works with lower levels. Her head of department said that the advantage of retraining Rita is that she is

> the devil we know. She was good in the context of this school before she went on the course. There’s been no continuity here, permanent covers and teachers I wouldn’t allow in front of a class. I allocate classes to Rita taking account of her skills with difficult students. We should use people with potential.

Jo worked for the tax office before starting in her children’s primary school as a parent helper, then she went on to be a teaching assistant which she has been for more than 11 years, the last four of them entirely supporting mathematics. Now, her children are getting older she has more time to do things, and to develop her thoughts about becoming a mathematics teacher. Jo has no formal qualifications beyond VCE.[1] An opportunity for study at the local university arrived and Jo took it.

> I’d always done an evening class or something, and always I’d been getting a bit of training through work, and to be honest some of it was damn easy, well I wanted to do something a little bit more advanced. I got on to the Diploma and enjoyed it so I thought I’d give it a

[1] Victorian Certificate of Education, last 2 years of secondary school in the state of Victoria, Australia.

> go. And there was an element of there not being many maths teachers, and seeing people coming in and thinking I'm sure I couldn't do any worse than they do. I might not be able to do any better but I don't think I could do any worse. It sort of spurs you on.

We note the resourcefulness, ambition for personal development and enthusiasm of each of these 'out-of-field' teachers (Drake 2009b) and wonder how these characteristics might be strategically developed in many more individuals working in schools, whilst not compromising the desire of a jurisdiction to recruit the 'brightest and the best'. Rita was a very experienced teacher who lacked a career path and so, through spotting an area of need, special needs in mathematics, set about taking advantage of local in-service provision to upskill her subject knowledge, which she did to a high level. Her experience as a teacher informed her judgment that she was not ready yet to teach at higher levels of mathematics at school but her enhanced subject understanding enabled her to make a valuable and recognised contribution in the middle years of secondary schooling. Jo and Annie were not experienced teachers, but ironically supporting the mathematics curriculum in school as teachers' aides—that is the same curriculum that sadly deters many school students—enthused them to study both mathematics and pedagogy as a preparation for graduate teacher preparation.

8.2.2 Policy Implications

For the purposes of consideration, different categories of out-of-field teacher are listed in order to point to different ways of supporting people from these categories into more specialist practice. Readers will apply hierarchies of importance to the needs of each group, and we argue that educational jurisdictions might usefully do the same, because currently initiatives to support each group tend to be more unsystematic and short term.

1. Primary and early years teachers teaching mathematics and science. Some countries have developed initiatives to enhance this group, such as the Mathematics Specialist Teachers (MAST) initiative in the UK from 2010–2014 (DfE England and Wales 2013; Stevenson 2016). Incidentally, this group, consisting as it does mainly of female teachers, is subject to the entrenched but rarely acknowledged inherent sexism in declaring that primary teachers are the problem because they cannot do mathematics. Well let us teach mathematics to these teachers!
2. Specialist teachers of science disciplines teaching other sciences, e.g. chemistry teachers teaching biology; physicists teaching environmental science.
3. Specialists from industry willing to become teachers but without teaching qualifications. People stepping back from careers as scientists in order to care for families would be part of this group, as would people from IT or people facing redundancy. Shorter courses that focus on pedagogy specifically provided alongside service could help this group develop its potential and contribution to schools.

4. Teachers of other subjects (not in shortage) teaching shortage subjects. For example, teachers qualified in physical education quite often teach mathematics as do teachers of geography. This group understands pedagogy but benefits from subject knowledge enhancement.
5. Well-qualified graduates unable to access postgraduate teacher preparation because their degree is not in a curriculum subject, e.g. graduates of psychology or economics. Subject enhancement courses, either alongside or as a precursor to graduate pre-service preparation, may be provided online, e.g. in the UK, see https://ske.online.
6. People working in schools as teachers' aides.

People from each of these groups may be teaching in schools finding it difficult to recruit, and each category should be supported in different ways, because without investment they are frankly 'less-qualified'. The investment of a country into new teacher preparation is balanced by considerations of how long the teacher is expected to stay in teaching; and the extent to which the country provides professional learning for teachers as the priorities of the country and the demographic distribution shifts over time. For example, on occasions of a bulge in the birthrate, secondary teachers may be retrained to teach primary; or when there is a shortage of mathematics teachers, teachers of other subjects not in shortage may be retrained to teach mathematics.

8.3 Retention

In the previous section, we discussed the possibility of policies aimed at recruiting high-quality teachers and upskilling less qualified teachers to address the shortages of in-field teachers. In this section, the relationship between these policies and other policies and practices at the school and district level are discussed, especially as they impact on retention of teachers in secondary schools. Policies, funding and school practices contribute to attrition and reliance on out-of-field teaching when they do not support and develop the knowledge and practice of graduate teachers and teachers are asked to teach out of field.

In some states in Australia, beginning secondary teachers have been provided financial inducements to take up teaching positions in rural and remote schools. Handal and colleagues (2013) had previously found that these teachers tended to return to metropolitan schools or schools on the east coast of Australia, or leave the profession, once their contracted position under these arrangements expired. They subsequently conducted a survey of 191 secondary mathematics and science teachers to identify the factors that contribute to the attrition of teachers from rural and remote schools. Principle among their findings was the requirement to teach out of field, the limited opportunities for professional development, the lack of support from within the school or district in the form of mentoring or coaching and the absence of quality curriculum and resources. In addition, because these schools are dominated by early career teachers, teachers in the first years of their careers were expected to take on leadership and other roles. They found that the inducements to take up these positions did not outweigh the negative professional and personal experiences of working and living in rural and remote Australia.

In the US, there is a high attrition rate of beginning teachers with a disproportionate impact on schools in low socio-economic communities. High-quality teachers tend to move from low socio-economic to higher socio-economic schools (Tamir 2013) or leave the profession:

> Ironically, as the call increases for highly qualified teachers, it seems to be the "be stand brightest" candidates that leave earlier and in greater numbers than their less academically grounded counterparts. (Quartz et al. 2005, p. 493).

However, Simon and Johnson (2015) questioned the findings that teacher attrition is related to the demographics of the school community. They pointed to school organisational factors including dysfunctional practices that resulted in unsatisfactory working conditions as the key factor in teacher attrition.

'Teacher churn' or the 'revolving door' (Ingersoll 2002), that is, the constant turnover of teachers and principals in rural and remote schools or low socio-economic schools, contributes to continual reliance on inexperienced and out-of-field teachers. It increases the time devoted to recruiting and preparing new teachers as well as to continual renewal of curriculum programs and a loss of attention devoted to improving and sustaining practices (Jorgenson 2012; Quartz et al. 2005; Simon and Johnson 2015; Tamir 2013).

The *Teach For Australia* (TFA) program is one of the elite recruitment policies implemented to increase supply of in-field teachers and to address shortages of in-field teachers in rural and remote Australia; in this regard, it is a sister program to Teach for America and Teach First (in the UK). In Australia, TFA teachers receive an intensive short course prior to employment as an associate teacher for 2 years while they complete their initial teacher education and qualification. Associate teachers have a workload reduction (0.8) during this period and have school mentor, a TFA mentor and a university mentor in their first year, but only a TFA and university mentor in their second year. Upon graduating, they have no further workload adjustment as a graduate, not even when teaching out of field, and are expected to take up leadership positions within the school (Weldon et al. 2012).

As the case study that follows shows, TFA graduates are expected to lead and innovate as an out-of-field teacher.

8.3.1 Case Study: Australian Rural Secondary School

The following case study is one of six Australian secondary schools from three different states, participating in a longitudinal study over 3 years of out-of-field teachers and teaching. Data collected included interviews of the school principal, the teacher responsible for the timetable who was also the mathematics leader, the science leader and three further teachers. Two of the teachers were science teachers who had just completed their 2-year initial teacher education as an associate teacher in the TFA program (Weldon et al. 2012) and were now teaching out of field. One of these teachers, Stefan, was teaching both mathematics and senior physics out of field, the other, Sally, was teaching drama out of field. The third teacher, Seamus, was a first-year teacher who was teaching their in-field subjects of mathematics, physical education and health. The teachers were interviewed twice in the first 2 years of the study. These interviews explored their beliefs, practices and experiences of teaching. Each year they also video taped two lessons, one of which was a lesson in their out-of-field area and the video-stimulated interview focused on significant moments for teaching and their learning in each lesson. One of the interviews in the second year of the study also asked them to graph their confidence and enjoyment in teaching their out-of-field subject and an in-field subject over the 2 years.

The secondary school (Years 7–12) is located in rural Australia with farming, tourism and mining the local industries. At the beginning of the study, there were approximately 420 students and 35 teachers (equivalent full time). The community is relatively monocultural, 4% of the school population identifies as Indigenous and 3% with a language background other than English. A significant proportion of students are from low socio-economic status families (41%). In the first year of the study and then again at the beginning of the following year, the school appointed 14 new teachers. That is, almost half of the teaching staff at the beginning of each new school year were new to the school. Almost all of these teachers were new to teaching, either as graduate teachers or as associate teachers who were commencing their teaching qualification to be completed over 2 years as part of the TFA program. The principal was also new to the school in the first year of the study. Whilst the school is working to reduce its reliance on teachers to teach out of field through its appointment of graduate and associate teachers, small numbers of teachers at the school have been asked to teach out of field upon graduation after completion of their tenure as associate teachers. At least one other experienced teacher was teaching Year 10 mathematics out of field. The school had at least two other TFA associates teaching in mathematics and science. One who would complete their qualifications at the end of the second year of the study, the other had commenced their TFA program at the beginning of that year. The teacher population at the school was, therefore, strongly skewed towards inexperienced and early career teachers.

The principal was anticipating less turnover of staff for the commencement of the third year of the study, but before the commencement of Term 4 in the second year of the study Seamus, the early career mathematics teacher, had resigned and left the school. Stefan, the early career science teacher who was teaching mathematics and physics out of field, had decided to leave the school and return to the state capital to pursue further study. He had been leading the development of a new program in Year 7 mathematics which was now to be abandoned. Sally had already moved schools at the end of the first year of the study. She took up a leadership position in another, larger, rural secondary school in the same regional district. Prior to the end of the second year of the study, the Principal had agreed to appoint two new associate teachers in science and mathematics through the TFA program for the next year. Clearly, a number of factors are contributing to teacher turn over or churn at this school. Some of these possibly concern the relative remoteness of the school, others are related to workload stress and factors of school culture including leadership, mentoring and the degree of collegiality and collaboration.

The person responsible for preparing the timetable (timetabler), also the mathematics leader, who was born in the area and returned to teach at the school after completing his degree and initial teacher education, believed that the early career teachers just did not want to live in the country:

> They come for a couple of years and then back to [the city]… the mentors are retiring and the, you know, younger staff are…tend to move on, they're not prepared to sort of develop roots here. (Timetabler/Mathematics Coordinator, July 2015)

The Principal and science leader both reported their experiences of teaching out of field during their career. However, neither the science leader nor mathematics leader realised that Stefan was teaching out of field. Analysis of the teacher interviews revealed that ignorance of the leadership team regarding teachers' knowledge and experience; the limited number of experienced teachers available for mentoring and no time allowance for the extra workload involved in teaching out of field all contributed to the difficulties encountered by the early career teachers at this school.

Stefan had completed his initial teacher education qualification in science and humanities after completing a science degree with majors in zoology and philosophy. During the 2 years of his associate teaching he had taught junior science, chemistry and physics in Year 10. He applied for the 1-year contract position as a mathematics and science teacher and argued that he had sufficient tertiary background in mathematics and physics to teach mathematics and senior physics. During his first year of teaching Year 8 mathematics out of field, Stefan had the opportunity of visiting a low socio-economic school to learn about their student-centred mathematics program. In his second year as a qualified teacher, he took on the role of developing a similar program for Year 7 students at the school with a colleague who was completing his second year as an associate teacher. In spite of some positive evaluations by students, the workload required to implement this innovation was too high and the skills involved in team planning and team teaching were too demanding:

> Introducing [the] Sunshine model has always been really hard, like a lot of work that's impacted the enjoyment factor, but-… we've kind of fluctuated but have felt really good about where the students are at and how good their understandings are. (Stefan, Interview 4, October 2016)

By Term 4, they had given up on the program and Stefan had decided to leave the school and return to [the city] to pursue further study.

In his first year of teaching, Seamus reported positively on the mentoring relationship with the mathematics coordinator and reported that he had visited and observed lessons conducted by other teachers in his field. However, he reported that there was a lack of documented curriculum at the school:

> Our curriculum development here isn't the best so I end up doing a lot of work on curriculum development and working out what I'm teaching. (Seamus, Interview 1, September 2015)

This was especially difficult in the second semester of his first year when he was asked to teach the advanced Year 10 group for the second half of the year and discovered that there was no documented curriculum for this subject. In his second year, Seamus also experienced a very heavy workload and a lack of support and collaboration which he described as ‘difficult, very difficult’. He reported very positively on his teaching, and especially the opportunity to teach the same subject for a second time. He also reported on his use of professional reading to improve on his planning and teaching. He developed innovative units of work in mathematics that he shared with other team members as part of the agreed process in alternating and sharing the planning of units for his mathematics classes. His main concern was the lack of contribution by other team members when it was their turn to plan units of work in mathematics:

> But then the politics came in at the end of the term where it was the other teacher’s turn to do their units and I had one particular senior teacher just not do any work whatsoever… he did zilch and so I had to then do that as well. (Seamus, Interview 3, June 2016).

During his second year of teaching, Seamus also took on the role of sports coordinator and found it difficult to get the support and involvement of colleagues for major sporting events and team coaching ‘because now you’ve got to get them to do things they don’t want to do’ (Seamus, Interview 3, June 2016). Seamus left the position at the school during Term 3. It seems likely that the workload and lack of support from colleagues contributed to this decision.

Sally, the third teacher from the school participating in the study had been fairly satisfied with her experience and developing expertise but had determined that she should seek further experiences elsewhere. In her first year as a qualified teacher, she designed and implemented the school’s first drama program as an out-of-field teacher and, realising that the school had appointed a graduate teacher specialist for this role in the second year of the study, applied for a position at another school not expecting to be successful but because ‘I wanted a bit of an ego boost’. Her interview was a positive experience and her application successful. She was granted a 3-year contract with a leadership position in the school’s Vocational Education Program (VCAL)—a new out-of-field experience but more closely related to her interests and with relevance to her undergraduate degree in horticulture. As she discussed the leadership practices, school culture, planning practices and her teaching, the differences between the two schools with respect to school leadership and collaborative practices became evident. Teams were larger at her new school but there was more collaboration. Rather than dividing the planning between the team members, each person had an opportunity to contribute to the planning of each unit. Even though there was quite a high proportion of early career teachers in each of the teams, they were able to build on well-documented programs from previous years for their planning. The principal at this school had made a conscious effort to increase the number of leaders in the school and their leadership capacity through the provision of specific leadership professional learning. He also valued and publicly acknowledged the many and varied contributions of staff. Personal communication and provision of personal support and services embodied an emphasis on teacher well-being.

Due to the teacher turn over at the case study school, the Principal was forced into offering short-term contracts for early career teachers or 2-year contracts for associate teachers. From his experience, it was very difficult to recruit in-field experienced teachers as these teachers were paid higher salaries and expected long-term or tenured contracts. Due to the employment of associate teachers and the very high proportion of early career teachers, there was a reliance on too few staff to conduct the mentoring. A requirement for employment of associate teachers was the provision of supervision and mentoring. The sole policy and strategy for induction of graduate teacher focuses on a slightly reduced workload and required mentoring which took the form of one weekly meeting and occasional observation of lessons. Consequently, at this school there was already insufficient experienced staff to mentor associate and graduate teachers, and no employment of coaches who could continue to mentor early career teachers or coach and mentor staff teaching out of field.

Government regulation in Australia stipulates that graduate teachers have a 0.95 teaching load, that is, a new teacher would teach 95% of the load of a more experienced teacher. However, this effectively means that graduate teachers have the highest teaching load in the school because, as this case shows, teachers in their second year are often expected to take up leadership positions, which while reducing the teaching load creates other workload issues. The mantra of the TFA program is the expectation that TFA graduates will be innovative and be leaders in their schools. Teacher registration does not identify a teachers' discipline specialisation, and hence there is no workload reduction for out-of-field teaching in workplace agreements for teachers and school funding does not provide for personnel or workload reduction for mentoring of these teachers unless they are graduates. At this school, the consequence of high workloads, the lack of mentoring, poorly documented curriculum and an expectation to innovate led to teacher dissatisfaction.

Whilst the education system in which this case study school was located strongly advocates developing collaborative practices for planning, teaching and assessment and building leadership, collaboration at this school was limited to job sharing of planning, except in a few cases where beginning or associate teachers worked together to plan their teaching. A lack of well-documented curriculum and a lack of contribution to planning by experienced teachers added to the workload and stress of early career teachers. They also reported that these colleagues failed to acknowledge their contribution or provide constructive feedback, adding to their disillusionment of the profession.

Whilst there are certainly actions that the leadership could take to develop a more collaborative culture and to improve the well-being of staff their capacity to actually change the employment and working conditions and mix of experienced and novice teachers are constrained by educational policy and school funding.

8.3.2 Other Studies of Retention

Other studies have also drawn attention to the importance of leadership, school culture and school practices on the support for development of and retention of out of field and early career in-field teachers (du Plessis 2015; Johnson et al. 2004; Jorgenson 2012; Quartz et al. 2005; Steyn and du Plessis 2007; Simon and Johnson 2015; Stockard and Lehman 2004; Tamir 2013). Johnson et al. (2004) used survey instruments to conduct research with beginning teachers in both low and high socio-economic schools in the USA. They found that there was a 'support gap' for beginning teachers in low socio-economic schools. Mentoring and support from experienced colleagues were lacking. There was also a lack of well-documented curriculum aligned to state standards that also provided for and supported teacher autonomy in their classroom. The study by Stockard and Lehman (2004) recorded similar results with beginning teachers' decision to stay in the profession related to job satisfaction and support from colleagues and leaders.

Simon and Johnson (2015) conducted an extensive review of research on teacher turn over in low socio-economic schools in the USA. In their analysis, they shifted the lens of analysis from a focus on student and teacher demographics as factors contributing to attrition to a focus on organisational theory and sociology. They found that the school environment contributed to teachers' sense of success and their decision to stay or leave the school. These environmental factors included their working conditions, administrative support and leadership and teacher agency within a supportive, collaborative teacher community. They described schools in low socio-economic communities with high retention of teachers as being 'good places to teach' where there was mutual trust, respect, openness and commitment to student achievement. In schools with good teacher retention outcomes teachers were less likely to be assigned to teach out of field and were provided opportunities and support to improve their teaching, such as peer mentoring, common planning times and well-documented curriculum. The staff at these schools took collective responsibility for improving the outcomes for their students and the leadership promoted the productive exchange of new ideas from beginning teachers and experienced practice of veteran teachers.

8.3.3 Policy Implications for Retention

Whilst the case studies point to various aspects of school organisation and culture as well as out of field teaching as factors contributing to teacher churn, the question is, how is education policy implicated in out of field teaching and teacher churn in low socio-economic and rural secondary schools? Recently, education policy has focused on individual teacher quality, especially regarding qualifications, teacher education accreditation, criteria for entry to teacher education and registration and promotion, and as noted above to teacher professional learning, rather than system, district- or school-level policies and funding (Adamson and Darling-Hammond 2012; Baker and Weber 2016; Simon and Johnson 2015). However, in this era of performativity it is important that 'before policy makers hold practitioners accountable for stabilising the teacher workforce, principals and teachers in high-poverty schools need the tools and time necessary to do that work' (Simon and Johnson 2015, p. 22). This recognition of context enables an important distinction. *Teacher* quality steers the discussion towards individual capability, and this is critical, but it is not the whole story. Aspiring for *teaching* quality points to features of education systems that can be predicted and planned for in order to assist teachers to do their jobs in the best ways they can.

The case study school in rural Australia raises issues, many of which are documented in the international literature as well, and are discussed earlier in the chapter. Before outlining these general policy issues, we rehearse some contextual professional matters that pertain to Australia, for even though the issues cross international boundaries, the circumstances that generate them vary.

In Australia, a large country with a relatively small population, teacher working conditions are a state government responsibility. In the state of Victoria, beginning graduate teachers receive a very small workload adjustment (0.95) and they are provided with a mentor whom they meet with regularly. In the past, beginning teachers were allocated a 0.8 teaching load.

High-performing countries in international studies provide all teachers much more time for planning than schools in Australia, UK or USA (Darling-Hammond and Rothman 2011). In these countries, teachers are expected to meet and collaborate to plan their teaching and to research their practice. One Australian state recently established a program for selected secondary schools with a high number of beginning teachers to provide additional funding to enable a reduced workload for these teachers as well as to provide mentoring and coaching at the school; however, this program did not extend to include teachers teaching out of field for the first time and the workload reduction is minimal (Department of Education, New South Wales 2014).

Without continuity in the teaching team, it is difficult to develop effective curriculum programs and develop and sustain successful teaching practices. The employment contracts in a number of Australian states also contribute to instability of working conditions. Initial employment contracts for graduate teachers are typically short term, a year or less and teachers find that they need to continually apply for short-term contracts. Tenured contracts are rare for early career teachers. As the case study showed without a sense of trust, mutual respect and productive support, teachers will look to other schools or leave the profession. The pervasive use of short-term contracts is pushing principals to keep on trying to employ the 'right' teacher for their school, rather than working to build collective responsibility and the capacity of all teachers at their school.

8.4 Conclusion

The phenomenon of teaching out of field is systematic and distributed across educational jurisdictions and is of recurrent concern to policymakers, parents and school leaders in the fields of mathematics and science, although it occurs in every subject area and every educational phase. As the case of Australia shows, there are specific features of each jurisdiction that would suggest caution on over-generalising causes and solutions because assuming that practices and solutions travel from place to place is a flawed assumption, tempting though it is in our global world (Drake 2015). Community schools in remote rural areas will be different from urban schools in inner cities and teaching out of field will look different in each setting. A clear message emerging from the school case study, as well as misinterpretations of policy, is the level of ignorance within schools of the expertise and experience of the new teachers involved. This is not the fault of any of the protagonists because; in this case study, each is on the receiving end of an allocated workforce about whom no one has very much in the way of say. That individual teachers were prepared to develop curricula to make for a better student experience testifies to the willingness of individuals to have a go, as we know 'having a go' is not uniformly best and evidence-informed practice, especially when the individuals, despite being keen, do not know what they are doing. The case studies of Annie, Rita and Jo in this chapter show how keen and committed individuals are at the mercy of almost random opportunities to develop new skills that are congruent with system needs.

Nonetheless, there are some lessons that can be taken forward. Systematic attention to recruitment and initial teacher education of particular groups of teachers who are currently teaching out of field and recognition of the differentiated preparation needs of these groups is required. The 'brightest and the best' need not be defined solely at a single point in time, currently that time is before they have actually started to prepare as teachers. This means developing at the very least a means of identification of need and the distribution of need. 'Out of field' is insufficient as a definition and lack of data is blocking specific opportunities being provided systematically for different groups of teachers. Some initiatives do address recruitment but fall over in providing ongoing support and development. Teaching is not always for life and so career pathways and succession planning must follow recruitment initiatives, identifying where teachers joining the workforce from other industries can make a significant contribution if only for a few years. Working conditions clearly matter, if there is to be retention of beginning teachers and teachers who are assigned to teach out of field. Given the current difficulties of teacher retention in disadvantaged schools, more appropriate workload reductions for beginning teachers and out-of-field teachers should be recommended policy.

The exposure of school students to out of field teaching should be recognised in terms of socially inequitable consequences of market forces of school autonomy. In Australia, there have been moves towards directing increased funds to low socio-economic, rural and remote schools to address the teaching and learning needs of these schools. But the policy has not been fully implemented, and underfunded disadvantaged schools continue to receive disproportionately low public funds in contrast with high socio-economic private schools who receive disproportionately large sums from the public purse (Lamb et al. 2015).

In education systems, where schools have increased autonomy and responsibility for recruiting and employing teachers, principals in the schools with high turnover spend a lot of time on recruiting and selecting teachers. They are continually reassigning teachers to teach different subjects, including out of field and to teach different year levels, thereby denying experienced teachers the opportunity to reteach the same subject and year level and resulting in fewer opportunities to build and sustain teams within schools to develop a collaborative culture. Darling-Hammond and Sykes (2003) identified the need for programs to protect beginning teachers from being assigned to teach out of field and to provide extended support and professional learning for beginning teachers to address the issue of attrition. Previous policies of particular governments in Australia have provided coaches for networks of schools as well as administrative support for principals in these networks. However, these policies have been short term and not sustained. Schools are expected to appoint their own mentors or coaches without sufficient funds to develop and sustain induction, mentoring or coaching programs for schools with greatest need, that is, low socio-economic and rural and remote schools.

As we have argued, some teaching out of field is inevitable because of the impossibility of preparing all new teachers for the requirements and circumstances of schools. Individuals in schools, from principals to novices, will do as much as they possibly can to ensure that students have teachers teaching them. Many will commit extra time (of their own) to doing their job as well as possible. But 'as well as possible' is not good enough, whilst it remains up to individuals to do the best they can the situation will not improve. Policy regarding the provision of teachers' needs to take account of teaching out of field at a systemic level and to provide professional learning in a strategic manner.

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Chapter 9
The Out-of-Field Teacher in Context: The Impact of the School Context and Environment

Anna E. du Plessis, Linda Hobbs, Julie A. Luft and Colleen Vale

Abstract School environments impact student behaviours and share specific goals, and they develop shared understandings through perceptions and experiences which demonstrate a specific culture in a school community (Shields 2002). Teacher support needs vary, but the adequacy of the support according to teacher needs will strongly influence whether teachers simply cope or manage their out-of-field teaching load. The challenge for out-of-field teachers, then, is how to manage to develop in-depth knowledge of the specific curriculum and how to contribute to planning and evaluating the fit-for-context/fit-for-purpose aspects of the curriculum and the school context. Supporting out-of-field teachers entails an in-depth look at the meaning of out-of-field teaching for enacting a specific curriculum and of the in-school context as a whole, with a specific focus on communication, collaboration and cooperation within the wider school community.

Keywords School environment and context · Professional knowledge School cultures and traditions · Shaping roles · Expertise · Teacher roles Subject-specific nature of teaching · Enactment of the curriculum

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_9

9.1 Introduction: Defining the Teaching and Learning Context

This chapter explores the important role of context in determining the quality and success of a teacher learning to teach a new subject. *Learning and teaching context* is defined as the immediate space in which teaching and learning takes place; *school environment* is defined as the wider space that enhances opportunities for learning and teaching; *school or education community* is seen as the stakeholders engaged in a specific school or education system. The chapter further defines school *culture* as the strong dispositions that represent the ethos or philosophies within specific school environments.

Furman (2002b) defined communities as multidimensional, with an impact on the dynamics of the school and classroom contexts. Context is explored in two ways: the school environment as the immediate context of the teacher, and the broader context of the school community concerning parent and student demographics. The chapter explores the multilayered realities within a school context while focusing on the specific school environment in which out-of-field teachers try to make sense of the phenomenon of teaching across subjects.

Teaching is ultimately a social act and out-of-field teachers[1] are part of their immediate professional and school communities. Redding (1996) defined the different components of a community as social capital which involves human relationships. Being part of a community means that people experience a sense of belonging, trust and safety and the existence of common connections and goals within a specific group (Furman 2002a). Sergiovanni (1992) explained how communities rotate around a centre of norms, values, sentiments, beliefs and structures. These norms and values give the school context a specific climate and culture.

A school community represents the 'home' curriculum, which means a curriculum that aligns with what is important in a specific local or wider education community. For example, the numeracy and literacy across curricula is currently of high importance in the Australian education community. An acknowledged part of this community is teachers who represent the school curriculum. A more recently recognised group are parents who support the work of teachers in their representation of the curriculum, which ultimately supports student learning. Active parents influence the school community that includes school climate and culture (Rosenblatt and Peled 2002). Rosenblatt and Peled claimed that the active involvement of parents affects the attitudes of teachers. When teachers are teaching across specialisations, the support of parents is important for the teachers' success and identity, and in supporting the teacher in cultivating knowledge of the learner and community.

The ways in which school context and its climate or culture, impact out-of-field teachers' success, identity and well-being are explored in this chapter. It reviews previous studies and draws on data from a number of research projects exploring the different experiences and outcomes for out-of-field teachers in different school contexts.

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[1] Out-of-field teachers are teachers who teach subjects or year levels that do not match their specialisations. It is also referred to as non-specialist teaching, or teaching across specialisations (TAS).

The chapter is built around three themes, namely: *school leadership*, including subject leaders and their influence on school culture and out-of-field teachers; *the professional community*, which includes teachers, its traditions and culture and the extent and ways in which out-of-field teachers are supported; and the *school community*, which includes students and parents and their relationship with out-of-field teachers and teaching. In conclusion, we provide key learnings from this analysis of the out-of-field teacher in context that are essential in identifying the need for a complex, multilayered conceptualisation and response to the issue.

9.2 Out-of-Field Teachers and School Leadership

Educational leadership has a major responsibility in the development of positive relationships among school community members. The effective development of positive relationships increases the social capital of a school community. A targeted advance of social capital also has implications for the improvement of both education and the profession, as it affects both students and teachers (Preston 2011). Researchers (du Plessis 2014) have revealed the role school leaders play in creating a specific school environment and culture, and the experiences of teachers within this context. This section begins with an overview of key ideas relating to context construction. It progresses to a discussion about how school leaders' impact the school environment and the out-of-field phenomenon. It concludes with an examination of specific findings from recent studies.

9.2.1 Leadership and School Culture

School leaders have valuable information and play an important role in sharing information to improve the school environment and the context in which out-of-field teachers function (Dubois and Luft 2014). Their impact on school policy (including curriculum and improvement priorities) and staff (school culture and staff professional and personal well-being) needs to be acknowledged.

School leaders pay attention to the development of close professional relationships with out-of-field teachers while following a philosophy of 'growing people' within the school environment and asking 'What do we need to equip you with?' The engagement of leaders in impacting and improving the school environment changes the culture and context in which out-of-field teachers work. The discrepancy between perceptions and real-life experiences in relation to out-of-field teaching has implications for school environments. Du Plessis (2014) showed that school leaders tended to contradict themselves, stating the expectation that 'good' teachers should be able to teach any subject up to the year 10 level, while they also underlined that passion and interest in specific subjects or fields impacted teacher effectiveness. Open communication and interaction about the out-of-field phenomenon within the school community (school leaders, out-of-field teachers and parents) have implications for, (i) the school context community/environment/culture), and (ii) out-of-field teachers. The reality, however, is that the out-of-field phenomenon greatly impacts the dispositions and culture within these contexts, environments and communities.

School leaders further shared perceptions that out-of-field teaching becomes a 'disaster' for the school environment when teachers do not have the required knowledge competencies for the specific discipline, field or subject aligned with the needs within a specific school community in which they teach. One principal claimed that his school did not have incidents linked to teachers teaching outside their field of qualification or expertise, while an out-of-field teacher in this school shared that he was currently on medication as a result of stress within his teaching context and the *situation* in his classroom. In this instance, the school context impacted the teachers' assignment, and then the out-of-field phenomenon impacted the context in which the teachers functioned.

Some principals assign out-of-field subjects to teachers without first discussing the matter with them. This process influences the school context and creates a specific climate within the school environment. Principals' leadership skills, styles, decisions and choices affect teacher attrition. Some principals perceived out-of-field teachers as negative and disengaged, not well enough prepared and not committed to the school environment. Out-of-field teachers, on the other hand, shared how excluded, unsupported and highly stressed they felt. Interview data regarding these teachers also showed that on average, they spent more time on out-of-field subjects than on subjects in their own field.

This research also claimed that the professional school community often perceived teachers in out-of-field placements as temporary staff. School leaders admitted that they would not send 'temporary staff' on expensive professional development sessions because of the financial constraints this would put on the school budget.

A critical point to make is that the expectations of school leaders are that teachers in out-of-field positions will achieve the same outcomes as teachers in positions for which they are fully qualified. Out-of-field teachers feel that school leaders are unaware of their needs and concerns in regards to the school environment and the classroom context. Analysis of the Australian performance in the 2015 Trends in Mathematics and Science Survey (TIMSS) (Thomson et al. 2017) show that there is some indication that the learning outcomes of students of out-of-field teachers can be compromised, although years of teaching experience appeared to be more of a predictor of achievement in mathematics. Both the absence of open communication and school leaders demonstrating delayed actions influence the school environment as a context where out-of-field teachers are able to build trust relationships. It is noteworthy that educational leaders are aware of the importance of communication within the learning and teaching environment (du Plessis 2014).

The context of the teacher extends beyond the classroom, the school and broader school community, to the system within which they operate, and to which they are accountable. As discussed in Chap. 8, at the government system level, policy relating to state teacher standards and competencies, is particularly important for delineating the professional responsibilities of teachers (AITSL 2014).

Both of these levels, the school level and the government policy levels create different school conditions. First, they create the conditions where school administrators need to appoint or assign teachers to teach out-of-field. Second, they also determine the capacity to respond by determining how out-of-field teachers are recognised or supported. This can vary if they are new teachers entering the system, or teachers who are assigned to teach out-of-field.

9.2.2 Different Leadership Practices and Attitudes

Empathy, awareness and understanding displayed by school leaders through transformational leadership styles (Hattie 2009) support dedication and partnerships within the school community. Support is defined as active engagement of leadership to encourage, understand and share the accountability and responsibility in fulfilling quality outcomes (du Plessis 2018/Forthcoming).

Hattie (2009) noted that leaders who effectively focus on moral purposeful support and construct collaborative teaching and learning environments effectively manage complex school and classroom contexts. School cultures play a significant role in supporting students and in engaging parents in their child's learning in the school (Hattie 2009). Effective school environments exhibit two-way, interdependent relationships between teachers and parents and the social resources of the school community.

Du Plessis (2014) has shown that schools which effectively focus on social and interpersonal relationships affect the school community by displaying constructive attitudes and an understanding of specific challenges that out-of-field teachers experience in the school and classroom contexts. Prew (2009) noted that effective school community involvement often has positive and unforeseen impacts on the wider school environment. Principals' engagement in the situations underqualified teachers find themselves can develop into a trust relationship between the principals and these teachers. Trust relationships are the foundation for constructing a positive management model in relation to the out-of-field teaching experience.

Du Plessis' (2014) classroom observations of teachers in schools revealed the importance of support for out-of-field teachers. With targeted support which consisted, for example, of context-conscious professional learning, encouragement and constructive feedback, out-of-field teachers started to see their situation as an opportunity for further career development or a new teaching career direction. Data in this research study further showed that out-of-field teachers are able to explore new fields, subject areas and pedagogies in an environment that encouraged and support novel instruction, as opposed to a continuous critique of their achievements and failures or level of successes (Du Plessis 2018/Forthcoming).

9.3 Out-of-Field Teachers and Their Professional Community

This theme examines the professional community within which a teacher operates, to which they contribute, and with which they interact. Tytler et al. (2011) stated that the discourse, which includes the meaning within communities are more than just teachers in their subject area, other subject areas and other school staff. They also include local professional community members, including parents, community leaders and school council, and members of the wider subject communities, such as subject associations and discipline-based professionals who can support teachers in curriculum development. Tytler et al. found that this tripartite professional community is particularly strong in rural and regional centres where a school is often a central point for the community. They also found, however, that the wider subject communities were the hardest for teachers in rural communities to participate in because of the distances required to find like-minded colleagues. Out-of-field teachers from such schools are at a particular disadvantage when looking to draw on resources from subject associations to which they do not belong. A key message here is that out-of-field teachers are part of a broad professional community, but possibly the most important part of this community is the ‘discourse community’. The impact of the out-of-field experiences aligns with the quality of relationships within school communities and with how the school community perceives and respects the role and work ethic of unsuitably qualified teachers within that community.

9.3.1 Schools as Communities of Practitioners

The school context plays a significant role in determining the climate of support, respect and innovation that is needed by teachers who are having to learn new content and ways to teach it. Some studies have shown that breakdowns in communication can negatively impact on teachers’ feelings of support. In Hattie’s (2009) study, the avoidance of open discussions can become a major barrier in the learning environment. Du Plessis (2014), on the other hand, showed a need for in-depth discussion about out-of-field teaching practices in school contexts. When there is acknowledgement, support, and embracing of the out-of-field phenomenon there is a positive collaborative effort to manage the phenomenon.

Not only a culture of support but also a culture of innovation is needed for teachers who are out of their comfort zone. Teachers who are adaptable can flourish in such environments, but even adaptable, energetic and creative teachers can be thwarted where the expectation in the school community is to perpetuate traditional teaching practices. Cultures focused on efficiency through tried and tested curriculum can make it easy for a teacher to pick up the materials, particularly when the support is for teachers to find out how to link theory and practice or which sections of the curricula/book may be used in class. However, in schools where the challenge has been set for schools to develop new curriculum, out-of-field teachers can be part of this innovation and there is potential for greater feelings of agency, being valued, and potential for leadership opportunities. For example, in a longitudinal study of eight early career teachers, Speldewinde et al. (2017) found that these teachers identified leading or being part of curriculum developments in their out-of-field subjects as ‘opportunities’ for their careers.

9.3.1.1 A Study from Australia: Context Determining Capacity of Teachers to Respond to Out-of-Field Teaching

How a teacher sits in relation to other members of the school and school structures determines the capacity of the teacher to respond to their out-of-field assignment. Also important is the teacher in relation to their own experience and how that experience affords and constrains teachers' ability to adapt, extend and form new identities (Hobbs 2013a). At the 'visible surface' of the classroom is the teacher in relation to their knowledge of the curriculum and expectations of what teachers are expected to know about content and pedagogy. A supportive school environment assists teachers to sit in relation to these complex shifts in role, identity and value commitments.

The study *Teaching Across Subject Boundaries* (TASB) explored how school culture shapes a teacher's understanding and identity when learning to teach a new subject, especially when they have little background in the subject and lack emotional or professional commitment to it. Using case study methodology (Stake 2005), six schools across three Australian states were involved, with each researcher taking responsibility for collecting data and developing a case study for one or two schools. The study involved a programme of research over three years where teachers new to teaching a subject (ranging from one to four teachers per school) were interviewed periodically to reflect on their changing practice, what and how they have learned, and changes in teacher perceptions of themselves in relation to their in-field and out-of-field subjects and as teachers generally. A number of tools were used to support this reflection, including teacher-generated metaphors and graphical representations of their experiences (White and Gunstone 1998, reported in Hobbs et al. 2017). Also, the teachers video-recorded a number of their lessons each year and in interviews reflected on critical incidents where teacher learning was important or where their teacher beliefs associated with teaching the subject were evident. Joint interviews with the teacher and their mentor or 'critical friend' were also conducted each year to understand the support processes at the school. In addition, interviews with the principals and heads of department or other leading teachers were undertaken twice during the three years to understand the context, how it changed, the school and system policy climate as understood by the principal, and the attitudes of leadership to out-of-field teaching.

A preliminary analysis of the effects of context on out-of-field teaching was carried out by the research team. The researchers each identified the critical factors relating to school culture and out-of-field teaching arising from their case study schools. We then reported these preliminary findings back to each school in order to promote conversation about how schools generally are dealing with the issues relating to teaching out-of-field. A summary of some of the key findings relating to school context is provided below.

Teachers were positive and showed improving enjoyment and confidence to teach their out-of-field subject when: they saw their knowledge of curriculum, content and teaching approaches improving; they sought and received support from colleagues; there were productive relationships with colleagues especially where there were mentors; and there were positive outcomes and relationships with their students.

Negative or declining enjoyment and confidence related largely to constant changes in their work environment, in particular changes in: relationships with colleagues, mentors or students in their class that were not always for the better; changes in their roles and responsibilities such as taking on leadership positions that they felt unprepared for; changes in demands on their content knowledge such as regular changes to the subjects, year level or curriculum/syllabus that they were expected to teach; and changes in support by colleagues and mentors that did not match the teachers' changing or continuing needs.

Some tensions that arose for the different schools and leadership included: the priorities for principals can be different across schools, depending on their context (e.g. rural, regional or metropolitan); their length of time at the school and the stability of the school leadership (for example one school had three principals during the three year study). There were clear tensions between appointing teachers who suited the rural lifestyle compared with appointing suitably specialised teachers to fill the required load. Also, there was evidence of principals appointing the 'right' teacher to meet the student needs, for example prioritising relationship building skills over background in a discipline.

A number of other school cultural factors were seen to impact on teachers. Procedural issues such as decisions around timetabling could result in teachers teaching different subjects or year levels each year and therefore having to constantly engage with new content and pedagogies. For instance, one principal in the study identified teacher passion and hobbies as influencing his decisions about inviting teachers to take on new subjects, for example, a science and Information and Computer Technology (ICT) teacher who also made her own clothes was asked to take year 8 textiles, and she was encouraged to incorporate metallic thread into garments and designs, thus bridging a gap between her two in-field areas and the out-of-field area. In contrast, at another school the principal used past results to remove an experienced teacher out of senior chemistry, without consultation with the staff member, so as to provide 'an outstanding student' the best chance of success, thus illustrating how student needs or general school needs were sometimes prioritised over the specific needs and preferences of the teachers.

Another set of factors related to structural arrangements, for example, close proximity to in-field experts in the staffroom increased the opportunity for incidental and just-in-time conversations about teaching and learning in one school. Where teachers were a long way from such experts, they found it more difficult to get the collegiate support they needed.

Leadership expectations relating to professional development, teacher learning and goal setting was also a key factor. All state education systems require teachers to set goals for their own professional development each year. At one school, as part of the professional development expectations, teachers were required to undertake 20 classroom observations throughout the year, ten within and ten outside of their domains or subject. A reduction in teaching allotments allowed for this, and a 'PD slush fund' was well resourced because the principal and assistant principals chose to relieve teachers when absent. This culture of innovation and reflection was recognised by the out-of-field teachers as being valuable for their learning.

Many of these factors relate to teacher agency and where the power lies. Beginning teachers have little agency in determining what and how they teach. But even experienced teachers can feel powerless when decisions are made without consultation or recognition of teachers' professional goals and preferences. Ultimately, teaching out-of-field is disruptive. But the school culture influences the degree of 'edification' or 'destruction' that is associated with this disruption. Disruption can have positive outcomes when there are opportunities for being innovative, learning or identity expansion, but it can be destructive when it results in an erosion of teacher self-efficacy, identity and confidence.

9.3.2 New and Experienced Teachers

The differences between newly hired and experienced teachers have been discussed by many different researchers. Berliner's (1986) seminal article on the development of expertise, highlighted how expert pedagogues had well-developed repertoires upon which to draw. Novices, on the other hand, struggled in instructional settings to adequately support student learning. Consistent with the development of expertise is stage theory, which associates the development of a teacher with the progression of knowledge and skills over time (Rolls and Plauborg 2009). Often varying levels of knowledge and skills are bound by stages such as pre-service, induction, competency building and career exit.

While the notion of novice, expertise and stage theory are agreeable to most scholars, it has recently been challenged by the conceptualization of 'well-started beginners' and 're-novicing'. Well-started beginners are newly hired teachers with limited time in the classroom, yet they perform at levels comparable to an experienced teacher. Avraamidou and Zembal-Saul (2010) depicted the ability of a well-starter beginner in their study of a new teacher in her first year. The teacher excelled in teaching the curriculum and supporting student learning. This was a result of her well-developed instructional ability, and the consistency of teaching context from her pre-service programme to her first years in the classroom. Re-novicing is when experienced teachers are assigned to instructional positions in which they have little experience (Blazer 2015). In the new position, experienced teachers become novices again and struggle with their instruction in ways common to new teachers.

Among these different views of new and experienced teachers, the influence of school context is important. Specifically, when the school context is stable, the knowledge and ability of the teacher can grow. When the school context changes, the knowledge and skills of a teacher are challenged, rendering even the most accomplished teacher returning to novice status. In the midst of the school context, a new teacher can be experienced or an experienced teacher can be new again.

More recent reports about the learning of teachers reinforce this complexity. The authors of the National Academies of Sciences, Engineering, and Medicine (2015) report on teacher learning concluded that experienced teachers become novices again when faced with new curriculum, new schools, or new standards. While they may not struggle to the degree that a 'true novice' might, they are facing changing conditions that may not render them as effective in terms of supporting the learning of students.

9.3.2.1 A Study from the United States: Context Influencing Induction Practices for Beginning Teachers

In the US, novice teachers can be identified as being new to teaching, new to teaching a grade level or new to teaching a content area. In each of these settings, teachers are in the midst of developing their knowledge, attitudes and skills. While there are many factors that can be associated with this newness, one important factor in the sciences pertains to the high turnover of teachers which increases the likelihood that teachers will teach out-of-field (e.g. Ingersoll et al. 2014; Nixon et al. 2017).

With the prevalence of newly hired science teachers in local schools, teacher educators have become concerned with ways to better support them. The initial thought of many teacher educators was that by providing a support system for newly hired science teachers, they would develop their skills as teachers and be successful in the context they were teaching. As a result, induction programmes in the US have proliferated in the last 20 years.

There have been many different views about how to support these newly hired teachers through induction programmes. Some educators have advocated for generalised programmes that can support all teachers, regardless of the content knowledge background or grade level of the teacher. Other educators have advocated for the important role of content knowledge and suggested that induction programmes be developed to bridge pre-service programmes with the first years of teaching (Blömeke et al. 2015; Luft and Patterson 2002). While both approaches targeted newly hired teachers and attended to the contexts in which they were working, one programme emphasised the important role of content knowledge and pedagogical content knowledge in teaching.

In order to understand how these different orientations towards induction programming influenced the learning and teaching of newly hired teachers, Luft et al. (2011) conducted a study of the teachers in these different programmes. The study sought to provide important insights into the impact of professional development programming of newly hired science teachers, and the role of colleagues and school context in the development of beginning teachers. This study has been described in several publications (Luft 2009; Luft et al. 2011, in review), and is summarised below.

The teachers in this study were initially identified as first-year secondary science teachers and came from five different states in the US. The initial pool of teachers was approximately 140, but over the course of 5 years the pool of teachers was reduced to 95 teachers. Most of the participants were female, Caucasian and first-career teachers. Most entered the teaching profession with bachelor degrees and worked at the high school level. Each teacher belonged to one of four different induction groups.

Two of the induction programmes focused on the teaching of science, and they lasted for 2 years. One programme, Alternative Support for Induction Science Teachers (ASIST), involved newly hired teachers who worked in districts in close proximity to universities with teacher educators. The 2-year programme had monthly meetings focused on the current reform of science as inquiry (National Research Council [NRC] 1996). During the second year, a component was added that required teachers analyse their instruction and student work in a lesson study format (Lewis et al. 2006). In order to support the learning of the newly hired teachers, they were visited once a month in their classrooms by project staff. During these visits, the newly hired teachers could co-plan or receive feedback on their teaching. Outside of these scheduled meetings, the project personnel were available for assistance, advice, or collaborative discussions around their current experiences. Over the 2-year period, the emphasis was on having the new teachers build their abilities and understanding about teaching science as inquiry (NRC 1996).

Teachers in the e-mentoring programme, which was also a 2-year science-focused programme, used a web-based system to collaborate with experienced teachers and science educators in institutes of higher education. The nature of the programme allowed a matching of experienced and new teachers who were often from different cities. At the core of the web-based programme were developed modules that focused on specific topics, such as lesson planning in science, or science as inquiry in the laboratory. The experienced and new teachers collaboratively selected and worked through the different modules.

The other two programmes, school district developed programmes and certification while learning to teach programmes, had a general induction programme format. This resulted in the organisers focusing on classroom management, instructional planning and student discipline. The newly hired teachers in these programmes had assigned ‘mentor’ teachers from their schools or in their districts, who were responsible for assisting with the instruction of their content and observing the teachers one to four times a year (if possible). The programmes were different in terms of the origin and oversight of the programme. The school district programmes were organised by school leaders or the school district, and this provided uniformity across the school or district in terms of supporting the newly hired teachers. The certification while learning to teach programme was associated with an alternative teaching certificate, which often meant that the newly hired teachers did not have prior educational training and had some support during their first year of teaching. These teachers may or may not have been out-of-field, and the certificate they were pursuing was general and allowed them to teach all types of science. During the second year, most of the teachers in these programmes typically did not have extensive contact with their mentor teachers.

In order to understand how the newly hired teachers were impacted by these programmes and their community, several forms of data were collected. Semi-structured interviews (Seidman 1998) at the beginning and end of each year focused on the experiences and expectations of the teachers. The practices of teachers were captured in two-way observations of and interviews about their classroom practice. The Collaboratives for Excellence in Teacher Preparation core evaluation classroom observation protocol (CETP-COP), which was developed by Lawrenz et al. (2002) and Appeldoorn (2004), was used two or four times a year to document the type and duration of the instructional activity, the number of students involved and the cognitive load of the activity. Throughout the study, artefacts were collected that pertained to the induction programmes, the types of materials that were provided to the teachers by their mentors, colleagues or through the induction programmes. Artefacts that pertained to classroom instruction were also collected.

The collected data were immense. Three important studies have emerged from this data set that pertain to out-of-field teaching. The first study was by Nixon et al. (2017) exploring the factors that resulted in them teaching out-of-field. This study explored different variables pertaining to out-of-field teaching, including: the number of students in poverty at the school, the degree level of the teacher, if the teacher was a middle or high school teacher, or if the teacher was in a rural or urban school. The analysis of the data showed that once new teachers were assigned out-of-field, they tended to remain out-of-field. Approximately, 64% of all of the teachers taught one class out-of-field over the five year period. Furthermore, teachers in high poverty settings were more likely to teach out-of-field.

In a second study, Dubois and Luft (2014) explored how school conditions influenced the development of teachers. In the US, teachers are often provided a classroom in which to teach, and students move to different classrooms throughout the day. In this study, the teachers did not have an assigned classroom and were expected to travel to a new classroom each hour (as many teachers do in countries other than the US). The teachers in this study relied upon their colleagues for instructional materials and tips. Unfortunately, the teacher who they shared a room with could be either an asset or detrimental in terms of supporting the development of the teacher. In this study, the school culture was considered important, but the micro-culture of the classroom impacted the development of a teacher, especially if he or she was out-of-field.

The final study by Bennet et al. (2018), explored how out-of-field physics teachers navigated their first three years. These teachers ranged from being out-of-field completely to just teaching a class or two in the area of physics. The findings from their study indicated that out-of-field teachers used isolated practices in their classroom, and that they represented their instruction in low-level ways. Often these teachers did not interact extensively with their colleagues, as they were the only teachers in a specific content area.

Collectively, these studies point to the frequency of out-of-field teaching among science teachers, the importance of logistical support for teachers who are out-of-field, and the effect of teaching out-of-field on the instruction of a newly hired science teacher. In each of the instances, out-of-field teaching certainly constrained the pedagogical development of the teachers—even if they had robust skills to begin with. For these teachers, they were true novices, and they were capped in their potential to become experienced teachers with a well-developed repertoire.

9.3.3 The Curriculum as Part of the School Context

The 'lenses' through which school communities view out-of-field teachers and form perceptions of these teachers' background and experiences influence the respect the teachers receive for the expertise they demonstrate as curriculum developers. Interview data (du Plessis 2014) showed that misunderstandings and misconceptions about their specialist knowledge, their expertise, their work ethic and the success they have in effectively enacting a curriculum impact a healthy school context.

Teachers in out-of-field teaching positions admit that they struggle to find the balance between the curriculum of home (which includes student behaviours, background and ethnicity) and the curriculum of school (academic development) when they teach in out-of-field positions. The lack of a sound knowledge base from which they can align the school and home curricula is experienced as a challenge. Schutz (2006) explained that teachers struggle to integrate effective teaching pedagogies in their classrooms when they entertain inaccurate images of their students and families. These inaccurate conceptions also involve images of curriculum expectations. The inexperience in subject areas, fields and year levels creates tension within school communities, and as Darling-Hammond (2010) observed, unsuitably assigned or qualified teachers in certain classrooms create 'inequalities' (p. 328). Imbalances between a teacher's qualifications and the position to which he or she is assigned hinder the development of healthy partnerships between the school context and the home context. For some out-of-field teachers, their focus on the requirements of an unfamiliar subject's curriculum and trying to survive each day influences the development of healthy partnerships. They can feel disconnected from their students' home context, which means awareness of specific learning needs because of background, culture, language challenges and conditions at home.

The enacted curriculum reflects the reality of the classroom context. Enacting the curriculum is what parents see as effective teaching and which becomes the attained curriculum representing the optimum learning opportunities for their children. Du Plessis (2014, 2017) showed that awareness of a lack of expertise, content knowledge or pedagogical content knowledge causes parents to doubt the quality of teaching their children receive. As soon as parents become aware of possible learning and teaching insufficiencies, they can either try to discuss these doubts with school leaders or support their children with extra lessons given by teachers with expertise in the subject area, with significant financial effects. Parents admitted that they felt powerless when the enacted curriculum failed their expectations and impacted students' preparedness for the next phase or level of knowledge construction. The nature and extent of collaborations and enactment of curriculum in the school and classroom contexts prepare students for their future subject choices and final career choices.

9.3.4 Conceptualising the Support Needs of Out-of-Field Teachers

Teachers in out-of-field positions require extra attention and guidance, which increases the pressure and workload on specialist teachers and subject leaders (Du Plessis 2014). Taylor (2000) highlighted the additional strain that supporting out-of-field teachers can have on subject coordinators due to the additional support, mentoring and resources required. It is noteworthy that teachers in out-of-field positions accentuate the fact that they '*would not be able to survive*' without the support of experienced specialist colleagues. Support from within their own school context influences these out-of-field teachers' attitudes concerning their out-of-field teaching situation. Targeted support develops positive sub-communities within the school context, with a significant impact on the school's professional learning culture and climate. For example, subject departments can act as the locus around which secondary teachers gather, collaborate, develop identities and support each other (Siskin 1994; Darby 2009). Positive sub-communities within the school environment tend to enthusiastically work together to reach common goals, which benefits student achievement while it additionally guides out-of-field teachers to develop expertise in a specific curriculum. However, teachers in out-of-field teaching positions clarify that trust, honesty, respect, an understanding of their specific needs and support are key points to encourage them to take risks in an unfamiliar curriculum. Supporting out-of-field teachers entails an in-depth look at the meaning of out-of-field teaching for enacting a specific curriculum and of the in-school context as a whole, with a specific focus on communication, collaboration and cooperation within the wider school community. These aspects are important for all teachers but research (du Plessis 2014) shows that it becomes a specific challenge for teachers teaching outside their fields of qualification and expertise. Beck (2002) asserted that communication between colleagues benefits both teachers and their students.

A concern highlighted by research (Du Plessis 2005, 2010, 2014; Du Plessis et al. 2014) showed that the out-of-field phenomenon greatly influences open communication within the school community. Additional key points in relation to communication are the influence that the out-of-field phenomenon has on openness and honesty in mentoring interactions, in confidence in sharing issues and in collaborating to develop the curriculum. Challenges also include misunderstandings during communication, constrained interaction, principals' reliance on feedback from parents and the total reliance of out-of-field teachers on advice and guidance they receive from teachers they perceive as 'specialists' in the school context. Unsuitably qualified teachers admit that they do not have the content or pedagogical knowledge to know how knowledgeable the teachers that guide them really are, and they further admit that they do not have the 'subject language' to ask curriculum questions with confidence.

Critical to consider here is that in some countries, such as Australia, the majority of out-of-field teaching is done by teachers in their first 2 years of teaching (Weldon 2016). Therefore identifying the support needs of out-of-field teachers intersects with the needs of early career teachers. The section above provides an analysis of this specific time in a teacher's career. For all teachers, understanding the content caused no problems, but all had different support needs in terms of learning how to teach the content: the needs of the experienced primary mathematics specialist (trained as a generalist primary teacher) related to learning to use secondary pedagogies based on textbook delivery of curriculum; the second experienced teacher was teaching vocational mathematics to students of very low mathematical ability so he needed to be supported in selecting appropriate everyday contexts for applying mathematics; and the early career teacher needed support in knowing the best way to support student learning. This analysis also highlighted that the early career teacher was more idiosyncratic in her reflection on the experience of teaching mathematics out-of-field because she had no other reference point. The experienced teachers, however, were able to reflect on their years of experience and identify the real learning opportunities for them in expanding their roles and identities.

9.3.5 Where Do Teachers Get Support?

Cooperation between the members of a school community makes the attainment of instructional goals easier (Redding 1996), for example, an increased level of student engagement, student outcomes and achievements. Schutz (2006) confirmed that loyal and dedicated engagement of school members, within school environments, changed the perceptions of the members towards a representative society with equal opportunities for all students. Du Plessis (2014) has accentuated the fact that out-of-field teachers are cautious in sharing concerns, asking questions or suggesting new ideas in open-subject or year-level meetings. Parents and fellow teachers can play a significant role in the support of out-of-field teachers within the school environment. Noddings (2006) underlined that developing 'education for whole persons' involves social, emotional, ethical and academic contributions (p. 238). Parents and school leaders explain that they place a high value on collaboration in school environments. However, experiences with the out-of-field phenomenon influence these environments (du Plessis 2014) and the specific culture within the school community has an impact on the support parents offer (Berthelsen and Walker 2008) for the school leaders, out-of-field teacher or students in out-of-field teachers' classrooms.

The dire position in which some out-of-field teachers find themselves in relation to extra support is unsettling. Goals and aims within the school context are decided upon by out-of-field teachers, parents, students and colleagues through dialogue, debate and a mindfulness of the diverse individuals in the school context who impact choices and engagements (Mawhinney 2002). Shields (2002) highlighted that communities who respect and explore their differences develop a better understanding of one another. It is noteworthy that Preston (2011) described the prominence of nurturing and trusting networks to unlock the available resources within the school context to benefit teaching and learning quality. Nurturing and trusting networks further impact the stability within classroom contexts, especially when teachers' capacity to achieve collaborative goals and objectives is questioned.

In Du Plessis' (2017) study, principals claimed that they received very little or even no assistance from particular education systems in relation to the capacity building of teachers in out-of-field positions. School leaders also shared that the only option they have is to rely on specialists in a specific area, for example, an accountant in the wider school community, to support and help teachers in subject areas such as business studies, economics or accountancy (Du Plessis 2017). Redding (1996) explained how shared educational values bind students, parents and teachers together. The objective of supporting out-of-field teachers to build their capacity with the aim of 'growing people' and exploring new career directions while leaders take 'care' of these teachers' well-being can make a significant difference to these teachers' effectiveness and their ability to develop confidence and feel valued.

Other research shows that a lack of support is one of the factors that can make a teacher 'feel' out-of-field (Hobbs 2013a, 2015), what Du Plessis (2014) call 'at-homeness'. Hobbs' study of out-of-field teachers in rural and regional schools in Victoria, Australia, identified a number of support mechanisms that teachers drew on (Table 9.1).

Seven categories of support were consolidated into three distinct methods of procurement: supports that were provided to them, those that they sought themselves, and those that they constructed for themselves. Of the seven categories of support, two of them ('processes and people', and 'collegial sharing and discourse') involve relationships between people in the school, and one ('external support') involves relationships with people outside of the school. Three ('professional development', 'personal experiences', and 'personal research') relate more to the teacher as agent and locus of change, and can to some extent be determined by the orientation of the teacher to learning. Only one ('support materials') relates to the disembodied

Table 9.1 Support mechanisms used by out-of-field teachers (as reported in Hobbs 2013a)

Support provision	Sought support	Constructed resources
1. Support materials a. Curriculum and syllabus documents b. Provision of materials c. Textbook 2. Processes and people a. Strong direction, leadership b. Reduced allocation c. Meetings d. Team teaching e. Observing others f. Formalised induction g. Mentors h. Access to principal i. PD in-service (school initiative) j. Coach	3. Professional development a. External (school or self-motivated) b. Further study 4. Collegial sharing and discourse a. Sharing of resources b. Discussion of concepts and teaching ideas (expert others) c. Mentors d. Interschool links, networking 5. External support Family and friends Community resources	6. Personal experiences a. Collecting examples and stories relevant to the topic b. Interests informing curriculum development 7. Personal research a. Mastery of concepts b. Collecting resources c. Construction of resources

curriculum and materials; in some circumstances a teacher may not be provided with anything beyond the state curriculum and syllabus documents, sometimes just the textbook is provided. If the move into a new subject is considered a boundary crossing (Hobbs 2013a), then some of these supports might be seen boundary objects that bridge the gap between the familiar and unfamiliar. Hobbs (2013b) showed that being aware of where the discontinuity lies for teacher, that is where teachers are struggling or challenged, is critical when providing the right kind of support. For example, the support needs of a teacher who does not understand the mathematical concepts are different than a teacher who doesn't know how to effectively use a textbook or identify meaningful contexts for using mathematics.

The support needs can also be influenced by the nature of the subject, and the expectations about teacher collaboration and the culture of innovation, as stated earlier. New curriculum models are coming into schools, such as through a move towards STEM (Education Council 2016), which requires new curriculum and pedagogies that embrace STEM skills and practices and exposes students to twenty-first-century technology and mindsets. Curriculum integration models are being explored (e.g. Hobbs et al. 2018) that may require teachers to teach content outside of their fields of expertise, but it may also involve working with teachers from other subjects to develop multidisciplinary projects. In addition, alternative curriculum and school structure models might have a small group of teachers teaching a number of the subject areas, similar to the generalist teacher model in primary schools. Secondary teachers can be challenged under these circumstances to rethink their role as subject specialists. Also under these circumstances, teacher teams can become very collaborative and draw on each other's expertise and support to gain confidence in teaching the students.

9.4 Out-of-Field Teachers and the Broader School Community

School leaders and subject leaders impact school improvement policies, which include curriculum and teacher placement strategies as well as school culture, staff professional development and personal well-being. However, teachers find it hard to demonstrate dispositions of 'at-homeness' in a specific school context or school community if they have a lack of knowledge about the school community. Teachers who experience a lack of knowledge about the school community or about parents who are culturally different often find it hard to connect with the students and parents, and they view these parents as uninterested in what is happening in the classroom (Berthelsen and Walker 2008). Social experiences which come with out-of-field teaching have a central position in the school community because of the impact they have on teacher/parent, teacher/student and teacher/colleague interaction. Furman (2002b) observed that school contexts are about how members of a particular school community understand social fairness in their daily lives. Social relations form part of the basis of learning, and as Vygotsky (1978) suggested, social interdependence helps the development of new thoughts, positions of trust, value and gratitude to progress in a school and classroom context.

9.4.1 Out-of-Field Teachers and Parents

The social culture in school communities improves when attention is paid to active relationships rather than to structures (Mawhinney 2002). Researchers have shown that school leaders tend to leave parents uninformed about the occurrence of out-of-field situations in the school environment, because they perceive this as the best strategy by which to manage the phenomenon (Du Plessis 2014). Schaps (2009) claimed that teachers have to nurture and guide students in their care to develop effective personal decision-making skills. Schaps also noted that when teachers and school leaders experience difficulties in fulfilling these expectations, members of the school community perceive the school context as lacking enthusiasm and as ineffective. A positive collaboration between schools and parents develops a school context which supports constructive relationships which profit the learning and teaching environment. However, teachers and education leaders tend to focus more on the school context and what happens inside the school, while often disregarding the value of exploring further collaboration possibilities outside the school context (Schutz 2006).

Hattie (2009) discussed the effect of healthy relations between the home and school on effective learning. Underqualified teachers influence relationships within the school community (Darling-Hammond 2010). Close collaboration between school and home enhances harmony between the school and home contexts. Berthelsen and Walker (2008) conducted a study which involved a global rating based on teachers' perceptions about the involvement of parents in school communities. Other research (Du Plessis 2014) also demonstrated that out-of-field teaching practices constrain teacher/parent relationships in the school context because of misconceptions in relation to these practices. These constraints have a follow-on effect on the students, colleagues and leaders.

Darling-Hammond (2010) underlined the important role of 'communal' (p. 65) approaches with a focus on coherence between the school, students, teachers and parents. Parents or colleagues who share experiences or concerns about the out-of-field phenomenon often form sub-communities within the larger school context (Du Plessis 2014). These sub-communities influence the culture and climate within the wider school community. The shared concerns of teachers, as well as parents, and the resulting distress have decisive repercussions for out-of-field teachers' effective functioning in these school communities.

School communities who perceive teachers as professionals who know their subject areas and are in control of the content and their teaching positions demonstrate respect, trust and appreciation. Parents are comfortable in accepting guidance, direction and advice from these teachers if they believe the teachers have expertise in the field. The school shares the responsibility 'in helping parents to understand the language of schooling' (Hattie 2009, p. 33). The school context as a positive learning environment benefits the well-being of all the students in the teaching and learning community (Preston 2011).

9.4.1.1 A Study from Australia and South Africa: Teaching Out-of-Field and the Broader School Community

Awareness of context is imperative (Du Plessis 2018) in strategies, approaches and decisions to confront the challenges out-of-field teaching practices add to the teaching and learning environment in addition to the usual challenges teachers face every day. Du Plessis (2018/Forthcoming) discussed the realities in different contexts such as:

- disconnected leaders and colleagues
- language challenges;
- school leaders not supported by employers, education systems;
- large student cohorts;
- diverse student cohorts;
- access to resources;
- professional support, learning and development opportunities;
- informed school environments, communities and education systems;
- database and evidence available about the out-of-field phenomenon.

The reality within school contexts that are greatly exposed to the out-of-field phenomenon is that the possibility of a teacher being assigned to out-of-field positions increases, while the opportunity for support from teachers with expertise in a specific field decreases. The school budget influences school leaders' decisions within certain contexts. Redding (1998) confirmed that engagement within the school community is influenced by socio-economic environments. Furman (2002a) also suggested that effectiveness within a school community is embedded in an inclusive partnership founded on trust, on feelings of belongingness and on finding emotional security through open and honest communication.

Principals acknowledge that out-of-field teachers often have to face hostile teaching environments. Out-of-field teachers, especially beginning teachers assigned to out-of-field teaching positions, experience dispositions from colleagues and parents that are often perceived as hostile, critical and confronting (Du Plessis 2014). Rosenblatt and Peled (2002) highlighted the ripple effects of relationships among school community members and how these effects influence the moral climate and atmosphere of an entire school environment. Du Plessis (2014) showed how the out-of-field experience influences communication and trust relationships in classroom contexts. Closely connected to trust is the quality of open communication in dealing with tension that develops within the school context and the classroom context. The trust culture within a school community influences social relationships related to the school and classroom contexts. Understanding the social interdependence of the school and classroom contexts and the community culture can guide awareness of the impact out-of-field teachers have on the harmony and attitudes in the school environment. A deputy principal underlined the importance of ensuring '*the right people surrounding you*' within the school and classroom context.

Vygotsky (1978) drew attention to knowledge construction as a social practice, and this is fundamental in understanding the implications of out-of-field experiences for the healthy social interdependence which is vital in the school environment. Parents place a high value on professionalism, respect and trust within the classroom context, emphasising the value of '*friendly, caring, nurturing*' teachers as experts in their classrooms. The creation of a caring learning environment entails knowledgeable teachers with skills to 'listen to students', while an 'insurmountable accumulation of ignorance' (Noddings 2006, p. 239) by teachers leads to anxiety in students and parents, with implications for a healthy learning and teaching environment. Actively involved school communities sustain schools and thrive on openness about school communities' efforts to support the development and production of a competent future workforce (Sanders 2003).

These teachers mention that parents often should make them aware of subject issues the students experience. Although parental participation at home and in the school context improves learning outcomes for students (Berthelsen and Walker 2008), parents want the teacher to be the expert; the parents must feel comfortable that the school is in control in order to fully engage in the school context. Research data (Du Plessis 2014) showed that parents' openness in supporting teachers assigned to out-of-field positions greatly depended on these teachers' attitudes. Parents further admitted that teachers assigned to positions for which they were unsuitably qualified increased the complexities within an already multifaceted social, school and classroom context with dispositions that often impacted the support climate and culture. Support in developing specific content knowledge and pedagogies to cope with out-of-field subject areas and year levels entails that school communities need to reflect and reassess the depth of skills and knowledge which are accessible.

Parents affirm that they do not want their children to be placed in certain teachers' classrooms, and they admit that this decision is related to perceptions that the teacher is not knowledgeable or is not a specialist in the specific field, subject or year level. Parents also admit that they would consider moving their children to another school because of perceptions in the school community about out-of-field teachers. Some parents have indicated that they would not approach an out-of-field teacher if prior incidents have been experienced as negative interactions, because of a 'block' that developed. This 'block' is trust-related, embedded in feelings of frustration and in misunderstandings in the school community. Furman (2002c) argued that creating an effective school environment involves the loyalty and dedication of teachers and leaders. Parents' perceptions of the school and classroom contexts are deeply embedded in their perceptions of the teacher as a specialist, a community leader and a professional expert in his or her subject area or in the position the teacher holds.

In school communities where limiting effects are experienced, the teacher's role in this context becomes vital to sustaining quality education for students in challenging contexts such as out-of-field teaching practices. Support from the educational leadership to ensure that out-of-field teachers in this community context have opportunities to enhance their content knowledge, their pedagogical content knowledge and their pedagogical knowledge has major implications for the school environment and success in the classroom context. Furman (2002b) described communities with challenging social circumstances as multidimensional, involving actions, structures and specific moral values; these aspects influence the dynamics of the community and need to be respected, understood and appreciated by knowledgeable teachers.

9.5 Conclusion

In this chapter, we have explored the relationship between context and the experience of teaching out-of-field. School environments bind people together through a central purpose, aiming to reach shared goals, values and ideas (Redding 1996). Both the school and classroom contexts influence how teachers in out-of-field positions cope with their teaching situations. Conversely, out-of-field teachers have a major impact on the school context and classroom environments. Of concern is when teachers in out-of-field teaching positions are more self-focused and less school context- or classroom context-focused, which often leads to misconceptions and misunderstandings of needs that develop because of the out-of-field phenomenon. The implications which the out-of-field phenomenon have for the school environment should not be underestimated. Darling-Hammond (2010) stated that 'untrained, inexperienced and temporary teachers' influence the teaching and learning, while they create an environment where 'students do not experience a right to learn' (p. 22). The evidence from the studies presented in this chapter underlines three key messages relating to teachers and their contexts.

The first message is that there is a need for a culture of recognition of the broad-reaching effects of out-of-field on all members of the school community. Teachers teaching outside their fields of expertise often experience feelings of disengagement from the school community as well as isolation, causing them to critically reflect on how their out-of-field position is understood within their school context and in the wider school community. Notably, Zedan (2011) claimed that active parental engagement in improvement strategies for school communities is expected to improve the quality of education through criticism and supervision, with the parents as clients of the school. However, the out-of-field classroom context is a fragile and vulnerable environment where continuous criticism without contextual support has the potential to stimulate conflict, especially when out-of-field teachers feel exposed and unsupported in the context in which they function. Rosenblatt and Peled (2002) emphasised the delicate situation that can develop when conflict-based engagements coexist with the cooperation-based contributions of parents. The reality within the classroom context is that teachers in out-of-field positions often feel defenceless and threatened by parents' critical analyses and enquiries. Berthelsen and Walker (2008) suggested professional development programmes to assist teachers to effectively engage parents in the school and classroom contexts to optimise the potential of their support. Redding (1996) suggested that school environments are built around shared community values and described parents as '*powerful contributors*' (p. 134) within the school context.

Studies (Du Plessis 2005, 2014, 2017) showed how the management of out-of-field teaching challenges in the school and classroom context by school leaders greatly impact positive outcomes for out-of-field teachers.

The second message is that there is a need for a culture of support for out-of-field and new teachers. To be effective a culture of support needs to recognise and respond to the specific learning needs of teachers in out-of-field positions. A common assumption is that out-of-field teachers lack the content and pedagogical knowledge, and that through professional development or retraining these deficits can be attended to (Productivity Commission 2017). To support teacher learning, teachers may be provided with, seek out, or construct support mechanisms. While we have indicated that demands on other school members may be debilitating, where there exists a culture of support, sharing and collegiality with the school, the demands may be reciprocated such that all may benefit from sharing, rather than the flow of knowledge going only to the out-of-field teacher. School leadership practices that acknowledge and create this type of collegiate environment may, for example, be thoughtful in where staffrooms are located to enable incidental interaction between teachers, encourage distributed leadership so that the burden of support does not fall on one person, and promote a culture that normalises peer observation, reflection and collaboration.

*The third mes*sage is that there needs to be a culture of respect for teachers, what they know and what they can do. From the outset, there should be appreciation that it is actually quite difficult to teach out-of-field. Also, teachers should be accorded some agency in their allocations, or at least consulted as to their perceived levels of confidence and competence, and their support needs identified. While there exists a degree of 'sameness' (Hobbs 2013b) in a teacher's job in that teachers work with curriculum, must set and meet goals for learning, and must have knowledge of and care for learners, it is important to recognise and respect the subject-specific demands of teaching, particularly in a secondary school. Teacher knowledge is complex (Shulman 1986) and borne from experience before and during teaching. Respect for knowledge related to teaching content was part of Shulman's rationale for re-positioning subject matter knowledge (as pedagogical content knowledge) in discussions about what teachers know. Knowledge is important, as are teachers' attitudes towards what they are teaching, and their orientation as teacher learners. These knowledge, attitudes and orientations need to be respected during the teacher allocation process, during the appointment of staff to positions, and when establishing sub-communities within the school.

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Chapter 10
Initial Teacher Education: Roles and Possibilities for Preparing Capable Teachers

Coral Campbell, Raphaela Porsch and Linda Hobbs

Abstract This chapter explores the role of initial teacher education in preparing teachers who can rise to the challenge of teaching out-of-field. While some teachers manage the transition into a new subject well, others can struggle to the point of exiting from teaching all together. Early career teachers are in particular danger of feeling the negative effects of teaching out-of-field as they are more likely than their experienced colleagues to teach out-of-field. However, the journey of a teacher begins before they assume their first teaching position. Initial teacher education is a foundational time for teachers as they begin to develop their teaching identity as they gain an understanding of what it means to be a teacher. This includes their appreciation of the likelihood of having to teach out-of-field, which, in many Australian and German schools, has become a commonly accepted practice. While teacher education programmes are not required to prepare teachers to teach out-of-field, they do have the challenge of preparing well-informed, capable teachers. Critical to our understanding of how to approach out-of-field teaching in initial teacher education is identifying the types of activities and actions that can be used to ensure teachers are adequately prepared for the challenge of teaching out-of-field. This chapter will draw on studies from Germany and Australia and explore the different situations of pre-service teachers with regard to their preparedness of teaching out-of-field during their initial teaching education. The chapter closes with thoughts about the degree to which, and in what ways, teachers can be 'prepared' for teaching subjects for which they have no background.

Keywords Out-of-field teaching · Initial teacher education · Germany · Australia

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10.1 Introduction

Teacher education programmes and the teacher workforce are national concerns for every country in the world. To ensure the preparation of effective teachers, various groups such as teacher regulatory bodies, teacher education providers (universities or teacher colleges), teacher employers and other representative groups collaborate to provide guidance to pre-service and beginning teachers. There is a compelling need to better understand initial teacher education programmes and the outcomes for pre-service educators about to enter the teaching workforce. Research has identified that a lack of consistent and timely data, at least in Australia, ‘hinders both continuous improvement in initial teacher education and workforce planning’ (Teacher Education Ministerial Advisory Group [TEMAG] 2014).

Initial Teacher Education preparation programmes attract students from a wide range of backgrounds and experiences. Many students come directly from a formal secondary education, while others may have undertaken paid employment prior to attending initial teacher education. A small but significant group undertake initial teacher education after completing prior qualifications and significant work experience. Different programme structures cater for both the various needs of the students, but also perceived government and societal needs. Overall, there are different qualification types, levels, study foci and types of attendance. In some countries, such as Australia, there has been a growth in the number of courses that offer distance and online learning as a large component of their course, and this has attracted an increase in student numbers into this mixed mode of delivery and learning (Australian Institute of Teaching and School Leadership [AITSL] 2017, p. 28).

All initial teacher education systems have to adhere to strong guidelines through regulatory bodies and the courses need to develop pre-service teachers’ capabilities and knowledge along a number of important areas. Teacher professional standards or competencies are a common focus. In secondary teaching, initial teacher education courses focus on teaching methodology as well as discipline knowledge in a specialist area.

As a result of this emphasis on specializations, little analysis has been undertaken on how the phenomenon of teaching out-of-field is attended to in initial teacher education programmes. This is partly because teaching out-of-field in not always prevalent in a country’s teaching force. In some countries, the design of teacher allocation into schools precludes the situation of a teacher being out-of-field. For example, some teaching authorities allocate teachers to schools based on their teaching expertise and these teachers only teach subjects for which they are qualified (Hobbs 2013). An example for the Australian context might be that someone with a mathematics undergraduate degree, with a minor strand in information and communication technology (ICT), and a secondary teaching qualification, would only teach mathematics to senior levels and ICT to year 10 (15–16 year olds).

However, where teaching out-of-field exists, the opportunity to consider the role of initial teacher education in attending to this issue, or how initial teacher education has contributed to its occurrence, has not been strongly pursued. In this chapter, two questions are addressed: (1) How do the education systems of Australia and Germany contribute to needing out-of-field teachers? (2) How might initial teacher education prepare teachers for out-of-field teaching? The teaching profession worldwide is subject to some forms of professional standards for teachers; these are called into question when teachers are required to teach out-of-field. Our starting point therefore is to examine this assumption that graduating teachers have a set of knowledge and skills when they enter teaching and as they advance in their teaching career.

10.2 Professional Standards of Teaching and Out-of-Field Teaching

Every teaching jurisdiction has professional standards for teachers that guide teachers' practice inside and outside the classroom across a range of proficiencies or competencies. In the design of initial teacher education programmes, universities and educational institutions need to consider how they can meet these standards for beginning teachers. Working backwards from the standards, initial teacher education providers ensure that across the extent of the course, pre-service teachers are provided with the opportunity to develop competence in all professional standards. For example, in the United Kingdom, The Teachers' Standards must be used by initial teacher education providers to assess when pre-service teachers can be recommended for qualified teacher status (Department of Education, UK 2011).

It is not surprising that most of the sets of professional standards from around the world are very similar. They all include requirements for:

- Knowledge of school curricula, assessment and teaching strategies.
- Knowledge of how to teach specific subjects.
- Classroom teaching/management skills.
- Professional skills related to working with others.

The first three standards conflict with being assigned to teach out-of-field. Curricula, instructional strategies and management all relate to the content one is teaching. All registration authorities have included some mention of subject content knowledge in their professional standards. Similarly, various professional associations support the need for high levels of subject knowledge to be evident in their documentation.

A review of various the professional standards for teachers from various countries indicated that teaching out-of-field is not recognized within the documentation. Without this explicit reference to out-of-field teaching, and the requirements of teachers to adjust their teaching practice to accommodate this, initial teacher education providers in general are not required to attend to this within their courses. Importantly, while all teachers are meant to be accountable to these standards, it is unlikely that teachers who teach out-of-field will be held responsible for their teaching in these areas.

10.2.1 Implications for Out-of-Field Teaching

If out-of-field teaching is not acknowledged within policy documents or by teacher professional standards, initial teacher education courses, which must align with both, are not addressing the needs of beginning teachers within their courses. Research by Hobbs and Campbell (2014) indicated that initial teacher education course directors did not construct their courses with teaching out-of-field in mind. One course director even commented, ‘It’s not our job to prepare them for teaching out-of-field’.

Research suggests that teaching, in particular for those in the early stages of their career, is very stressful (Thomson and McIntyre 2013; AITSL 2017). Not only do beginning teachers have to navigate the social and cultural expectations of their work environment, but also they have to manage the teaching workload and professional expectations. There is a significant trend highlighting that these first few years are crucial for the retention of teachers within the profession. A recent study in Australia (AITSL 2017, p. xv) indicated that 15% early career teachers (those in their first 2 years of commencing teaching) were considering that ‘they would leave teaching within one to five years’. A further 4% had intentions to leave within the first 10 years.

If you then add into this mix the various components of teaching, such as curriculum development and delivery, classroom management, student support, collegiality and support, the reasons for the retention or attrition of teachers in the profession become complex. Recent research literature (Gallant and Riley 2014; Howes and Goodman-Delahunty 2015) suggests that the most common reasons for teachers to leave relate to a high workload, lack of support from leadership and insufficient recognition and reward. Similar results are indicated for the United States, where 35% of teachers who leave teaching do so due to job dissatisfaction (Ingersoll and May 2011). In Australia, up to half of early career teachers were reported to have received some form of support in terms of induction, but of those, only two-thirds felt that it was beneficial (AITSL 2017, p. 98). This is despite there being policy provision for resources to be made available to support beginning teachers. It would appear that often early career teachers do not receive the support they need to navigate the complex world of teaching. Even prior to starting as a teacher, PSTs who leave initial teacher education course cite health and stress as the most common reason for leaving and education students are significantly higher in the number leaving for this reason, when compared to the attrition of other higher education students (AITSL 2017). These stressors for beginning teachers have serious implications for teachers who are required to teach out-of-field. Teachers in this situation are likely to have substantially greater workloads associated with learning new content and pedagogies; high workloads is one of the most cited reasons for leaving a teaching profession. This adds to their stress, which is often higher than for other occupations, and little relief is provided without significant support from the leadership team and other colleagues.

Thus, the reality is that beginning teachers often find themselves teaching out-of-field, and therefore experiencing the additional strain associated with learning to teach a new subject. Research has shown that this process involves more than simply learning new content, but also involves implications for teacher identity, self-efficacy, commitments and sense of belonging (Bosse and Törner 2013; Hobbs 2013; du Plessis 2014). The question is, how might universities play a role in preparing teachers for this reality? Case studies from Australia and Germany are provided to analyse how the initial teacher education system in each country contributes to the conditions that lead to out-of-field teaching. Each case study beginning with an overview of the teacher education system, followed by a description of the professional standards, how subject specialization is determined and how pedagogy is attended to. Some preliminary data from current research studies from each country is then used to show the preparedness of teachers to teach out-of-field field.

10.3 The Case of Australia

Drawing on research within Australia, this section explores the different situations of pre-service teachers with regard to their preparedness of teaching out-of-field during their initial teacher education.

10.3.1 Overview of Teacher Education in Australia

In Australia, there are approximately 373 accredited teacher education programmes offered by 48 providers (universities and other educational institutions) at 85 different locations across the continent (AITSL 2017). These include programmes aimed to accredit teachers in preschool, primary and secondary education.

Apart from the initial teacher education programmes, each state or territory in Australia has its own teacher accreditation board, which is involved in the initial course accreditation process and also the teacher qualification accreditation process. All initial teacher education courses are accredited for a period of 5 years and must undergo an extensive review process with the accreditation body at the end of the period to reapply for continuing accreditation.

Initial teacher education courses present in two main formats. The first is a 4-year undergraduate degree in education. Most early childhood and primary teaching courses provide a generalist cover of education, without a specific specialism. However, others may offer a major or sub-major in a particular teaching area or expertise. This is particularly relevant for a 4-year secondary teaching qualification. There is a recent move in Australia to incorporate ‘specialisms’ to the bachelor’s degree for primary education, where students complete a minor (four units) in their selected specialism.

The other main structure used for an initial teacher education course is a 2-year masters’ level course. This typically employs a generalist approach to supplement the detailed expertise gained through the preliminary undergraduate degree in a specialized field. However, some masters' programmes also offer education specialist strands consisting of 25% of the course content to add depth and breadth to previous knowledge of the pre-service teacher.

This masters' level qualification has been a requirement since about 2015 when AITSL, under direction from TEMAG, increased the level of qualification needed for teaching from a graduate diploma to a masters' level. Teachers graduating prior to this time will have either a graduate diploma (1 or 2 years), bachelor's degree (4 or 5 years) or masters' (2 years) level degrees.

During the time that they are undertaking their initial teacher education programme, pre-service teachers are required to spend time in schools, in order to gain practical experience of teaching under the mentorship of a classroom teacher. This requires them to become proficient with the standards for beginning teachers, learning not just the teaching strategies but also other aspects of professionalism.

Specialization of teachers is determined at the point of entry to an initial teacher education programme, not at graduation. These requirements are determined at the state and territory level as well as the national level, depending on the accreditation of the initial teacher education programme (see, for example, the Specialist Area Guidelines from the Victorian Institute for Teaching [VIT 2015]). An incoming student must show that they have the required qualification—major or minor in the discipline—to undertake one of the specializations on offer at that institution. Sometimes recognition of prior learning, such as professional experience as a carpenter for 20 years, may be considered suitable for meeting the entry requirements for a Technology teacher.

In Australia, there is no subject-related state exam required for teachers to complete before gaining registration as teachers of those subjects. However, a new literacy and numeracy test has been imposed on all PSTs that must be satisfactorily completed prior to teacher registration, to ensure 'that all graduates of initial teacher education meet the Australian Professional Standards for Teachers at the Graduate career stage' (AITSL 2018).

Only the state of New South Wales registers their teachers with 'approval to teach' meaning that according to their registration body, they have met the requirements to teach in the specified subject areas. All other states and territories register their teachers as 'teachers' without record of year levels, school types or specializations. Principals then have full discretion, across Australia, as to whether a teacher is 'suitable' for a position, and this suitability may or may not relate to their specialization. This failure to record teachers' specialization (Doecke et al. 2013) has resulted in a lack of available data to inform targeted governmental response to the high incidences of out-of-field teaching in some subject areas, but also difficulty in establishing who is teaching what and who is in-field and out-of-field. In particular, such data could inform intakes of students into teacher education programmes, and the provision of appropriate funding for requalification opportunities (extended professional learning or postgraduate qualifications) in the worst affected subjects. These large system issues are important when considering how initial teacher education can play a role in attending to the issues around this phenomenon, whether it is through the recruitment of more teachers in certain areas, as well as being part of a system that recognizes that teachers' specializations matter if the teaching standards are to be maintained, especially the expectation that teachers will know the subject knowledge and how to teach it.

In Australia, over the years, there have been many significant initiatives to address the disproportionate balance of teachers across subject areas and across rural and regional areas. One such scheme related to the provision of scholarships for those prepared to teach in: hard to staff subject areas; hard to staff schools; hard to staff rural areas; priority schools; growth areas; and minority schools. Despite opportunities for increasing mathematics and science graduates into teaching, not all mathematics scholarships were taken up and most of the science scholarship holders ended up teaching in metropolitan schools (Doecke et al. 2013). Other schemes included the fast tracking of graduates through an initial teacher education course and involved a paid internship for participants, linked with mentoring. However, the latest reports from the Australian Council for Educational Research (ACER) (Weldon 2015) and Australian Institute for Teaching and School Leadership (2017) indicate very little change in this situation.

10.3.2 Professional Standards of Teaching in Australia

Australia has seven Professional Standards for Teachers that identify what teachers should know and be able to do as practising teachers. These standards are:

1. Know students and how they learn.
2. Know the content and how to teach it.
3. Plan for and implement effective teaching and learning.
4. Create and maintain supportive and safe learning environments.
5. Assess, provide feedback and report on student learning.
6. Engage in professional learning.
7. Engage professionally with colleagues, parents/carers and the community.

The standards are grouped into three main areas: professional knowledge, professional practice and professional engagement. Obviously, these areas are overlapping as teachers draw on all three in their practice.

According to AITSL (2011, p. 2),

> The Australian Professional Standards for Teachers are a public statement of what constitutes teacher quality. They define the work of teachers and make explicit the elements of high-quality, effective teaching in 21st century schools that will improve educational outcomes for students. The Standards do this by providing a framework which makes clear the knowledge, practice and professional engagement required across teachers' careers. They present a common understanding and language for discourse between teachers, teacher educators, teacher organisations, professional associations and the public.

Within the professional standards, four levels of career stages are detailed: graduate teacher, proficient teacher, highly accomplished teacher and lead teacher. These four stages recognize the developing complexity of teacher practice and the developing professional expertise—from beginning teaching through to being a leading teacher in the field. The initial Graduate standard is the focus of the accreditation of initial teacher education programmes, which must demonstrate the inclusion of graduate standards within their programmes. On successful completion of their initial teacher education programme, graduate teachers should possess the requisite capabilities, knowledge and skills as indicated in the graduate standards. During their teaching career, teachers will be measured against these standards, including when teaching out-of-field.

10.3.3 Subject Specialization in Teacher Education

In Australia, pre-service teachers undertaking a secondary teacher programme have to specialize. This generally requires that they undertake an undergraduate degree with a major and sub-major in a specialist area, or they undertake a masters' level degree, where their specialization comes from their prior degree. Some programmes offer preparation for primary and secondary levels, such as through Foundation to year 9 or 10. During the teacher education programme, the disciplinary content knowledge is assumed, and curriculum area units tend to focus on pedagogy and curriculum rather than attending to content knowledge.

At the preschool and primary school levels, teachers are considered generalist educators and their initial teacher education programme reflects that role. In Australia, the focus on out-of-field teaching is generally placed on secondary schooling because the preparation of primary teachers incorporates units relating to all of the subjects offered in primary school. That is they are prepared as generalists. In the preschool system, however, there is no set curriculum, although the Australian Early Years Learning Framework (Department of Education 2009) does set out specific guidelines around learning across five learning outcomes, although only one actually mentions cognitive learning: 'Children are confident and involved learners' (p. 8). There is a recognition that early literacy and numeracy form part of that learning, but nothing is really subscribed for the common curriculum areas, which are evident in other teacher education curricula documents. Most initial teacher education programmes do, however, attempt to address the requirement for pre-service teachers in early childhood to understand the content and teaching pedagogies related to maths (more than just numeracy), science, STEM and humanities.

Despite primary teachers being prepared as generalists, the idea of specialist knowledge, or at least more in-depth knowledge, in mathematics, science and languages other than English, has started to achieve traction in the last few years. However, the uptake of the offers into the areas of mathematics, science or STEM as specialist areas is not strong. This is not surprising, given that most pre-service teachers in primary courses come from a humanities rather than a science or maths background. With fewer than 20% of students in secondary schools finishing with a strong science or maths background, this is not surprising. During their 4-year course, pre-service teachers will engage in units of study, which prepare them to teach the discipline areas of mathematics, English, the humanities, science, technologies, the arts, languages and health and physical education. Often the discipline units in a primary education course are taught by discipline experts with little or no teaching background. The content can become isolated from the teaching context. The pedagogical units of the primary teaching courses, now often contain some content knowledge in the recognition that PSTS need greater understanding of both content and strategies to engage students in learning.

10.3.4 Pedagogical Preparation in Teacher Education

In Australia, for secondary school teaching courses, 'methods' teaching (subject-specific pedagogy) is taught along with subject content. While there are other education subjects that target general classroom pedagogy, such as classroom management, engagement of students, understanding learners' needs, the importance of subject-specific pedagogy is acknowledged for enhancing teaching capability and improving student learning outcomes (AITSL 2011). In many initial teacher education courses, the discipline content is taught by lecturers and tutors from other faculties without a background in teaching. The discipline knowledge taught is rarely linked to the curriculum focus in schools, so the 'methods' units translate the knowledge to workable aspects for a school focus and introduce the pedagogies needed to teach the subject matter. The Table 10.1 indicates some common initial teacher education programme structures, although it should be noted that in Australia competition for students is strong, so each course or programme attempts to differentiate themselves from others through different structures.

10.3.5 Teacher Preparedness for Teaching Out-of-Field

While secondary pre-service teacher education programmes prepare teachers for certain specializations, the reality is that many teachers will be expected to teach out-of-field, especially in Australia (Marginson et al. 2013). In primary or preschool teaching, those without a strong background in any one of the subscribed curriculum

Table 10.1 Some initial teacher education degree options in Australia

BArts/B. Teach BScience/B. Teach	4 years	Year 1 discipline studies	Year 2 discipline studies	Year 3 general pedagogy	Year 4 discipline methods focus
M. Teach	2 years	Year 1 general pedagogy		Year 2 discipline methods focus	

areas will feel inadequately prepared to teach it, although the label of out-of-field is not generally ascribed to the generalist teacher in Australia. Despite this, studies of beginning and in-service teachers (primary and preschool) have found that many lack confidence in teaching science and mathematics and often request further professional learning (Campbell and Chittleborough 2014; Campbell et al. 2018). It is difficult to provide evidence that this is affecting primary students' overall results, other than to say that international measures such as the Trends in Mathematics and Science Survey (TIMSS) and Programme for International Student Assessment (PISA) have shown little improvement over the years, despite a stronger focus on mathematics and science in the curriculum.

Alarmingly, in secondary schools, unfilled science and mathematics positions are very often filled by out-of-field teachers. A recent report by the Australian Council for Educational Research (Weldon 2016, p. 1) highlighted that '26% of teachers at Years 7–10 are teaching a subject in which they have not specialised as part of their teaching load, as are about 15 per cent of teachers at Years 11–12' (see Fig. 10.1). These figures increase as specific categories are considered: early career teaching, schools in rural areas and schools deemed as having students from low socio-economic backgrounds.

In a pilot study undertaken in 2013 called *Teaching out-of-field: Preparing Adaptable Teachers* (*TOPAT*), a team of Deakin researchers investigated the role of universities in preparing teachers to teach out-of-field. Using a PST survey and interviews with PSTs and teacher educators, the project investigated two components: how the structure and content of secondary pre-service teacher education programmes supported the development of teacher-ready, adaptable teachers and how the pre-service

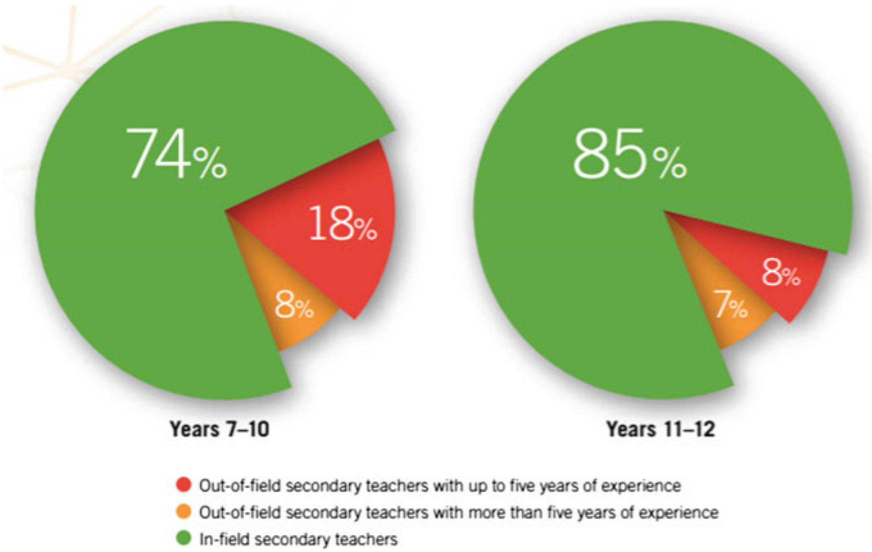

Fig. 10.1 Proportions of teachers of years 7–10 and years 11–12 teaching out-of-field, at least some of the time. (Weldon 2016, p. 8)

teachers responded to the potential challenge of teaching out-of-field. A small PST survey sample and PST interviews have shown (Hobbs and Campbell 2015) that the PSTs were aware of the potential of out-of-field teaching in their teaching career. There was general positivity towards this practice around the opportunities that can emerge, with PSTs discussing the opportunities for new learning, extension of teaching strategies and becoming more employable. However, this was also predicated on the expectation of support from within the school and the PSTs' capacity to deal with unknown challenges. The evidence also suggested that their commitment to various elements of teaching was less likely to be influenced simply because they were teaching out-of-field. This is a positive finding as it shows, at least at a philosophical level, that these PSTs considered their roles within their teaching career would not be totally restricted to their specializations, suggesting flexibility at least in their dispositions as learners.

This research has messages for teacher education in ensuring that pre-service teachers are exposed to a range of supports that may be needed to make them less apprehensive about their first years in teaching. The relatively high proportion of respondents indicating the need of support highlights a need for the teacher education courses to promote team and collegial support as an important part of teaching, particularly in the beginning years of teaching. While the provision of support cannot replace re-specializing in a new specialism, support is very important in determining a teacher's capacity to cope, adapt and learn when crossing boundaries between in-field and out-of-field teaching spaces (Du Plessis 2014).

The fundamental question is, 'What roles do universities play in preparing teachers to teach out-of-field?' Further data analysis from the TOPAT project, initially presented as Hobbs and Campbell (2014) showed that teacher educators pointed to the tension between, on the one hand, preparing their students for the reality of teaching where they would likely teach out-of-field, and on the other hand, a tightly regulated teacher education system where their courses were accredited to offer specializations and general education. Interviews with 16 teacher educators, two placement officers, and seven teaching course/programme coordinators, showed that there were differences in how the interviewees positioned initial teacher education. This positioning depended on their perceptions of what it means to be an effective teacher and their response to tensions between 'a teacher first then a subject teacher', the fundamental role of subject and pedagogical content knowledge, and what is possible within their programme structure.

Another tension was between the subject matter knowledge and general teacher knowledge that their students will need, with some teacher educators preferring to focus on the fluidity of teacher knowledge and the need to be flexible: 'a teacher first and foremost, and teacher of a discipline second, I think that we have to be really careful that we have the potential to step outside our disciplines' (Jodie, teacher educator: Hobbs and Campbell 2014). Others maintained the importance of the 'epistemic values of the discipline' and the need to maintain subject boundaries because 'there is an element that is specific to the discipline that I don't believe you can achieve unless you actually explore that discipline' (Mandy, teacher educator; Hobbs and Campbell 2014). The first view centres on generic teacher knowledge as being the main remit of initial teacher education, the second view centres on the subject-specific nature of teaching.

So, while teacher educators may recognize the reality that their students are likely to teach out-of-field, and that there is a greater need to raise awareness and possibility of future out-of-field teaching, how this might be achieved remains an important question for initial teacher education. In the more traditional programmes with defined subject specializations, exposure to the issue of out-of-field teaching was usually indirect rather than explicit discussion of skills, knowledge and attitudes needed in out-of-field contexts; however, alternative programmes that integrated specializations challenged the subject-bound identity of a teacher. A dilemma exists in teacher education in Australia that must begin with a conversation: Should initial teacher education take action on out-of-field teaching? Are alternative models needed for teacher preparation?

10.4 The Case of Germany

The following section investigates teacher education in Germany, considering the phenomenon of teaching out-of-field and the various situations of pre-service teachers, such as initial teacher education, which contribute to their preparedness to teach out-of-field.

10.4.1 Overview of Teacher Education in Germany

In Germany, education is mainly the task and under the control of the federal states. Consequently, each of the 16 states has its own school system with its own curricula and different teacher education models. Particularly the number and types of schools in secondary education differ immensely. However, all of the different school systems share most of the following characteristics: in most states, children enter secondary education after year 4, in two states after year 6. It is compulsory for children to attend at least ten years of schooling followed by vocational training or after 12 or 13 years of schooling and receiving a high school diploma (Abitur) a university education can follow. The school type Gymnasium exists in all states as a secondary school that traditionally prepares for a university education although a high school diploma can be achieved at other schools as well.

The most common and the regular way to become a teacher in Germany today is by university education (requiring bachelor's and master's degree) followed by a post-qualification phase of school-based practical experience completed by passing a state exam, also called first and second phases. However, especially in times of teacher shortage in general or in subjects like STEM alternative ways to become a teacher are possible (see Wolter 2015, for a historical overview of the German labour market for teachers). Applicants with a university degree that allows at least teaching one subject can enter the profession under certain circumstances. Depending on the state-specific requirements and the applicants' initial qualification, these *side-entrants* or *career changers* can either directly work as teachers and obtain pedagogical knowledge in in-service teacher education courses or attend university courses and/or pre-service teacher education before entering the profession.

Three main features characterize teacher education in Germany (see Cortina and Thames 2013). First, as there are different school types after elementary education, future teachers can obtain one out of six types of teaching certificates in all states (but not at all universities). The 'Standing Conference of the Ministers of Education and Cultural Affairs' (*Kultusministerkonferenz* or KMK) as the central coordinating committee for the 16 states distinguishes the following types (adapted from Cortina and Thames 2013, p. 55):

1. Certificate for elementary education.
2. Certificate for elementary and lower secondary level (up to grade 10/except for Gymnasium).
3. Certificate for all (or some) school types at lower secondary level (up to grade 10/except for Gymnasium).
4. Certificate for upper secondary level (up to grade 12/13/Gymnasium, in some states combined with a certification for comprehensive schools).
5. Certificate for upper secondary level/vocational schools.
6. Certificate for special education.

With the current exception of two states (Hamburg and Lower Saxony), new applicants at university cannot choose to acquire the certificate for elementary and lower secondary level (Type 2) anymore. Instead, persons pursuing the interest in becoming primary school teachers can only achieve a certificate for elementary education after graduating from university and completing a further pre-service teacher education.

This refers to the second feature of the German teacher education system: the two-phase teacher education model. After graduating from university, student teachers work as pre-service teachers at schools and teach—mostly supervised by mentors—with a reduced number of lessons. In addition, they attend state-run teacher seminars that are, for example, responsible for regular classroom visits and for organizing the final state examination after 18 to 24 months.

The third characteristic of teacher education refers to the situation of how teachers are hired. Most teachers work as civil servants with a permanent contract, although the private school sector in Germany has been growing in the last years.

10.4.2 Professional Standards of Teaching in Germany

In Germany, two different documents exist that form the national standards for initial teacher education: (1) *The Standards for Teacher Education: Educational Sciences* (introduced in 2004, see KMK 2004/14), which contains concrete descriptions about 'general' competences for teachers in the areas of teaching, education, assessment, and innovation; and (2) *The Standards for the Teacher Education for the Subjects on Contents and Methods* (introduced in 2008, see KMK 2008/17). The introduction of teacher standards in Germany is the result of a process of standardization in the educational system which was initiated by reforms undertaken after the so-called 'PISA-shock' in 2001 (see Waldow 2009). Both documents describe competences and skills that are expected from qualified teachers at the end of the first university-based study phase and at end of the second phase called induction phase (see Sect. 10.4.1). In the introductory part of the first document, a remarkable comment is to be found (KMK 2015, p. 4): 'In addition, it should be noted, that in-service teacher education are taken into account as the third phase of teacher education. This phase will not be explicitly addressed but all competences presented are also considered as aims of life-long learning in the teaching profession' (R. Porsch, Trans.). As the standards describe the 'ideal' competencies teachers should develop after initial teacher education and while practicing the profession, the documents can be also regarded as a normative guideline for all teachers including out-of-field teachers, *side-entrants* or *career changers* into the teaching profession. However, the standards indirectly assume that teachers have the opportunity to receive a subject-specific education (after school), which is not the case for teachers teaching out-of-field unless they have attended in-service teacher education or have acquired the knowledge in informal learning settings.

10.4.3 Subject Specialization in Teacher Education

In the German context, the term 'out-of-field' relates predominantly to the formal qualification and is usually applied when referring to teachers without a subject-specific teaching certificate (Porsch 2016a). With the exception of obtaining a certificate as in-service teachers in a post-qualification course, secondary school teachers in Germany are typically trained as subject specialists majoring in two subjects at university as well as receiving practical experience in these subjects in the second post-qualification phase of teacher education. With the final state examination, pre-service teachers receive their teaching certificate for certain school types and for the two subjects that were part of their previous education.

In contrast to the education of secondary school teachers, teacher education for primary school teachers is very diverse in Germany. It depends on the state whether future primary school teachers have to study two or more subjects and whether there are any limitations for their choice of subjects. A system review of the primary teacher education models in the 16 states based on official documents undertaken in September 2016 revealed the existence of three main models of primary teacher education classified by the number of school subjects included in the first and second phases (see Porsch 2017):

1. An *education for specialists* of two subjects (two states).
2. An *education for generalists* with a specialization in three or more subjects (seven states).

3. *Hybrid models*: This refers to systems where three or four subjects are to be studied at university but only two of the subjects are included in the second phase (seven states).

In addition, the systems differ with regard to the obligatory subjects (Maths and/or German). At the time of analysis in 2016, in four German states future primary teachers can obtain their teaching certificate without being trained either in German or in Maths.

It is evident that the term 'out-of-field' does not represent the various (formal) qualification statuses of teachers in Germany. Thus, one could differentiate between three types of teachers (see Porsch 2016a):

1. *Experts* are teachers who obtained their subject-specific education in the first and second phases of initial teacher education.
2. *Semi-experts* have a various qualification background:
   (a) Teacher education comprises a subject in the first phase but not in the second phase (mainly methods).
   (b) Subject-specific education takes places in the first phase and second phase.
   (c) Teachers obtain a subject-specific teaching certificate as in-service teachers.
3. *Autodidactics* did not receive any subject-specific education and do not have a certification for a school subject that they teach regularly.

Potential reasons for out-of-field teaching in Germany are mainly a lack of (specialist) teachers as well as the class-teacher principle, which is regularly applied in primary but also in secondary schools. The class-teacher principle refers to a concept in German primary but also in lower secondary schools. It means that in a given class almost all lessons (and subjects) are taught by the same teacher—the class teacher. Due to the structure of German teacher education as outlined above, out-of-field teaching is likely to happen in schools working with the class-teacher principle, especially when teachers are trained as subject specialists for two subjects but have to teach other subjects as well.

10.4.4 Pedagogical Preparation in Teacher Education

One can assume that teacher education systems in all countries integrate the teaching of academic subject knowledge, subject-specific pedagogy ('methods') along with general pedagogy and educational sciences. The importance for professional teaching and the success of each element for students' learning has been researched empirically (e.g. Kunter et al. 2013) and has been the focus of profession-specific approaches determining the demands and knowledge needed for professional teaching (e.g. Baumert and Kunter 2013). But especially the question what role the teaching of pedagogical knowledge should play in relation to other types of knowledge within teacher education has been an issue for an ongoing debate in German education policy and among educationalists. The situation in the first phase can be summarized as follows:

> The subject knowledge, especially for grammar school teachers, is still very much orientated towards the corresponding academic discipline rather than the school subject and its didactics. Educational and didactic studies which should be the core disciplines of initial teacher education seem to be rather arbitrary and dependent on the individual preferences of the tutors and lecturers. (Kotthoff and Terhart 2013, p. 78)

The proportion of general pedagogy and educational sciences within the first phase of teacher education (based on the number of credit points) differs highly between the six types of teaching certificates. In general, student teachers aiming for a certificate for teaching in higher secondary education need acquire a low number of credit points in pedagogical courses at university in contrast to future primary teachers. However, by questioning the effectiveness of the first phase of teacher education with its focus on academic content, in many states reforms have taken place that concerns internships in the first phase. Universities in these states have implemented in their study programme an extended period of practical experience as a post-qualification phase that lasts up to 5 months where pre-service students should learn by doing research and acquire relevant teaching competencies (for a summary on empirical findings see van Buer 2015, pp. 159–161). With regard to the phenomenon of out-of-field teaching, it has to be noted that students observe and practice teaching mainly in their subjects (majors).

10.4.5 Teacher Preparedness for Teaching Out-of-Field

What is known about this situation in Germany? Research in the field of teaching out-of-field from Germany is scarce and mainly concerned with the question whether students who are taught by out-of-field teachers show lower competencies in comparison to those who are taught by content specialists (e.g. Tiedemann and Billmann-Mahecha 2007; Richter et al. 2013; Porsch and Wendt 2017). Studies with this focus show mixed results (see Chap. 7). A survey among 219 German pre-service teachers to become primary and secondary school teachers conducted in 2015 at two universities in North Rhine-Westphalia (Porsch 2016b) reveals the following about the students' knowledge and preparedness about the situation of teaching out-of-field: Almost 90% had not known about the phenomenon before the survey. There were no (statistical) differences between primary and secondary teacher students. With regard to the source of information, more than half of them heard about this 'unofficial' teacher duty from family/friends or from teachers during their internships for the first time. Very critical is that almost no information is provided from university staff. Further results concern emotions towards teaching out-of-field. Imagining teaching sciences such as Chemistry and Physics evokes more anxiety than teaching German or PE suggesting differences in epistemological beliefs. Despite its limitations, especially as convenience samples do not produce representative results, the study gives first insight into the view of German pre-service students about the phenomenon of teaching out-of-field with a specific focus on teachers' emotions. Further studies with a longitudinal perspective are needed exploring the impact of teaching anxiety on teachers' classroom behaviour.

With respect to the outlined models of teacher education, one can see that the current structure is one reason for the phenomenon of out-of-field teaching in Germany along with teacher shortage in general or at individual schools. The class-teacher principle that is applied in elementary and frequently at lower secondary schools demands that teachers teach almost all subjects emphasizing the necessity of an intensive student–teacher relationship. Without changing the aforementioned principle implemented in primary schools, some states realized the teachers' need for possessing content knowledge in all (core) subjects in primary level. Thus, some states have changed their models of teacher education for primary school teachers within the last years. A small shift from specialist to generalist education can be observed—one way to prevent teachers from teaching out-of-field. There is only one study known undertaken in German primary schools addressing the situation revealing that 'primary school music teachers define themselves and their music lessons as discrepancies' (Hammel 2011, p. 376, R. Porsch, Trans.).

In contrast, teacher education for lower secondary teachers is in all states organized as an education for content specialists in two subjects. Although the amount of courses in pedagogy and methods is higher in comparison to students trained as teachers for higher secondary level, no secondary teacher is explicitly prepared within initial teacher education for the situation of teaching out-of-field. Only known from personal reports from teachers so far, the situation at lower secondary schools is very diverse. Principals revealed in interviews great differences in their attitude towards the situation ('challenge' vs. 'normal situation') and how they deal with a lack of teachers for some subjects. For example, some principals consider it necessary that teachers take part in post-qualification courses, others do not. One principal emphasized that it is sufficient if 'teachers have a passion for teaching a subject'. If team-teaching is implemented at schools (especially known in year 5 to 6 with class-teacher teams), at least one teacher has to possess a subject-specific qualification, the view from another principal.

10.5 Discussion

With the exception of changes in teacher education for primary teachers—an increase in the obligatory number of subjects (in Australia)—teachers are not prepared in their initial teacher education to teach out-of-field in Germany nor Australia. One way to look at this issue is to consider initial teacher education as just that—the initial stages of a teacher's education, assuming that teachers continue to learn, hence the northern hemisphere's label of 'continuous professional development'. However, in most German federal states any continuing education is voluntary. Regarding this issue, there are recommendations by the Standing Conference of the Cultural Ministers for the Primary School (KMK 2015, p. 20, R. Porsch, Trans.): 'Teachers attend further teacher education and in-service teacher education for subjects that were not part of their initial teacher education'. This indicates again that the responsibility for professionalization lies in the hands of teachers and schools. In Australia, teachers' approaches to continued learning can be related to the subjects they teach, the school's direction, or other general topics in education such as classroom management and inquiry learning, and can be subject to availability of funds, permitted time release and other contextual factors.

In fact, research is emerging showing that a teacher may not seek formal professional development in an out-of-field area for a number of reasons, such as feeling disconnected from the subject and not being interested in extending their knowledge and identity (Hobbs 2013), distance from the professional development in the case of rural and regional schools, and sometimes a concern that they will become the main teacher for that out-of-field subject where no other teachers exist and hence relinquishing a claim on their preferred in-field subject. If teachers are faced with the situation of out-of-field teaching, they may feel the need to attend additional teacher education as they provide structured learning opportunities in order to obtain necessary subject knowledge ('deficit hypothesis'). In contrast, findings from studies (e.g. Desimone et al. 2006) suggest that teachers prefer to follow their interests. According to this assumption ('interest hypothesis') teachers more often choose professional development in a subject that corresponds to their specialization to expand their professional competencies in that field. An analysis from TIMSS-2011 of German primary school teachers teaching social and science studies in year 4 shows that there are only significant differences in the number of attended courses in the last 2 years by teacher qualification (major in science or another subject) with regard to teacher education focusing on content knowledge. Teachers with less than 5 years of experience and a major in science attended more courses than those with another subject as a major (Porsch and Wendt 2015). The point is that an assumption that teachers will continue to learn is fair, except where there are barriers, perceived or real, that can prevent teachers from accessing these learning opportunities. Informal teacher learning, however, may take place within the school from peers, or from their own networks outside of school.

The role of universities in providing this professional development is not always clear. Often schools seek out professional development from private providers. The question is whether universities, or initial teacher education providers, should be responsible for the continued development of teachers. In Australia, there appears to be a tendency for the university and school systems to be mutually exclusive, except where schools become an essential site for 'work-integrated learning' (ACEN 2015) through the formal practicum that is integrated into all initial teacher education programmes, and which is a required part of the programme accreditation. Once graduated, schools and teachers in many countries work in isolation from universities. The onus on universities is to continue to be associated with schools. While this is not initial teacher education, there is an argument for universities to expand their remit to include postgraduate offerings and other professional development opportunities that can support out-of-field teachers at their point of need. Some institutions manage to do this but often with additional funds from the Government or from other funders such as philanthropic organizations (see Chap. 11 for examples of professional development programmes in Australia, Ireland and England). For example, professional development targeted at teaching out-of-field teachers are offered in some German states. Accompanied by intensive research are courses by the *German Centre for Mathematics Teacher Education* (DZLM) that is addressing the needs of out-of-field mathematics teachers (see, e.g. Eichholz 2018). However, it cannot be concluded that there is a comprehensive support system of in-service teachers teaching subjects out-of-field in either Australia or Germany currently.

The descriptions of the teacher education systems in Australia and Germany have highlighted some interesting differences in how the relevant systems influence or generate the out-of-field teaching phenomenon:

- *Regulatory responsibility for teacher education*: State-based regulation in teacher education and the education systems generally in Germany; compared to regulation of teacher education to meet national accreditation standards in Australia. Australian States and Territories, however, regulate and have responsibility for teacher registration or certification and some differences across the states exist similar to Germany.
- *Who is regarded as out-of-field*: High incidences of out-of-field teaching in German primary schools in most federal states because as a result of specialization in a small number of subjects despite there being a 'class-teacher' principle; compared to, in Australia, primary teachers are trained as 'generalists' and so would not technically be considered out-of-field.
- *Representation of out-of-field as undesirable*: There is a general acceptance that Australia has a 'problem' with out-of-field teaching with high incidences being recorded in broadscale studies for some subjects and in some states and territories, although this does not always translate into policies that provide for funded teacher re-specializing; compared to, in Germany out-of-field teaching continues to be regarded as a tabooed subjects, although there are some funded out-of-field re-specializing programmes.

There were also some similarities evident across Germany and Australia, which give insight into which aspects of the out-of-field phenomenon may arise independent of contextual factors. In both countries:

- Teaching out-of-field is seen as a solution to teacher shortages due to an inability to attract the required subject teachers to the teaching profession or to certain schools.
- There are concerns from teacher educators and researchers about the effects of out-of-field teaching on the quality of instruction, teacher well-being and the potential long-term impact on the public trust in the teaching profession.
- There is limited capacity for teacher education programmes to attend explicitly to the preparation of teacher to teach out-of-field during initial teacher preparation courses due to tight regulation around teacher specialization being tied to subject-related knowledge of content and pedagogy.

- While professional development opportunities for out-of-field teachers exist (although are not widespread) in both countries, teachers' engagement with these programmes is not mandated, and patterns of uptake depend on teacher- and school-related factors.

Teaching out-of-field is a dilemma in many countries, although little is really known accurately. There persists a lack of recognition of the phenomenon in many education policy documents or initial teacher education programmes. In research conducted in Australia (Hobbs and Campbell 2015), it was suggested that during initial teacher education programmes, support could be offered to PSTs through:

- raising their awareness of the situation, so they are prepared for the possibility through exposure to the realities of teaching and exposure to other disciplines;
- developing their capacity to deal with teaching out-of-field through increasing their knowledge and skills required to teach in out-of-field areas they are likely to be required to teach (for example, science teachers being introduced to some mathematics content) and how and from where to seek support; and
- enhancing their identity as a teacher rather than a 'teacher of content' by facilitating a teaching philosophy and enhancement of dispositions and attitudes that are amenable to being adaptable in situations such as teaching out-of-field.

Teacher education institutions have a responsibility to recognize the teaching situation that their graduates are likely to move into and to prepare them adequately to teach. Currently, institutions prepare for the 'ideal' teaching scenario, without consideration for the current and increasing trend of out-of-field teaching.

What is possible and what can teacher education programmes do? How do teacher education programmes respond to teaching out-of-field when they are not built into national directions or teacher standards? Based on the analysis presented in this chapter, Table 10.2 summarizes a number of possible approaches, with focus on the increasing provision of more attention to raising PSTs' awareness, building their capacity and enhancing their teacher identity. Option A describes the consequences when there is no preparation for out-of-field teaching, that is, continuing the status quo in many institutions. Options B and C refer to situations where the reality of having to teach out-of-field is recognized, but C occurs where there is explicit attention to the skills, knowledge and dispositions that would assist teachers in out-of-field situations. The two D options propose increasing the number of specialized teachers, through radical changes to teacher education programmes where graduating teachers have more specializations (D1), or by increasing the number of appropriately specialized teaching graduates (D2). Option D1 runs counter to expectations by the registration or certification bodies and would require a radicalisation of initial teacher education in terms of what is considered suitable knowledge for teachers, especially with respect to subject-related knowledge. Option D2 would require concerted efforts by universities to attract more teaching candidates, by school teachers to promote teaching as an attractive career option, and governments to play an important role in promoting public confidence in our education system so that teaching is seen as a rewarding career. Both D options require policy responses, first, to change the

Table 10.2 Possible approaches to improving initial teacher education for teaching out-of-field

	Concept	Consequence(s)
A	No formal preparation in initial teacher education	Individual responsibility of teachers to 'compensate' their lack of professional knowledge
		Need for in-service teacher education, support by schools/colleagues, etc.
		High proportion of teaching out-of-field
B	Raising awareness in initial teacher education by informing teacher students about the phenomenon before and during teacher education	Awareness of the situation before entering teaching + reducing teacher attrition + need for in-service education, support by schools/colleagues, etc.
		High proportion of teaching out-of-field
C	Preparing teacher students explicitly in initial teacher education for the situation of teaching out-of-field (e.g. observation/teaching of lessons during practical school experiences in subjects that are not their minors/majors)—building capacity and enhancing identity	Awareness of the situation before entering teaching + need for in-service education and support by schools/colleagues, etc.
		Formally still teaching out-of-field but preparedness of teachers + lower teacher attrition
D1	Raising the number of subjects in initial teacher education	Less teaching out-of-field
D2	Raising the number of teacher graduates with the specializations needed by schools	(Almost) no teaching out-of-field

regulatory requirements of teacher preparation, and second, that shows a commitment by government to increase funding for to provide incentives to support teacher attraction.

10.6 Conclusion

This chapter set out to interrogate the role of initial teacher education programmes in preparing teachers for teaching out-of-field, across subject boundaries. The international situation was investigated and two cases (Australia and Germany) were detailed, to provide an overview of how teaching out-of-field arises. Policy documentation and professional standards of teachers do not recognize the phenomenon of out-of-field teaching yet the likelihood of having to teach out-of-field, in many Australian and German schools, has become a commonly accepted reality of teaching practice. Factors relevant to early career teachers were considered, such as workload, in-school support, and initial teacher education preparation, and placed in context with the high attrition rates of this specific group. Initial teacher education preparation was signalled as providing opportunities to prepare teachers who were well-informed, capable but most importantly, adaptable to changing teaching contexts and situations.

There are significant implications for practice in terms of the support teachers need when teaching across subjects, however, without changes to policy, which recognizes the seriousness of the issue, little will change. Policy at the level of government requires a strong focus on evidence—research evidence which documents clearly and strongly how we can address out-of-field teaching within our school systems.

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Chapter 11
Teacher Learning and Continuous Professional Development

Fiona Faulkner, John Kenny, Coral Campbell and Cosette Crisan

Abstract This chapter discusses teacher learning and professional development of out-of-field teachers from the point of view of the literature. It examines what makes this kind of learning and development effective and explores the ideas surrounding the varying rationale for the introduction of such teacher learning and professional development opportunities. Classical approaches to professional development are discussed in addition to several emerging international models of professional development that are currently being employed in the Republic of Ireland, England and Australia for in-service out-of-field teachers of mathematics predominantly but also a range of other subject disciplines (in the case of South Korea). Details of the structure of each of the models of professional development for in-service teachers are outlined using a country case study approach. Comparisons are made between the techniques employed in each country to upskill out-of-field teachers in specific disciplines. This chapter also proposes an international framework for teacher learning and professional development for out-of-field teachers that encompasses the best aspects of each country's approach.

Keywords Teacher learning · Professional development · Continuous · In-service

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_11

11.1 Introduction: Professional Development and Professional Learning

Before professional development or professional learning can be defined or discussed, one common challenge must be overcome and that is making the explicit difference between these two concepts. Although the terms professional development and professional learning are often used interchangeably, if the literature is examined carefully one can differentiate between them (Mayer and Lloyd 2011). Professional development has been described as 'activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher' in the OECD's extensive study across 23 countries (OECD 2009, p. 49). Another definition of professional development which is in keeping with that of Mayer and Lloyd (2011) description is that of Knapp (2003, pp. 112–113) who describes professional development as 'the full range of activities, formal and informal, that engage teachers or administrators in new learning about their professional practice'. Knapp (2003) also compares professional learning to professional development and describes professional learning as being linked to 'changes in the thinking, knowledge, skills, and approaches to instruction that forms practicing teachers' or administrators' repertoire' (Knapp 2003, pp. 112–113). In their extensive literature review on professional learning, Mayer and Lloyd (2011, p. 3), therefore, deem professional learning to be linked to 'one's capacity for practice (i.e. changes in professionally relevant thinking, knowledge, skills, and habits of mind) and/or changes in practice itself (enacting the new knowledge and skills in one's daily work)'. Professional learning has also been characterised as learning that is not structured in any systematic way but occurs as a teacher goes about their working day in their classrooms (e.g. Day 1999; Doecke et al. 2008). In this chapter, the differences between the two concepts are acknowledged and it is a combination of both professional development practices and the resultant professional learning that will be examined.

Much research in the area of professional development highlights that little is known about the effects of engaging in professional development on improvements in teaching or on students' outcomes (Garet et al. 2001; Luke and McArdle 2009); however, there is, in fact, literature that has extensively detailed the characteristics of effective professional development (Ingvarson et al. 2005; Kriewaldt 2008; Meiers and Ingvarson 2005; Timperley 2008; Timperley et al. 2007; Wilson and Berne 1999) which will be outlined next.

11.1.1 What Makes Professional Development and Professional Learning Effective?

An extensive examination of literature in the area of effective professional development resulting in professional learning carried out by Mayer and Lloyd (2011, p. 4) emphasised the need to focus on 'developing subject matter/content knowl-

Table 11.1 Meta-synthesis of effective professional development literature

1. The content of professional development focuses on what students are to learn and how to address the different problems students may have in learning the material
2. Professional development should be based on analyses of the differences between actual student performance and goals and standards for student learning
3. Professional development should involve teachers in the identification of what they need to learn and in the development of the learning experiences in which they will be involved
4. Professional development should be primarily school based and built into the day-to-day work of teaching
5. Professional development should be organised around collaborative problem-solving
6. Professional development should be continuous and ongoing, involving follow-up and support for further learning—including support from sources external to the school that can provide necessary resources and new perspectives
7. Professional development should incorporate evaluation of multiple sources of information on learning outcomes for students and the instruction and other processes that are involved in implementing the lessons learned through professional development
8. Professional development should provide opportunities to gain an understanding of the theory underlying the knowledge and skills being learned
9. Professional development should be connected to a comprehensive change process focused on improving student learning

Note Based on Hawley and Valli (1999)

edge; active learning sustained over time with opportunities to put the learning into practice and with follow-up and support; a focus on student learning and examination of student work; and, collective participation'. In addition to this, Hawley and Valli (1999) carried out a meta-synthesis of research in the area of effective professional development and outlined the following design features (Table 11.1) which need to be in place for effective professional development to be rolled out.

Many of these characteristics of effective professional development are also mentioned in other extensive studies of teacher professional development programmes (Garet et al. 2001; Luft et al. 2015). Garet et al. (2001) studied the responses of 1027 teachers and presented a model by which professional development programmes could be compared and evaluated. It explored the characteristics of professional development in terms of *structural features* and *core features*. *Structural features* are concerned with the design of the professional development activities and include the form, duration and degree of collaboration of the activities, whereas the *core features* relate to the substance of the professional development programme, including the degree of focus on content knowledge (including pedagogical knowledge), the extent to which it provided opportunities for active learning and the coherence of the activities with other demands, needs and expectations of teachers (Table 11.2).

Consistent with the points in Table 11.1, Garet et al. (2001) maintained that PL for teachers is more effective when it is aligned with how they work in their classrooms, the *Duration* of the professional development and the extent of active learning are key factors in its effectiveness, largely because sustained professional development

Table 11.2 Framework for comparing teacher professional development

Structural features	Core features
Form: The type of activities involved: Workshops or conference compared to 'reform' activities such as network, study groups and mentoring.	Content: The degree of focus on improving teachers' content knowledge (in mathematics and science), e.g. subject-specific or more general teaching topics)
Duration: The number of hours of PL activity and the span of time over which it was conducted	Active learning: The degree to which PL offers teachers opportunities to become engaged in the meaningful analysis of teaching and learning (e.g. observe experts, review student work, get feedback on their teaching, give presentations and lead discussions)
Collective participation: The degree of emphasis on groups of teachers from a school learning together or individual teachers from many schools	Coherence: The degree to which PL fits with broader educational agendas to reform teaching, links to previous PL and encourages continuing professional communication among teachers

Note Based on Garet et al. (2001)

activities promote coherence and teachers are more likely to be able to discuss content and to explore the effectiveness of different teaching strategies in their classrooms and reflect on their practice.

Content knowledge is clearly one area where the needs of out-of-field teachers will differ from colleagues with expertise in a curriculum area. However, the literature is clear that the term refers to more than knowledge of subject matter; it also encompasses knowledge of pedagogical practices that will enable students to develop a deep conceptual understanding of the subject and 'sound content and curricular knowledge, an understanding of learners and learning, an ability to enact appropriate instructional strategies, to embed assessment in their practice, to support the learning of all students and to build their professional disposition' (Luft et al. 2015, p. 41).

Luft et al. (2015) looked at studies of teacher PL for beginning teachers, as 'Newly Hired Teachers of Science' (NHTS), over the 30-year period from 1982–2012, which included both those with strong science knowledge (secondary teachers) and those with relatively little science expertise (primary teachers) and compared their responses to professional development programmes. They argued that the subject matter knowledge alone does not necessarily translate into better teaching practices, especially those related to student-centred and inquiry-based practices. They call for development of a clearer understanding of what we mean by the term *content knowledge* as it pertains to teachers. Suggesting that it includes a range of aspects such as conceptual understanding of the subject area, deep knowledge of the curriculum and connections between topics, an understanding of how students learn, understanding of assessment practices that promote learning. Further, they argue that teachers can develop their expertise in these aspects over time as they work in classrooms, but their ability to develop is influenced by their beliefs about science and their identity as teachers of science and access to professional learning opportunities.

> Furthermore, a tested model of teacher content and curricular knowledge could identify high-leverage areas that could better assist generalist teachers, such as those teaching elementary grades, and those teaching outside of their specialisation. (Luft et al. 2015, p. 15)

Finally, these studies also indicate the context in which a teacher professional development programme is developed can have a direct effect on its structure, purpose and core design, and therefore its effectiveness. These aspects of a professional development programme can vary depending on whether it is driven by needs external to the school, such as government policies or political agendas, or by more local needs such a shortage of expertise or a desire for improvement recognised by teachers themselves. Thus, systemic issues, local school circumstances and identity issues may all affect how teachers approach being an out-of-field teacher and the benefits they may gain for participating in professional development opportunities. Drawing on the notion of boundary between fields (Akkerman and Bakker 2011), Hobbs (2013) also claimed that out-of-field teachers need to reshape their identity to encompass themselves as teachers of their out-of-field subjects. Along with, Luft et al. (2015), she maintained that effective PL would need to be based on a clearer understanding of the motivations and needs of the individual teachers involved. So, in addition to a better understanding of the content knowledge needed by out-of-field teachers, effective professional development programmes would also ‘attend to their beliefs and identity formation as they are in the midst of learning and teaching content and in enacting the curriculum’ (Luft et al. 2015, p. 12).

This has clear implications for the design of professional development programmes. Luft et al. (2015, p. 26) suggest that programmes ‘need to be conceptualised in a manner that encourages the cultivation of professional practice over time’. This suggests that effective PL incorporates ‘broadening experiences, building capacity for the future, support, mentoring’ with an ‘emphasis on peer observation, feedback and sharing’ (p. 36). Garet et al. (2001) warned that effective teacher PL is an expensive exercise which is consistent with the case studies discussed below:

> …providing activities with multiple high-quality features is challenging, and requires a substantial amount of lead time and planning, which schools and districts may not always have. Second, providing activities with these high-quality features is expensive. (Garet et al. 2001, p. 935).

Such contextual differences are likely to lead to teacher learning being situated differently in different contexts and countries with the consequence that certain professional development offerings might be more effective than others.

While much of the literature considers teacher professional development, in general, there is little mention teaching out of field. It is not unreasonable to assume that, in many aspects, the *structural features* of effective professional development for out-of-field teachers would be similar to programmes designed for teachers with expertise in the area, but it is also likely that the *core features* will differ for out-of-field teachers, particularly, the *content*, in comparison of teachers with disciplinary expertise who typically attend subject-related programmes.

In the next section, four different case studies will be analysed against the features of effective professional development as outlined in Table 11.1 (Hawley and Valli 1999) and Table 11.2 (Garet et al. 2001) to compare and contrast, and identify key aspects of effective professional development for out-of-field teachers.

These case studies indicate that internationally, a variety of approaches to the provision of professional development for out-of-field teachers has been implemented, with some approaches specifically designed for out-of-field teachers, while others are inclusive to all teachers. The evaluation of these programmes will inform the development of an emergent model for effective professional development which supports professional learning for out-of-field teachers.

11.2 Existing Professional Development Programmes for Out-of-Field Teachers: International Case Studies

The following case studies are recent examples of the response in a number of countries to the professional learning needs of out-of-field teachers. Each case is relevant to the particular context and was developed independently of the others described within the chapter. As such, cross-case analysis provides an effective way to interrogate the salient features of each case, to arrive at a set of common parameters for effective professional learning for out-of-field teacher.

11.2.1 The Case of Ireland

In 2008, the Irish government rolled out a revised mathematics curriculum in all post-primary (secondary) schools with the aim of addressing issues in the Irish education system relating to students' understanding of mathematical concepts, their ability to solve problem and over reliance on rote learning procedures. All stakeholders in Irish education agreed that such an initiative could not be successfully implemented and these existing issues could not be resolved without significant improvements in the quality of mathematics teaching. Furthermore, the problems which existed with implementation of the new curriculum were intensified by a concentration of 'out-of-field' teachers teaching mathematics at lower secondary school (Junior Cycle) (Ní Ríordáin and Hannigan 2009). Thus, while changes and improvements in initial teacher education in mathematics will lead to improvements in the long-term, compensatory actions such as continuous professional development and other upskilling opportunities were considered necessary to improve quality and support practicing teachers in the medium term. As such, a continuous professional development programme, entitled 'The Professional Diploma in Mathematics for Teaching' (PDMT), was rolled out in 2012, specifically, for out-of-field teaching mathematics teachers in Ireland. The primary stimulus for the development of the programme was a report published by Ni Riordain and Hannigan in 2009 which highlighted that 48% of in-service post-primary (secondary) mathematics teachers in Ireland were not suitably qualified to teach mathematics but rather were qualified secondary school teachers in other subject disciplines (see Chap. 3 for more details on teacher education in Ireland).

Therefore, to tackle this issue the Irish government is in the process of funding four cohorts of 400 out-of-field teachers teaching mathematics (maximum) per year. Initially, over 2 million euro was provided in funding for the programme to cater for these four cohorts. In January 2015, the first cohort of 300 teachers graduated (400 teachers were initially enrolled) while in January 2016, approximately 250 teachers graduated. In January 2017, there are approximately 200 teachers due to graduate with 140 teachers likely to graduate in January 2018. The interest and willingness of eligible teachers to engage with the programme have declined as the years progress. This may be in part due to teachers learning of the heavy workload and commitment that is involved during the programme and/or those teachers teaching out of field with a higher relative propensity to mathematics teaching having already enrolled on the course. Details of the structure of the programme will be outlined next.

11.2.1.1 The Structure of the Professional Diploma in Mathematics for Teaching (PDMT)

The PDMT is a 2-year part-time blended learning programme which is offered free of charge nationwide. The National Centre for STEM Education (EPI STEM) (formally, the National Centre for Excellence in Mathematics and Science Teaching and Learning) at the University of Limerick (UL) leads a national consortium of Higher Education Institutions (HEIs) established for the purposes of delivering this programme. The programme is jointly accredited and run by UL and the National University of Ireland, Galway (NUIG).

The requirements for the structure of the programme were set out by the Minister for Education and Skills, and Teaching Council regulations in Ireland. The Teaching Council regulates the teaching profession in Ireland and outlines criteria which teacher education programmes have to meet if they are to be recognised by the council. As such, it is a 75 ECTS credits[2] level 8 programme[1]. This can be broken down into 60 ECTS credits towards mathematics modules (five modules per year worth six credits each) and 15 ECTS credits towards mathematics pedagogy (two modules: one worth nine credits and one worth six credits).

[1]The Bologna Process, which was developed in 1999 and is now used by 45 countries, is a standardised accreditation process for higher education. It was put in place so that countries had a mechanism to relate national frameworks to each other allowing for international transparency, international recognition of awards and international mobility of learners and graduates. The system consists of 10 levels

with each level being associated with a certain number of ECTS credits depending on the programme demands.[1]

The participants complete the pedagogy elements of the programme concurrently with the mathematics modules. Upon completing the first five mathematics modules in year 1 of the programme, participants are required to attend a week-long summer institute on mathematics pedagogy which is offered in two venues in Ireland; University College Dublin and UL.

This summer institute outlines the criteria for much of the pedagogy and continuous assessment which must be completed as part of the programme. Participants are also required to attend five pedagogy workshops which take place on saturdays throughout year 1 and 2 of the programme. These workshops inform the teachers directly on best mathematics pedagogical practices for second-level mathematics teaching with a particular focus on the mathematics curriculum in all Irish post-primary secondary schools.

11.2.1.2 The Blended Learning Platform

Participants have the option of attending 9 different lecture venues and 19 different tutorial venues in a variety of higher education institutions around Ireland. The large variety of venues requires a lot of coordination; however, it maximises accessibility and participation from the out-of-field teachers across the country. The course is designed so that it facilitates teachers who are working during the day as contact hours are in the evenings. The blended learning format allows for participants to attend live lectures for approximately 50% of the mathematics content modules and use an online platform to engage with the rest of the material. Google is a partner in the programme and provides the online platform on which it runs.

On the evenings of live lectures, one lecture venue is responsible for delivering the material and this lecture delivery is streamed live to all other venues for participants to watch. At three different intervals during the live lectures, there is a break in the live streaming for participants to engage in onsite problems related to the content being delivered. Each lecture venue has a qualified mathematics lecturer onsite to facilitate the 3 h lecture with the onsite lecturer playing a particularly important role when the live streaming breaks for onsite problems to be completed. The onsite lecturer also serves as a fail-safe option who is able to take over the delivery of the lecture should the technology break down for any reason. Participants are required to attend three 2 h tutorials for each 6-week module and these are all live onsite tutorials.

[1] The European Credit Transfer and Accumulation System (ECTS) is an academic credit system based on the estimated student workload required to achieve the objectives and learning outcomes of a module or programme of study (Trinity College Dublin 2016).

11.2.1.3 Management of the Professional Diploma in Mathematics for Teaching

The programme is managed and coordinated by the National Centre for STEM Education (EPI STEM) in conjunction with the Department of Mathematics and Statistics and Department of Education and Professional Studies at UL. These parties are responsible for the marketing, recruitment, admissions and academic and student administration, academic standards and the delivery and implementation of the programme. In addition, under the terms of the Department of Education and Skills (DES) contract, a group consisting of DES officials and members of the course team monitor the programme.

The programme has a course director, appointed by EPI STEM, who chairs the course team which contains members of faculty from the two leading institutions, UL and NUIG. A full-time National Programme coordinator and a Teaching coordinator are responsible for the day-to-day running and organisation of the programme with contributions from mathematics educators in the EPI STEM centre.

11.2.1.4 Recruitment Practices and Eligibility for the Professional Diploma in Mathematics for Teaching

As previously mentioned, all advertising and recruitment for the PDMT are carried out through the administration team at UL. Newsletters, detailing the programmes call for teachers to submit applications, are sent to schools along with electronic notification to principals, teachers and school administrators. Many teachers choose to participate for personal and career advancement reasons; however, others, who may be less intrinsically motivated to participate, come to engage with the programme due to encouragement or instruction from their school management/principal. In the Irish context, there is no written requirement from a government perspective for teachers to be placed in the school subjects which they are qualified to teach. Thus, it is the school principal's role to deploy teachers and organise school timetabling. However, many factors at a school level, such as teacher quotas, subject offerings, location and contractual issues, have led to principals facilitating out-of-field teaching often with no other viable options in order to keep the school timetables functioning. Encouraging/instructing in-service teachers to undertake the PDMT has been seen as one way to try to redress this situation.

Similar to the programme structure, the eligibility for the programme is set out by the Minister for Education. Applicants to the PDMT must meet the following criteria in order to be considered for a place on it:

- They must be currently teaching mathematics in a second-level school in Ireland.
- They must be a qualified second-level teacher in a discipline other than mathematics and be registered with the Teaching Council.
- The above two criteria points must be signed off by the principal of the second-level school in which the applicant currently teaches.

In terms of academic eligibility, there is no specific mathematics requirement for the programme.

11.2.1.5 Programme Evaluation

A platform for ongoing programme evaluation was a priority from the outset of the PDMT development. This programme evaluation is carried out through real-time evaluation in addition to longitudinal research. The real-time evaluation includes teacher and lecturer feedback through various programmes and informal mediums. Daily feedback from the lecturers on all sites is monitored and responded to by the programme coordinator and the Course Director.

In addition to day-to-day evaluations and monitoring of the programme from lecturers and teachers, a series of end of year general programme evaluations have been conducted by the UL Centre for Teaching and Learning (CTL). The CTL has carried out three evaluations to date covering cohorts 1, 2 and 3. These evaluations involve teachers completing an online questionnaire which aims to determine teachers' general satisfaction with the programme. Teachers are also asked to give advice to others considering taking on the PDMT. This evaluation also serves as a means of adapting and improving the programme on a yearly basis. To date, the major finding from this form of evaluation was that 33.5% of teachers stated that they were not satisfied or unsure of their satisfaction levels with the programme. Primarily, this was due to teachers feeling stressed as the programme requires a significant amount of work in addition to having a full-time teaching job and a family. They also reported dissatisfaction due to inconsistencies with regard to the teaching conducted across different centres while issues with the technology breaking down from time to time were also highlighted. However, there was a slight majority of participants (52.5%) who agreed with or strongly agreed with the statement that they were satisfied with the programme. This agreement was mainly due to it being effective professional development for career advancement and participants' support for the tutorial structure. More specifically on the tutorial structure, these participants commented on how beneficial and enjoyable it was to engage with the tutors and other participants within this context resulting in improved self-confidence. In the section of the evaluation which asked participants whether they had any advice for others considering enrolling on the course, three major themes emerged: (1) prospective students were advised not to underestimate the level of prerequisite mathematical knowledge required, (2) the importance of attending tutorials and reading lecture notes prior to lectures commencing was stressed and (3) that it was a programme they would encourage people to do as they felt it was a good career move in spite of the fact that it was not an easy programme to successfully complete.

An additional evaluation is ongoing which is examining teachers' content and pedagogical knowledge before and upon completion of the programme. This study is being conducted by a mathematics education professor in Boston College and mathematics education lecturers in NUIG. Extensive details of the results of this research can be found in Chap. 5. Some of the major findings indicate that teachers' mean cognitive score has increased pre- and post-completing the course and that teachers' mean conceptual error score has decreased over this same time period. However, neither of these improvements was as significant as the programme team would have anticipated.

Research is also being carried out on the perceived effectiveness of the mathematics-specific pedagogy workshops. This research aims to investigate if in-service out-of-field teaching mathematics teachers think that it is necessary for them to engage with mathematics-specific pedagogy and whether these perceptions change throughout their engagement with the PDMT. The study also examines whether the teachers' classroom practices change as a result of engaging with the PDMT to align with the intentions of the new mathematics curriculum in second-level education in Ireland. Prior to engaging with the pedagogy workshops 71% of participants felt that it was a necessity for them to engage in mathematics-specific pedagogy. This figure increased to 82.9% upon completion of the workshops showing that participation in the workshops led to an increase in the value placed on them. The predominant response of the participants on the teaching style they employed prior to undertaking the pedagogy workshops was 'didactic teaching'. Significantly, of the 60.6% of participants who stated they changed their teaching style upon completion of the pedagogy workshops, all, except one, changed to a more student-centred teaching approach as advocated for in the workshops and in the new mathematics curriculum. Overall, this research found a positive response to the mathematics-specific pedagogy workshops as indicated by the growth in those considering it necessary upon completion of the workshops.

The final element of programme evaluation that is currently underway is a doctoral study examining teacher identity (re)construction whilst undertaking the course. As this case study research is only in its infancy, there are no substantial findings to report to date. However, once completed, this work should provide extremely useful insights into the journey from out of field to in-field that a teacher experiences while undertaking an extensive professional development programme specifically for out-of-field teachers of mathematics. The initial findings indicate that the salience of mathematics teaching to the identity of the teachers involved in the study reflects to some extent their intentions for undertaking the course. This suggests that the teacher's identity at the point of departure can impact positively or negatively on how these teachers participate in the programme and engage with the course material. Furthermore, the teachers participating in this research appear to rely heavily on, and believe primarily in, the capacity to learn to teach lower secondary school mathematics through experience. This portrays that these teachers, in terms of lower secondary school mathematics, seem to believe in what Britzman (1986) refers to as 'vocational training' or the 'apprenticeship model of education' (Gordon 1985)—in effect, learning through repeated practice. Significantly, this is not the case for these teachers with regard to teaching higher secondary school mathematics (senior cycle). Instead, these teachers described their fear of teaching senior cycle mathematics and for some this was a key contributory factor for undertaking the course. Thus, it remains to be seen, does the professional development programme challenge and alter these teachers' perceptions of learning to teach lower secondary school mathematics and/or alleviate their fear of teaching higher secondary school mathematics, and in doing so, affect identity (re)construction.

Finally, the aforementioned DES Monitoring Group has a responsibility to submit reports on the programme upon carrying out ‘spot checks’ at centres whilst lectures and tutorials are ongoing. This element of the programme evaluation has produced very positive reports to date. Additionally, the members of the Monitoring Group actively engage with teachers on the programme when they are in their schools. Based on this, they reported (after 3 years of the programme being in operation and 527 teachers qualified from it) that the programme is having a positive impact on mathematics teaching in schools.

The forms of evaluation discussed here will continue to be carried out for the duration of the running of the PDMT. The most effective elements of the programme which have emerged from the evaluation research to date are outlined next.

11.2.1.6 Effectiveness of the Programme Development Programme

The PDMT programme receives and responds to feedback from lecturers and participants in real time. This results in continuous changes being made to the programme to ensure an ever-evolving improved service over time. The evaluation of the satisfaction levels of the programme demonstrated the relative effectiveness of the small group tutorial structure which is provided to students during the course of each mathematics module in conjunction with the content lectures. This has been reported to be a forum in which the participants really learn and engage with the mathematics being delivered in lectures. The pedagogy workshops appear to be an element of the programme which supports and encourages teachers to change from predominantly didactic classroom practices to one which engages in active learning methodologies and focuses on students’ understanding of mathematics. A significant proportion of teachers maintained that the pedagogy workshops were the most effective element of the programme in terms of providing them with ideas and strategies to improve their teaching with some stating that they would prefer a heavier weighting on this aspect compared to content lectures.

11.2.2 The Case of England

The shortage of mathematics teachers in the UK has led to a number of government initiatives aiming to increase the supply of teachers of mathematics. One such initiative concerns upskilling teachers who are already employed at a school or college in England and who are teaching some mathematics, but who initially trained to teach in a subject other than mathematics. The **MDPT** initiative (Mathematics Development Programme for Teachers) was specifically commissioned for such serving teachers and it was launched by the Teacher Development Agency (TDA) in 2009. Participation on the MDPT course required that a teacher had completed their Newly Qualified

Teacher (NQT) year and was employed in a state school and teaching at least some mathematics to pupils in the secondary age range (11–16 years old) and had no post 18 mathematics or any mathematics teaching qualification (although primary trained teachers were allowed to take the course), had the support of their head teacher and had a school-based mentor to support them. The structure of the course comprised 30 days based at the university and 10 days based in school, each with specific pedagogical tasks to complete. The participating teachers were offered a £5000 bursary on completion of the course where ‘completion’ included having at least 80% attendance and an assessment at a level of a final undergraduate of 40 CATS credits (Credit Accumulation and Transfer Scheme) which is used by many universities in the UK to monitor, record and reward passage through a modular degree course and to facilitate movement between courses and institutions; one credit is equivalent to 10 h of study comprising of contact time and allocation for self-study. Schools could claim for cover on the days where the teachers were in the university for the MDPT course sessions.

Various providers in different regions of England offered these MDPT courses and had the freedom to design their own curriculum. The participants in the MDPT courses were expected to transfer their pedagogical knowledge from their initial specialism into the context of mathematics teaching as a result of developing their mathematical subject knowledge.

The structure of the MDPT course, one of eight similar national courses, as designed by the mathematics education team at the UCL Institute of Education, University College London is reported in this chapter.

11.2.2.1 The Structure of the MDPT Programme

The design principle of the in-service mathematics courses for non-specialist teachers of mathematics was that effective secondary mathematics teaching is founded on sound subject knowledge, together with a thorough knowledge of a highly connected curriculum and a sympathetic understanding of pupils’ needs and interests. Thus, the emphasis of our in-service courses was on revisiting and teaching the subject matter (school mathematics), aiming to develop the participating teachers’ technical fluency of some of the more challenging topics taught at different levels of school education (Key Stage 3: 11–14-year-old pupils and Key Stage 4: 14–16 year olds).

Even with the full engagement and efforts of the teachers on the course, the aims of the course could not have been achieved if an attempt was made to cover exhaustively all aspects of mathematics in the National Curriculum for Mathematics in England (NC) at Key Stages 3, 4 and 5. Our course, thus, made careful design choices about the most appropriate places to focus attention.

The aims of our MDPT course were thus to

- present mathematics as a coherent and connected living web of meanings,
- encompass the most challenging topics for teachers in the target group to understand,

- involve the teachers in developing technical fluency and
- provide opportunities to create a range of ideas about mathematics-specific pedagogy.

The various providers in different regions of England who offered these MDPT courses had the freedom to design their own curriculum. The curriculum of the mathematics education team at the UCL Institute of Education, University College London was designed to deliberately avoid mathematics National Curriculum classifications; in support of OfSted's observation (OfSted 2006), the MDPT curriculum covered four broad mathematical content themes: infinities, uncertainties, structures and spaces.

In all settings, both schools and FE colleges, the most effective teachers understood how the particular aspects of mathematics they were teaching fitted into the wider development of mathematical themes and concepts. They were aware of the progression of mathematical ideas and the rich links across them. This enabled teachers to develop students' secure understanding by making links with previous and forthcoming work on the same topic and by emphasising the recurring mathematical themes and ways of thinking (p. 5).

Theme 1: Infinities

- Gaining an understanding of how procedures and techniques used in school mathematics are underpinned by notions of infinity.
- Understanding some of the history of how rigour needed to be established in order to develop processes such as convergence.

Theme 2: Structures

- Recognising and using similarities and differences across mathematical topic boundaries.
- Understanding how knowledge about one area of mathematics may be applied to support learning and problem-solving within another area of mathematics.
- Improving confidence and competence in mathematical reasoning.

Theme 3: Uncertainties

- Gaining an understanding of different probability models, with opportunities to use ICT and simulations to model real-world phenomena.
- Contextualising the use of these theories in society's endeavours to conceptualise and measure risk.
- Understanding that a set of data that can be represented in various ways.

Theme 4: Spaces

- Representing and visualising two- and three-dimensional situations in a variety of ways.
- Euclidean geometry of the plane.
- Modelling in three dimensions, for example, movement or stability of physical structures.

Between them, these four broad connecting themes were not exhaustive of all aspects of the school mathematics curriculum, but they provided a deep appreciation of the connections between those areas of mathematics where we expected a lack of competence and the study skills to enable them to address other areas of mathematics independently.

The selected content areas provided many opportunities for attention to pedagogical issues such as planning, observing and reviewing lessons; a rich variety of learning approaches and teaching resources, including digital technologies; developing and adapting personal resourcefulness and creativity; developing questioning strategies; developing a range of assessment strategies; developing an awareness of the connectivity of mathematics and its place in a wider societal context; taking advantage of the opportunities provided by communities of practice and professional associations.

Through the teaching of these themes, the intention was to address the learning outcomes of the MDPT course, namely, teachers learning about modes of mathematical enquiry, namely, generalisation and abstraction, reasoning and proof, precision in mathematical language, conceptual structures within mathematics and appreciating the potential for mathematics teaching and learning of digital technologies.

11.2.2.2 Mode of Delivery of the MDPT Course

The course consisted of three interrelated parts: face-to-face contact sessions based at university, directed work arising immediately from the taught contact sessions and school-based work where teachers relate the university-based experiences to their own practice. Each teacher was allocated a personal tutor from the mathematics education team at the UCL IOE. The personal tutor was to help participating teachers to steer their way through the course, developing the portfolio of evidence in response to the needs analyses. Each teacher's school needed to commit at the outset to the allocation of a mentor within the school. This mentor, usually a senior colleague, possibly the Head of the Mathematics Department ensured that the teacher on the course received continued support for his/her activity, reducing as far as possible the obstacles that might normally intervene on the teacher's study time. Where possible mentors also provided advice on planning and outcomes of school-based tasks. A Virtual Learning Environment (VLE) was used throughout the course to enable participating teachers to maintain contact with each other and with tutors, enabling the ideas to be embedded in professional practice.

The VLE provided a central delivery system of course documentation, including course structure and assessment. It offered reading and links to other places of support on the World Wide Web and during school-based aspects of the course, the participating teachers were encouraged to maintain contact with their personal tutor by email or through the VLE.

11.2.2.3 Assessment

Participating teachers benefited from thorough and continuous formative assessment, aimed at ensuring that the course as experienced by any individual was tuned to that individual's needs and progress. Although much of the formative assessment took place in the everyday interactions between tutors and the participating teachers, we were able to identify several specific formal mechanisms that will support the development of the teachers which are as follows:

- A *needs analysis* was carried out on the first day of the course in order to establish areas in which individuals felt confident, and which were reviewed and modified in the light of interviews and course progress.
- A *portfolio*, in which participating teachers collected information, ideas and relevant materials from teaching and other resources.
- A *Dialogue Notebook* throughout the course where teachers were able to reflect upon issues that concerned or interested them in the face-to-face sessions.
- A *Virtual Dialogue Notebook* on the VLE where the participating teachers shared experiences of directed and school-based work with colleagues and tutors on the course.

There were two elements of summative assessment which are given as follows:

- A *Structured Portfolio* (6000 words) consisting of five sections, one for each of the five powerful connecting themes. In each section, participating teachers were required to provide evidence of their mathematical achievement in relation to a particular aspect of the theme and to reflect upon their learning processes. The Structured Portfolio was assessed according to H-level criteria (Honours H level).
- An *Essay* (5000 words) where participating teachers chose to write about a pedagogically oriented focus that cut across or drew upon several of the four themes. The essay was assessed according to M-level criteria.
- At the end of the course, the participating teachers were asked to give informal group presentations. These presentations were intended as supporting the summative assessment at M-Level (Masters M-level).

11.2.2.4 Accreditation

Since the aims of the course encompassed both mathematical content and subject pedagogy, the accreditation of the course was divided into two modules. The first module, *Mathematical appreciation, knowledge and technical fluency,* was assessed by the Structured Portfolio and accredited at H-level (60 credits), while the second module, *Mathematical pedagogic content knowledge,* was assessed by the Essay that was accredited at M-level (30 credits). On successful completion of the course, the teachers were considered to 'have gained an additional specialism' (TDA 2009, p. 10) in mathematics.

11.2.2.5 Recruitment Practices

All advertising and recruitment for the MDPT course were carried out through the administration team in the UCL Institute of Education, University College London. We promoted the course through our 500 partnership schools in London as well as through the publications of the London Education Research Unit, which reaches all London schools.

During all of the recruitment and marketing activity, care was taken not to overburden schools, whose focus is on the teaching and learning of their students. Our approach was to ask interested teachers to complete a simple application form. Teachers were also asked for contact information of the principal of their school. At the second filtering stage, principals of schools were asked to confirm

- that the teacher was expected to continue teaching mathematics in the forthcoming years and that the teacher would teach mathematics in the next year;
- the name of a mentor, who was needed to be a senior colleague whose duties would be set out in the letter to the principal;
- that the school would support the teacher as they worked on the course by allowing the teacher leave for those days in the course where attendance at the university was needed, by guaranteeing time and resources for school-based tasks to be completed and for in-school mentoring to take place.

The material advertising the course summarised: the target audience, including qualifying criteria; the three core aims of the course; the content of the course, based around the four powerful connecting mathematical themes; the need to reach levels of fluency that support the development of confidence coming from competence; the methodology of the teaching that will take into account differentiated needs and the level of commitment needed by participating teachers and schools.

11.2.2.6 Evaluation of the Programme

The course described above was taught to four cohorts of non-specialist mathematics teachers on two different programmes: the 40-day MDPT courses in 2009–2010 and 2010–2011 and the length of the programme being imposed by the government specification. Participant numbers at the beginning of each course were 14 and 16, respectively. The teachers participating in these courses were recruited from the London area and regions from which it was possible to travel into the capital. The QTS specialisms of the teachers enrolled on the course included languages, science and business studies, with the most popular specialisms being primary and physical education, while four of the participants were from overseas, one of whom did his training through an Overseas Trained Teacher (OTT) scheme in England and the others used their European Union (EU) qualifications.

Soon after the start of the course, the university tutors for this course realised that in algebra, particularly, there was a lack of meaningfulness in the teachers' work that we witnessed through their 'instrumental' application of methods and their displaying defence mechanisms like avoidance, talking or requesting explanations to them personally. Similar topics that brought to surface unexpected emotional responses from the teachers were solving two linear simultaneous equations, factorising a quadratic and working with inverse proportion. This brought up the very practical question: how can these participating teachers develop into mathematics teachers who are fit to teach the secondary age and ability range? We had 30 meetings with them over a school year! This motivated us to collect data more systematically in the second year concerning participating teachers' mathematics teacher journeys. Hence, our orientation was to look at a purposive sample of case studies to investigate the transitions towards a mathematics teacher identity, thus research took place alongside the course and was subordinate to the course.

Given the small number of participants on these courses, the evaluation of the course was mainly qualitative. The main element of our course evaluation was our research focus on examining the mathematics teacher identity trajectories of the participating teachers during and after undertaking the course.

The participating teachers embraced the challenges presented to them throughout learning new mathematics, reflecting on their understanding of the school mathematics, learning from mathematics teacher colleagues' practices and reflecting on their own experiences of the in-service course. As the course progressed, we noticed that our participating teachers became more focussed on the learning and doing of mathematics compared with their focus at the beginning where 'how do you teach this [mathematical topic]?' was the central concern (Crisan and Rodd 2011, 2014a). While some teacher participants resisted changing their conceptions about the teaching of mathematics ('understanding a topic' was construed by some as an instrumental facility with a mathematical procedure sufficient to answer standard questions), we witnessed powerful moments when the participating teachers experienced joy and surprise at noticing connections between different topics, starting to see mathematics in a new light, more than just a set body of knowledge and skills (Crisan and Rodd 2014b; Rodd and Crisan 2015). During interviews and oral presentations, the participating teachers talked about the interconnectedness of the mathematics topics, use of investigative approaches and group work. Despite the gaps in their knowledge of school mathematics topics and despite their technical mathematical competence still needing further development, the participating teachers gained confidence in themselves as learners of mathematics, which in turn gave them confidence in their mathematics teaching.

As the participating teachers' confidence in their own mathematical ability increased, we noticed a change on how they talked about themselves as potential mathematics teachers. The teachers became preoccupied with whether and how they will be recognised as mathematics teachers by their colleagues on the course, current school or potential employing schools and mathematics departments. Gaining certification at the end of the course that indicated their new specialism in mathematics teaching was a goal to which many of the teacher participants aspired.

In the research we conducted (Crisan and Rodd 2014b) we found that, by the end of the course, the participants' views had expanded from a limited understanding of mathematics subject knowledge to be able to articulate a wider view of what mathematics is about. At the end of the course, the teachers still lacked fluency with mathematics and were far from having secure subject knowledge. However, the teachers overcame some difficulties they had with mathematics in the past and by immersing themselves in learning mathematics, they felt more secure and confident in their mathematics and teaching of it. These teachers came to appreciate and understand mathematics, and relate to it in a more personal manner. Familiarity with and learning of new mathematics topics on the course increased their confidence in themselves as learners of mathematics.

11.2.3 Two Cases from Australia

Across Australia, about 21% of classes in years 7–10 (13–16 year olds) are taught by out-of-field teachers. For STEM subjects, the figures are as follows: mathematics (21%), biology (14%), chemistry (18%), physics (23%) and general science (10%), with the majority being teachers with less than 5 years experience (Weldon 2016). Price and Hobbs (2014, p.11) claimed that, in some secondary subjects, 'Australian students are more likely to be enrolled in schools with a lack of mathematics and science teachers than other OECD countries'. They also presented data from numerous other reports showing estimates of those teaching out of field in Australia which ranges from 15–25%, with an alarming 38–50% suggested in mathematics and physics. One of these reports (McConney and Price 2009) described the situation in Western Australia (WA) where out-of-field teaching was 'higher in Catholic and Independent schools and considerably higher in country schools across all sectors' and 'teachers teaching out-of-field had over 21 years of experience—calling into question conventional wisdom that it is often new teachers assigned to teach out-of-field'.

This section explores the second of the three approaches to dealing with out-of-field teaching (mentioned in the introductory section of this chapter) through the provision of PL programmes for out-of-field teachers in Victoria and Tasmania.

11.2.4 The Case of Australia—with a Focus on Tasmania

Along with the growing national and international emphasis on the need to improve the student retention and interest in Science, Technology, Engineering and Mathematics (STEM) subjects in schools, due to their perceived links to national prosperity (Marginson et al. 2013; Office of the Chief Scientist 2014).

According to Weldon (2016), the northern territory (at 40%) has the highest proportion of teachers in years 7–10 teaching out of field in Australia, followed closely by Tasmania at 37%. Of approximately 230 government schools in Tasmania, about 198 (86%) would be classed as rural or regional with many of these considered remote according to the criteria used in the SiMERR[2] report (Lyons et al. 2006). (Note this does not include private schools).

The University of Tasmania (UTAS) is the only university in the state of Tasmania. The Tasmanian Department of Education approached the University of Tasmania in 2015 to develop a Professional Learning Initiative (PLI) programme designed to upgrade the skill and knowledge of secondary teachers currently teaching out of field in science and mathematics. This section explores the evolution of the design and effectiveness of the PLI programme which was developed and conducted in July–October 2015.

11.2.4.1 Structure of the PLI Programme

While the PLI is a relatively small programme compared to the scale of some others discussed in this chapter, it illustrates a practical example of how a professional development programme was conceived, developed, implemented and modified to address a pressing concern about out-of-field teaching. The Department of Education supported the PLI programme financially by releasing the teachers from all teaching duties for the 10 weeks of term 3 and covering travel, accommodation costs associated with their participation.

The primary purpose of the PLI programme was to support teachers who were teaching out of field in science and/or mathematics in schools at that time, and who had at least 5 years of teaching experience. Initial discussions with the Faculty of Education about the structure of the PLI programme were held at managerial level, and it was not until later the academics who would be developing and teaching the programme were brought into the discussions. The participants were to be awarded credit towards a postgraduate qualification on successful completion of the PLI programme initially in the form of two postgraduate units, one in science pedagogy and one in mathematics pedagogy to the selected participants.

Based on the literature concerning good PL practice for teachers, the academics requested a modification to the structure by suggesting that the participants retained access to at least one class during the PLI programme to enable an active learning approach to try out ideas from the programme with their students and reflect on their experiences, with the support of peers and their academic leader in a safe and supportive environment.

As the preparations for the PL progressed through the early part of 2015, a political desire to be seen to address the shortage of specialist teachers led to pressure to change to the scope of the project. The goal was to promote the participants as 'specialist' teachers of mathematics or science, even though they would not meet the qualification requirements of the Registration Board to be categorised as such. In addition, this effectively doubled the workload for both the academic staff, tasked with the development and teaching of the PL programme. The faculty was required

[2] Science, ICT and Mathematics Education for Regional and Rural.

to proceed with the revised PL programme, despite objections from the academic staff, and to consider how it might be improved in subsequent years.

11.2.4.2 Recruitment Practices for the Professional Learning Initiative (PLI)

The Department of Education called for expressions of interest from teachers who were teaching science or mathematics out of field in government schools and who had at least 5 years teaching experience. Those selected were to be enrolled in four units of science (or mathematics) to be completed in two blocks of 5 weeks.

11.2.4.3 Blended Learning

As teacher participants came from schools all around the state, to minimise costs associated with travel to the university and accommodation, the programme was structured as a blended learning mode, with the teachers to attend three face-to-face sessions, interspersed with online learning activities through the universities online learning platform.

11.2.4.4 Assessment

The units were designed to consider theory of teaching in science or mathematics, effective teaching strategies and to try these out in their classrooms, with sharing and reflection on their experience to occur in the face-to-face sessions at the university. Formal reflective summative assessment tasks were required chiefly based around classroom activities where the participants were to plan and try out an idea considered in the university sessions and to try it out with their class between sessions. In the following, face-to-face session, they would present their observations and examples of student work to their peers and the academic staff for discussion and reflection upon their experiences, and consider what they might change in the next phase of their learning.

11.2.4.5 Evaluation of the PLI Programme

For evaluative purposes, and due to its innovative nature a research project was established to study the effectiveness of the PLI programme. This used an emergent methodology and a mixed methods approach to data collection, in the form of pre- and post-questionnaires (adjusted slightly for participants according to whether they were teaching science or mathematics), pre–post interviews, assessment of student artefacts, planning documents, observations and communications (including email) to explore the effectiveness of the programme. Ethical issues associated with conducting research while teaching the programme were addressed by ensuring the teachers' participation was optional and had no bearing on their assessment. In addition, an external evaluator and a research assistant were appointed to administer the research and collect the data during the teaching and assessment phase, so that the names of those teachers participating were unknown to the academic staff teaching into the programme.

Summary of findings from the research
A total of 14 of the 23 participants agreed to participate in the research and responded to the pre-survey, but only six responded to the post-survey. The key elements of their feedback are discussed below, using the framework and terminology from Garet et al. (2001).

11.2.4.6 Structural Features

Form
There is evidence that the structure of the PLI programme had a detrimental effect on its effectiveness. For example, the workload put the teachers under a huge pressure. This was exacerbated in some cases through poor communication, in cases where school leadership did not have a clear understanding of the demands on these staff while undertaking the PLI programme. As a consequence, in some cases, the context for learning was not as expected in the design. Some teachers were expected to maintain some of their non-teaching duties and others reported having been taken off all classes, and so had difficulty accessing to a class in which to explore their new learning. There was a long delay (3 weeks) in the teachers gaining access to the university's online learning system and, as there had been no induction for the teachers prior to the PLI starting, this affected the ability of some to participate. The increased requirement to undertake four PG units in 10 weeks, with two running concurrently over each of two sequential 5-week blocks compounded the workload pressure on the teachers and academics and as a result, there was little engagement with the online activities between classes.

Duration
The participants also reported that the tight timelines and technical issues mentioned above meant there was insufficient time to try out many of the ideas and to help their students to adapt to the new ways of teaching. In terms of coherence, most of the teachers reported that the workload pressures were too great and others found ongoing demands placed on them while in their school, such as a need to cover absences and perform other duties made it even harder to complete the tasks as expected.

To address these structural concerns there is a need for clearer communication between the stakeholders about the structure and expectations and to identify the needs of the teachers much earlier. Clearly also, as indicated by Garet et al. (2001), a longer *Duration* is needed for the PL to enable the teachers to explore changes to their practice and to alleviate many of the structural issues identified around the

PLI programme. In the next iteration, it has been agreed to spread the PL over two terms (terms 3 and 4), with a break of 2 weeks between the terms, this essentially doubles the time to carry out the classroom based activities and provides more time to complete the assessment activities.

Core features
In terms of the active learning aspects of the PL, the teachers found the tight timelines made it difficult to try out the ideas with their class and meant their students had insufficient time to adapt to the new ways of learning. The density of the programme also meant that the academics had difficulty giving feedback on their assignments in a timely manner.

Content
The participants all expressed a desire to gain a deeper understanding of the content of their out-of-field area, be it science or mathematics; however, this term ‘content’ meant more than simply covering subject matter content. While the teachers were able to learn the content for a given lesson, they reported a lack of relational knowledge in the out-of-field discipline. They were looking for a deeper understanding of the curriculum, how the concepts were linked and how to plan for effective teaching. This is consistent with Luft et al. (2015) who stated that subject matter knowledge alone may not necessarily equip teachers to take an inquiry-based approach. Clearly, the PLI needs to consider carefully how to support those teachers to build their pedagogical skills.

Active learning
Despite the organisational difficulties alluded to, the teachers valued the highly ongoing active learning aspect of the PL, where they shared with the lecturers and their peers what they were doing in classes and the ideas they picked up about teaching. They appreciated the insights into teaching which were presented and many said they would change their practice as a result.

When interviewed at least 6 weeks after the programme, four teachers reported their students as being more engaged, and eight of the nine teachers who responded to the final evaluation reported benefits in terms of the understanding of pedagogy and a willingness to use more student-centred approaches in their teaching.

To improve the learning opportunities, the assessment activities in the PLI need to be more integrated across the four units, although university course regulations may not make this easy to achieve. In addition, as teaching in a class forms a key part of the assessment, the academics designing the course need to ensure that the assessment tasks are designed to be adaptable to different subject matter and year-level groups.

Coherence
Coherence relates to support and context of the learning. Several participants said they experienced a lack of support from their school and some resentment from colleagues not involved in the programme. This suggests that some of these teachers remain on the periphery of the legitimately science-trained teachers. These teachers took on the role of out-of-field teaching for a variety of reasons. Most saw an opportunity to improve their career options and others were given little choice but to teach out

of their field due to local needs of the school. Three teachers reported that their colleagues were not necessarily supportive of their participation in the PLI.

This indicated that the support for the participants varied considerably from school to school. Research indicates that school-based support is essential for the teachers to gain the most a PL programme (Luft et al. 2015). Attention needs to be paid to building teachers' capacity to teach effectively in the out-of-field discipline, and this is affected by the school culture within which the teacher operates. However, we must be mindful that limiting support to in school colleagues would not necessarily challenge preconceived ideas about the out-of-field discipline area, and may perpetuate didactic teaching approaches and limit exposure to more progressive teaching approaches. In some cases, the progressive ideas promoted within the PLI clashed with the more traditional teaching approaches used by the in-field teachers in schools. This also points to the need for greater coherence around the selection process and consideration of how the PLI can be designed to benefit other staff within the school, not just the individuals who happen to attend. Should there be some requirement to report on or share what is happening with the rest of the science (or mathematics staff)? After all, these staff may be supporting the absence of the participant in some way, especially in rural schools.

Developing a new professional identity as a teacher of science or mathematics is one in which the teachers will need the support of their school administration, the university and ideally their colleagues (Hobbs 2013; Luft et al. 2015). Unfortunately, the tight timelines associated with the initial iteration of the PLI meant that little attention was paid to the identity issues and this will need to be emphasised more in the next iteration.

The teachers of science reported a lack of science-related professional development opportunities, compared to mathematics, which seems to be reflected in the concentration on mathematics in the other case studies reported in this chapter. They also commented on the difficulties of coming to terms with the various disciplines within science (e.g. chemistry, physics and biology).

11.2.4.7 Recommendations

1. The purpose of the PLI programme as offering support to teachers teaching out of field needs to be reiterated, and it raises the question of what is meant by the content knowledge they required.
2. The term 'Content knowledge' should be understood in the broader sense of incorporating a relational understanding of concepts and an ability to plan and implement student-centred teaching practices, rather than perpetuating didactic content-driven approaches.
3. Supplementary programmes would be needed to develop these teachers as subject 'specialists', with the full range of qualifications that implies.
4. There is a need for more clarity around, and better communication of, the purpose of the PLI programme and the associated expectations so that all the stakeholders,

including the principals understand the expectations and support the outcomes of the PLI programme.

5. The PLI programme needs to be modified to include an induction session to orient the students to the university systems and the expectations and the *Duration* of the PL programme needs to be doubled to at least 20 weeks (or two terms). The blended learning provides an opportunity to build a learning community and overcome the remoteness, but it needs to be more thoroughly incorporated into the programme.
6. The associated administrative and technical issues need to be sorted out early, with some induction provided to the teachers into the expectations and the university systems.
7. In terms of the design of the learning (core features), the induction mentioned above and the assessment tasks should include sessions where participants consider their identity as teachers and reflection on how the current identity changes to incorporate themselves as teachers of the out-of-field discipline.
8. The assessment tasks across the four units need to be more integrated and should be modified to include some work on developing a professional identity within their chosen subject, as this leads to improved content knowledge.
9. To maintain their ongoing professional development, it is likely that the participants would need ongoing support in terms of discipline-related professional development and mentoring, but this needs further research to explore the longer term gains.

11.2.5 The Case of Australia—with a Focus on Victoria

In 2016, Deakin University developed a programme to support out-of-field teachers in STEM pedagogy. Initiated through a funded grant from the Victorian, Department of Education (DET), 30 schools from low socio-economic areas were offered the opportunity for a principal (or leadership member) plus two teachers from year seven and eight to participate in a comprehensive professional learning programme running across 2 years. The DET funding provided ‘buy out’ time for all teachers to participate as well as the teachers’ fees for the academic study for the Graduate Certificate of STEM Education.

The programme operated with five specific features as given below:

- A **guiding vision** that includes innovative pedagogies in the separate STEM disciplines and interdisciplinary approaches.
- An **induction programme** that involves the alignment of teachers’ current beliefs and practices with exemplar STEM practices, and exploration of change directions.
- **Principals’ workshops** that focus on STEM Education practices and possibilities and how these can be effectively supported. These workshops can provide entry into the Deakin Graduate Certificate of Education Business Leadership.

- A purpose-built **Graduate Certificate of STEM Education** that moves teachers from personal knowledge building to leading, and monitoring change in schools. This will be supported by trained STEM mentors, and explicitly linked to the Principals' workshops.
- A **research and monitoring programme**, whereby school and teacher change processes will be tracked and analysed, and fed back into schools and the units to support ongoing innovation.

With a focus on STEM, many of the teachers undertaking the STEM Catalyst Programme will be teaching out of field in one of the areas. With an appreciation of the complexity surrounding out-of-field teaching, such as a teacher's level of experience and their perception of their competence and confidence, a supportive school culture and a sympathetic leadership are essential for fostering teacher learning and maintain teacher well-being. These insights inform all parts of the programme, especially, the principals' workshops. Through the programme, teachers are supported to examine their own understandings, beliefs and practices and then to explore new and innovative ways of engaging students in STEM practices, collaborating within and across schools. The out-of-field teachers will be supported to adapt their existing expertise to STEM disciplinary cultures and practices. 'Leading change' programmes will support teachers and principals to gain insight into exemplar STEM practices and to lead improvement in STEM provision in their schools. The programme is delivered over a 2 year period to the DET cohort of teachers.

11.2.5.1 Induction Programme

Prior to commencing the Graduate Certificate of STEM Education, the 3-day induction programme was initiated. This involved representatives from DET, principals and teachers participating in a 'STEM Vision' framework. DET representatives followed the development of the STEM vision as schools (teachers and principals) worked together to develop and plan their own STEM vision. Using a workshop environment, participants were introduced to exemplars of successful implementations of STEM visions in schools. Teachers gained insights into and shared their experiences in developing STEM practice. They explored how their different roles contribute to their schools' STEM vision. Principals, recognised as the drivers of change in their schools, were presented with opportunities to reflect on their leadership practice and how to support STEM priorities for their schools.
Induction outline

Day 1: Moving from current practice to a STEM focus

- All participants session,
- Catalysts-only breakout session,
- Principals-only breakout session.

Day 2: Exploring the possibilities for school-based STEM initiatives

- Inquiry through representation,

- Approaches to problem-solving in mathematics,
- Design-/challenge-based learning.

Day 3: Developing a school-based STEM vision

- Resourcing for schools 1: Digital learning environments (Digital technologies in Vic Curriculum),
- Resourcing for schools 2: School industry and community partnerships,
- School-based STEM vision development.

The DET wanted to ensure that the academic workload associated with undertaking a university unit of work would not be overwhelming for the teachers. The university structured the programme to allow a slow progression.

11.2.5.2 Principals' Workshops

These were run as one-day interactive workshops to introduce Principals to STEM education practices and possibilities and how these can be effectively supported. Principals were given an overview of the requirements of the Graduate Certificate of STEM Education and what their teachers were expected to complete as part of that.

11.2.5.3 The Graduate Certificate of STEM Education

The Graduate Certificate of STEM Education is specially designed to meet aims of this initiative. It is not designed to teach content knowledge. Units will equip teachers with deep knowledge of the Victorian STEM Curriculum, including digital technologies, reflect on their teaching and leadership practice in STEM, learn more about STEM pedagogies that support student engagement and learning, and enact and research these practices in their classrooms and with STEM colleagues. Specifically, for out-of-field teachers, material related to developing themselves as out-of-field teachers is embedded in each unit and additional support is provided (see below under research and monitoring programme).

The units are given as follows:

- Unit 1: Knowledge, Learning and Learners in STEM.
- Unit 2: Designing Contemporary STEM teaching and learning programmes.
- Unit 3: Researching Your Practice as Teachers and Leaders of STEM.
- Unit 4: Supporting and Leading Development of Communities of STEM Practice.

Successful completion of the units will provide credit towards a Master of Education at Deakin University.

11.2.5.4 Unit Delivery

The delivery of each unit is considered 'mixed mode' (blended). Students are enrolled into one unit at a time and this is undertaken both as intensives and through an online environment. There are 5 days allocated to intensive teaching—broken down into a 3 day initial intensive (aligned with the Principals' workshop), followed by a 2 day intensive closer to the end of the semester of study. This allows teachers to have significant information about the academic unit and also allows them to 'try for themselves' aspects of their learning from one intensive to the next. Each assessment piece in each unit is designed to fit into a school curriculum, to add value to the teaching, rather than adding unnecessary extra work to the teacher.

11.2.5.5 Research and Monitoring the Programme

This involves the tracking and analysis of school and teacher change processes, which are fed back into schools and the units to support ongoing innovation. The research component involves the development of case studies of eight selected schools so that in-depth understanding can be gained about how schools developed their STEM vision and implemented sustainable and successful change to students' STEM outcomes. Due to the innovative nature of this programme, the methods for support are emerging through the monitoring aspects. The monitoring component involves discussion and feedback from teachers and principals through the use of a group Facebook site and through the use of a School Liaison Officer (SLO). The role of the SLO is to keep in touch with schools regularly via email and school visits and to assist with any aspect of school change/curriculum matters. The SLO is a previous teacher of STEM subjects who searches answers to teachers' questions—saving them time and effort. In addition to this, a number of other measures of teacher and school development are undertaken which are as follows:

- a pre-programme survey.
- mapping of teacher capabilities using an STEM component mapping tool developed specifically for this purpose.
- collection of teacher artefacts: school vision statements, planning documents and students attitude survey (aggregated results).
- Post-programme survey.

11.2.5.6 Recruitment Practices

For this specific initiative, the DET sent out invitations to the 30 schools identified as low 'socio-economic status' (SES) across the state of Victoria. The school had to apply to be part of the programme with the recognition of compliance with the defined elements of the participation: principal and teacher participation. Teachers involved in teaching mathematics, science, technology or STEM, in year seven and eight (children aged 12–14), were offered the opportunity to participate, although it is uncertain how much of the detail of initial information was understood. Often with other professional learning structures, teachers are not expected to 'study' or undertake additional workload to complete the professional development. The expectations of an academic qualification are different.

11.2.5.7 Programme Evaluation

The programme is being evaluated in a number of ways. Through monitoring and research, the programme will be evaluated for components such as teacher development, school change processes and leadership in STEM. Whole cohort data collection will consist of the collection of artefacts developed by the teachers across time. In parallel with this, in-depth case studies of 8–10 schools, featuring interviews with all stakeholders and artefact collection will be developed and used in a cross-case analysis. This information will be combined with the individual unit evaluations which occur as part of the university procedure at the end of each unit. The evaluation of each unit considers students' satisfaction with the teaching, quality and provision of materials and aspects enabling student learning.

Initial evaluation findings suggest that the role of the SLO has taken on much greater importance than originally predicted. The feedback from the STEM teachers is that they find the SLO staff crucial for providing on-the-ground support, guidance and materials. Considering that the teachers involved include a mixture of experienced and non-experienced teachers who are meant to support each other in their paired roles, this finding was quite surprising. However, the added element of completing coursework assignments related to their course has stretched the teachers' capacities to deal with new curriculum developments in STEM without further support.

The first unit of the course was one which required teachers to develop understanding of theoretical perspectives on learning theories. The subsequent unit evaluation indicated some interesting trends. The more experienced teachers did not value the time spent on discussion of theories and wanted specific advice and material to move more quickly in the school environment. However, the younger, less experienced teachers appreciated the slower approach and having the opportunity to apply theory to their practice—to better understand why they were doing it. This information will be fed into the subsequent units so that they can be developed along lines to accommodate both groups of teachers.

Another aspect of evaluation is the appointment by the Department of Education (Victoria) of an independent evaluation company. Its role will be to make contact with all schools and teachers to undertake a full evaluation of the programme and its components, including the Graduate Certificate of STEM Education.

At the completion of this programme, a detailed report will be written by the provider of the professional development, providing insight into all aspects of the programme. This information will be used to support a revised version of the professional development and the delivery of an ongoing Graduate Certificate of STEM Education, in online mode only and open to all teachers.

11.3 A Cross-Case Comparison of the International Case Studies

We applied a cross-case analysis to the international case studies to facilitate a comparison between commonalities and variances in events, processes and activities that inform the evaluation of the cases. As indicated earlier, we considered components of analysis derived from previous literature—the features of effective professional development as outlined in Table 11.1. Normally, cross-case analysis extends understanding beyond the single case to the numerous, allowing for the delineation of a variety of factors that are contributors to the results of a case; to explain why differences and similarities are evident across cases; to understand perplexing or distinctive case findings or to extend concepts, hypotheses or theoretical positions uncovered or developed from an original case (Khan and Van Wynsberghe 2008). For this cross-case analysis, we use direct case knowledge generated from the 'thick description' of each professional development setting, to support further discourse on the professional development models. It is this form of qualitative, comparative research design that allows the distinctive traits of multiple cases to support reflections on similar or contrasting findings (Bryman 2012) and allows us to develop a framework for effective professional development for out-of-field teachers (see Fig. 11.1).

From reviewing each of the international case studies detailed in this chapter, thus far, it is clear that there are many similarities and indeed differences between the out-of-field professional development programmes in terms of the context and goals, structure, recruitment practices and the means through which the quality of the programmes is measured. The following characteristics are present across country case study for each of the parameters being used for comparison.

11.3.1 Context and Goals

- All programmes are government funded and aim to specifically tackle the issues of out-of-field teaching in the area of STEM education in an attempt to improve the current teaching situation within these disciplines due to them being linked to the economic prosperity of a country (Marginson et al. 2013; Office of the Chief Scientist 2014).
- All programmes came about due to the incidence of out-of-field teaching being investigated in some formal way in their respective countries.
- Programmes were developed for different purposes. Some aimed to support teachers currently teaching out of field (e.g. Australia) to be better teachers, while others

Fig. 11.1 A framework for effective Professional Development (PD) programmes for out-of-field teachers

aimed to upskill the out-of-field teachers into specialist subject teachers (e.g. England).

- The case study from Victoria in Australia was unique in that it only offered the upskilling programme to teachers from lower socio-economic schools.

11.3.2 Structure and Design Features

In terms of the structure of the programmes, there was a larger variety across countries with some similarities present. The design of the programmes should be aligned with the desired outcome of the PL. In the Tasmanian case, late changes to the design due to political imperatives caused organisational difficulties and affected the quality of the learning.

- Some of the programmes were 2-year part time with a level 8 discipline-specific qualification as the outcome for a successful candidate while others involved 40 days of engagement with the programme and resulted in the teacher gaining an additional specialism in a specific discipline.
- All programmes, with the exception of the Irish case, involved having some form of school-based discipline-specific mentor and also enabled out-of-field teachers engaging with the programmes to get some 'buy out' time from school with some additionally supporting the engagement with the programme by providing an addition £5,000 in teachers' salaries for that year (the case of England).
- All programmes required the support or at least approval from the school principal/management, with the Victorian case study detailing that the programme also included sessions for the principals as well as the out-of-field teachers.

The programmes also have some contrasting elements when it comes to their design features:

- The focus of each other programmes varies considerably. Some programmes specifically detail that they are not focussed on teaching content knowledge but rather focussed on curriculum, leadership, pedagogy and research (the cases in Australia) and some focus on both mathematics-specific content knowledge and discipline-specific knowledge (the case in Ireland and England). These variations in design features could be seen to be reflected in the time over which the programmes are run; however, variations exists even across programmes which run over the same time frame.
- The blended learning format is common across all programmes often being mentioned in the context of reducing travel time for participating out-of-field teachers.
- The assessment strategies for the programmes vary depending on what the focus of their design features are (i.e. focus on content only or pedagogy and school practices only or both); however, all programmes have some assessment which involves out-of-field teachers attempting to bring their learnings to their classroom and reflect on their practice as out-of-field teachers.

11.3.3 Recruitment Practices

In most country case studies, the recruitment process began with the government calling for an expression of interest from out-of-field teachers to come forward to engage with the professional development programmes with the exception of the case of Victoria where 30 socio-economically disadvantaged schools were invited to apply to take part. All programmes detailed in the case studies in this chapter insisted that school principals sign off on teachers within their schools who had applied as being out of field and in some cases ensuring the support that they and the school would provide the participating teachers while engaged in the programme (the case of the England). In the case of Victoria, the principal had to sign off on the 'whole school' involvement in the programme (principals, catalyst teachers and other teachers as necessary). In no case was the out-of-field teacher obliged to take up a place on a professional development programme; however, some of those who did volunteer may have underestimated the level of work and commitment which was involved.

11.3.4 Programme Evaluation

There is some variation with respect to the extent and weighting that different professional development programmes currently place on evaluation:

- In the case of Ireland, the presence of a full-time academic coordinator allows for real-time feedback about the programme to be reported from nationwide staff and students with the benefit that real-time changes can be made to improve practices if needed.
- Many programmes implement a general programme review where participants can detail their overall satisfaction with different aspects of the programme. This appears to provide general useful information for advancement of the programmes.
- Some evaluations involved interviewing a small number of participants or discussion and feedback from teachers via an online forum.
- The Irish professional development programme evaluation involved a very extensive evaluation of pedagogical and content knowledge of out-of-field teachers through pre- and post-programme completion which is discussed in detail in Chap. 5. There is also an examination of the effectiveness of the mathematics-specific pedagogy workshops within this programme and a doctoral thesis currently looking into teacher identity upon programme completion.
- One programme had an external examination of the programme in the form of a monitoring committee which consisted of government members and involved report writing on the programme effectiveness over time (the case of Ireland).

11.3.5 Programme Effectiveness

Several common themes emerged in terms of programme effectiveness from the case studies presented in this chapter:

- A very strong theme was one which found that the discipline-specific pedagogy elements of the professional development programmes to have a strong impact on teachers opinion of the importance of and willingness to implement student-centred/inquiry-based teaching as opposed to a more didactic traditional approach to teaching STEM subjects. Enquiry learning was deemed as something that was worth the effort as practice in the classroom showed improvements in student engagement to many of the professional development programme participants. Some evaluations demonstrated that participants found the pedagogy aspects of the programme to be the most useful in terms of developing ideas and strategies for the classroom and called for more of this. The research showed the focus of the out-of-field teachers changed from 'how to teach a specific topic' to learning and doing mathematics, i.e. the teachers began to see mathematics as more than knowledge and skills.
- Another theme which emerged in terms of programme effectiveness was participants' appreciation for the face-to-face aspects of their respective programmes, i.e. the spaces in which there was room for discussion and sharing of ideas whether it be mathematics content tutorials or sharing pedagogy experiences from the classroom.
- In spite of this appreciation for the face-to-face aspects of the programmes, the evaluations also noted that the blended format in which some material is presented online was seen as a positive by many as it enable the reduction in travel time.
- Participants across the cases who successfully completed their respective professional development programmes appear to have reported embracing the significant challenges that all programmes seem to have presented. Out-of-field teachers reported growth in their confidence as teachers of a particular discipline increased inclination to take risks and learn from mistakes and a motivation factor relating to the status of becoming a specialist teacher.

There were also some common negative aspects of the professional development programmes across country cases:

- Some programmes did not focus on content knowledge and this is something which evaluation showed that out-of-field teachers would have preferred.
- A lack of coherency and support of the teachers engaged in the out-of-field programmes (no 'buy out' from class time, poor leadership support/knowledge on what the professional development involved) resulted in a more challenging environment and larger stress levels on the teachers involved in the programmes.
- Several evaluations reported a professional development programme with a workload that was too heavy and rushed both in terms of trying to implement pedagogical practices learnt into the classroom and summative assessments. Many participants across programmes felt that a workload that was too heavy with a time frame that was too short to implement and reflect on change and in some cases students dropped out of programmes for these reasons.
- Problems with the online platforms not working from time to time seemed to have caused issues across the board also despite the support for the blended learning

style due to its accommodation for those who had to travel long distances to attend class/lectures.

The comparison of the case studies across countries and, in particular, the examination of the effectiveness of each of the programmes allows for some concrete ideas to be pulled together to determine what a framework for effective out-of-field professional development programmes might look like based on lessons learnt from existing structures. Such a framework will be discussed and put forward in the section which follows.

11.4 Towards a Framework for Effective Professional Development

As the reporting of the incidence of out-of-field teaching and indeed the development of programmes aimed at upskilling out-of-field teachers is a relatively new phenomenon, the case studies presented in this chapter go some way in trying to determine what aspects of a professional development programme specifically designed for out-of-field teachers work and which do not. The comparison of characteristics and their perceived success of each of the country case studies presented in the previous section allowed for the pulling together of the most effective aspects of all programmes, along with caveats that should be born in mind, and these are presented in Fig. 11.1.

The framework detailed in Fig. 11.1 outlines characteristics and elements for consideration for effective professional development programmes for out-of-field teachers; it also takes in the components of the meta-synthesis of effective professional development as outlined by Hawley and Valli (1999). In this meta-synthesis, the authors detail a need for the content of professional development to focus on what students learn and addressing students' difficulties. This would be covered in the discipline-specific pedagogy aspect of effective professional development for out-of-field teachers. It also calls for professional development to be based on an examination of the gap between students' actual performance and curriculum goals and standards for teaching. The focus on student-centred learning and teaching for understanding, as outlined in the framework proposed in Fig. 1, provides a platform for this gap to the closed. Hawley and Valli (1999) call for professional development to be primarily school based and to involve teacher identification of what they need to learn and develop—the framework for professional development programmes for out-of-field teachers calls for out-of-field teachers to still be engaged in their everyday teaching and to have some 'buy out' from class time which allows for these aspects of effective professional development to be fulfilled. All other aspects of Hawley and Valli (1999) meta-synthesis of effective professional development are possible within the existing proposed framework for the development of effective professional development for out-of-field teachers. This includes things such as: being organised around collaborative problem-solving (pedagogical aspects of the programmes should involve this), it should be continuous and ongoing providing internal and external support (the presence of a school-based mentor system and the consideration for ongoing support for all school teachers allows for this), it should involve multiple evaluations (as seen in the Irish case study and incorporated in the framework in Fig. 11.1) and finally it should provide an opportunity to gain an understand the theory underlying the knowledge and skills being learnt (pedagogical aspects of the programme would provide a platform for this along with the delivery of the programme using an inquiry approach).

11.5 Conclusion

This chapter brings together current international developments in the area of the professional development of out-of-field STEM teachers. Using research literature, several models of professional development from the Republic of Ireland, England and Australia (four in total) were interrogated against proposed examples and components of effective professional development for teachers. A cross-case analysis was undertaken, searching for themes related to similarities and differences across the cases. The examination of the models, each of which included results from evaluation studies, detailed key components for effective professional development models for out-of-field teachers. These key components were similar to the features of effective professional development programmes highlighted in the literature, but also included aspects that were not as well defined and were particular to the 'out-of-field' teacher. An international framework for effective teacher professional learning for out-of-field teachers was developed using data from the four cases. In the analysis of the four models, key insights and new knowledge were gained in relation to the needs of out-of-field teachers' professional learning. These are summarised below:

- Teacher quality requirements recognise that the teachers assigned to teach subjects other than their own specialist subject need to be targeted and supported with continuing professional learning opportunities. The common finding of the studies presented in this chapter is that this type of professional learning requires substantial support at all levels.
- Subject knowledge and identity-related issues were highlighted to be amongst the factors affecting the professional development and retraining of high-quality out-of-field teachers. There is not a quick-fix retraining of an out-of-field teacher to become a subject specialist teacher.
- Developing the out-of-field teachers as a subject specialist is linked to reshaping their identity as teachers of their out-of-field subject. Professional development needs to attend to teacher identity development.
- Professional development that promotes engagement with school curriculum content (e.g. mathematics) and alignment with the particular teaching practices (e.g. mathematics) contributes to teacher identity in that area.

For each of the four case professional development programmes studied, the aim was to support teachers to become better teachers in their out-of-field area by building their identity as teachers of the out-of-field discipline as a continuous process (as they teach) and by allowing them to gain content knowledge and pedagogical skills as they grow. This is a distinctly different approach to that where, for specialist teachers, the aim might be to further develop specialist knowledge to meet accreditation standards.

As with any comprehensive research or analysis of practice, findings often point to ways to move forward or recommendations for the future. There are significant implications from the study of the four cases, implications which have impact on both policy and practice. With most professional development being highly reliant on contextual factors that influence its impact and uptake, the programme needs to be both designed around its purpose and be specific to the teachers' needs and situations surrounding the teachers. Developers of professional development need to be clear on what they are trying to achieve and this would require a close examination of the context, and local and institutional policies and practices. From the cross-case comparison and analysis, recommendations were framed as follows:

- At the school and policy levels, provision of high-quality in-service professional learning opportunities needs to occur through professional development and funded retraining programmes.
- Funding, time and space for out-of-field teachers are needed to allow them to adapt to and understand new teaching approaches to maintain quality teaching. This will assist with the retention of teachers, avoiding the loss of teachers due to stress created from teaching outside their specialism.
- School leaders need support to appreciate the demands of out-of-field teaching, and to foster communities that respect and support continuous learning of teachers.

In designing and delivering the training, schools should work with strategic partners (for example, higher education institutes, teacher training institutions and national centres of excellence). All staff directly involved in the development and delivery of training of out-of-field teachers should have a deep understanding of both the specialist subject required for high-quality teaching of the subject and of how teachers develop this knowledge. Considering that out-of-field teachers are already working in potentially stressful situations, any programme should offer teachers some form of professional recognition. Such courses could offer professional awards (such as Masters level credits or a professional award/certification) nationally recognised so that out-of-field teachers could use them as evidence as professional development in their new subject specialism. Professional development offered within a school or through external courses need to offer both discipline and pedagogical knowledge, so that the out-of-field teacher has the opportunity to develop their own pedagogical content knowledge.

Teachers are continually learning and developing in their profession. In particular, out-of-field teachers face this 'learning imperative' in a much more concrete and intense way on a daily basis. Professional development, as outlined in the framework above, offers opportunities to out-of-field teachers to change their thinking, knowledge, skills and approaches to teaching in an informed and continuous way.

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Chapter 12
The Out-of-Field Phenomenon: Synthesis and Taking Action

Linda Hobbs and Günter Törner

Abstract Having examined the various dimensions of the out-of-field phenomenon, and methodological issues facing researchers, this chapter provides a synthesis of the themes emerging from across the chapters. The chapter begins with aligning some of the ideas emerging in the preceding chapters with a set of priority actions proposed at the first TAS Collective symposium in 2014. Five recommendations are proposed to highlight what is needed to *reduce* the need for out-of-field teaching and *improve* the quality of teaching when teachers are faced with having to teach out-of-field, and the need to *prepare* teachers for the challenges that they may face on entering the teaching profession. Where is change needed and why? Who is responsible for creating that change? And what disruptions within the education systems in different countries will be needed to bring the traditional school structure and teaching into the twenty-first century? Informed by the findings of the chapters in this book, an agenda for research and action presents the locus of change as sitting not only with the teachers, but also with those responsible for school governance structures, systemic and societal change, and initial and continuing teacher education. A cross-national perspective on understanding the out-of-field phenomenon is presented as being essential for informing both local and national responses to the issues.

Keywords Teaching out-of-field · Teaching across specialisations · Taking action

12.1 Introduction

Long traditions of education have privileged discipline-bound segregation of curriculum, based on an acceptance that immersing young people in the range of disciplinary

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L. Hobbs and G. Törner (eds.), *Examining the Phenomenon of "Teaching Out-of-field"*, https://doi.org/10.1007/978-981-13-3366-8_12

ways of knowing and inquiry are needed for preparing an informed, socially acceptable and capable citizenry. These disciplines have become 'silos' of knowledge that are taught in isolation from each other. Teacher preparation in many countries perpetuate and align with these silos, although at times through history the traditional silos have been challenged through integrated curriculum and context-based learning, for example, as is seen through the latest STEM education movement.

At the tertiary level, these silos are maintained, as has been demonstrated in this book; however, school teachers are often required to teach a subject they are not trained in. In the face of teacher shortages, this disparity arises because of two factors that are inherent within most education systems worldwide: (1) teacher allocation within schools is largely at the discretion of the principal, and (2) there is an imperative to get a teacher in front of every class.

Is this acceptable practice? How much out-of-field teaching can a system tolerate before the effects have a detrimental impact on the education system? What responses are needed? This chapter is written with the assumption that out-of-field teaching needs to be recognised and managed, and sets out a number of actions and recommendations for responding to out-of-field teaching.

12.2 Beginning with Priority Actions

In 2014, the first symposium of the Teaching Across Specialisations (TAS) Collective involved researchers and practitioners from five countries. An agenda for research and action was generated at the symposium and published in a conference proceedings (Hobbs and Törner 2014). This agenda provided a number of priority actions, summarised in Table 12.1.

The first priority action focuses on removing the need for out-of-field teaching by ensuring that there are enough teachers in the system to meet demand. This means recruiting enough teachers, recruiting the right type of teachers, distributing the teachers to schools according to need and ensuring that where adequate numbers of teachers are available that they are allocated to subjects that match their specialisations. Required for this action is adequate data to identify demand, and ongoing monitoring of this demand, both as teachers exit initial teacher education through teacher registration or certification, and as they move through the education system so that there is continued accounting of who is teaching what subjects. Under such a regime, relationships between school academic performance and teacher specialisations should be treated carefully, especially when out-of-field teaching is subject to the same accountability measures as in-field teaching.

Given that we are unlikely to remove the need for out-of-field teaching immediately, the second priority focuses on maintaining the quality of teaching where out-of-field is unavoidable. This recognises that sometimes out-of-field teaching is desirable when teachers are pursuing interest areas, or where curriculum innovation demands integrated curriculum models. The main thrust of this action is to provide adequate professional learning opportunities and resourcing needed to support

Table 12.1 Priority actions on Teaching out-of-field

1	Priority action 1. Reduce the need for out-of-field teaching
1.1	Increase supply of high quality qualified teachers
1.2	School leaders aim to appoint and assign the appropriately qualified teachers to teach science and mathematics
1.3	Raise the profile of, and level of respect accorded to, education and teaching as a career
2	Priority action 2. Improve the quality of out-of-field teaching
2.1	Providers to supply quality in-service teacher learning opportunities: professional development, retraining programmes
2.2	At school and policy level, provide funding, time and space for out-of-field teachers to adapt to and understand new teaching approaches in order to maintain quality teaching, as well as to avoid losing teachers due to stress created from teaching out-of-field
2.3	Support school leaders to appreciate the demands of out-of-field teaching, and to foster school communities that respect and support continued learning of teachers
3	Priority action 3. Increase the readiness of teacher graduates to face the challenge of out-of-field teaching
3.1	Teacher education programmes to raise an awareness of, capacity to respond to, and expand identity in the face of the out-of-field challenge, while still maintaining commitment to subject-related requirements

Source Hobbs and Törner (2014), used with permission

teacher learning. At the school level, this means respecting the demands associated with out-of-field teaching. Retraining provides additional qualifications that mean that technically teachers are no longer regarded as out-of-field, although a Graduate Certificate in a new subject area may not be picked up by broad-scale surveys that use undergraduate training (such as completion of a second year unit, see, for example, Weldon [2015]) as the measure of being in-field. This priority action acknowledges the tension between teacher qualifications and teacher experience when making decisions about whether a teacher is suitable for teaching a subject.

Numerous studies show that teachers within their first few years of teaching are more likely to be assigned out-of-field than their more experienced colleagues. The third priority action focuses therefore on the need to ensure that teachers entering the teaching profession are aware of this reality. Universities and teacher education providers are often subject to strict regulation around teacher standards or competencies, which are tied to teacher registration or certification processes; although this is not the norm in all countries. Where teacher preparation is disciplinary-based, that is, teachers undertake studies that relate to specific specialisations, often a restricted set of specialisations are offered, such that teachers are not 'prepared' adequately to teach other specialisations. Tensions, therefore, exist between what teacher education providers are able to cover in order to meet regulatory requirements, and the reality that teachers will likely teach out-of-field at some time in their teaching career. The challenge for initial teacher education is to provide multiple opportunities for their students to obtain or develop the necessary knowledge, dispositions, identities and capabilities that will enable them to recognise the learning potential, support mechanisms and personal resources that will be needed to manage teaching out-of-field.

These priority actions are our starting point. The insight provided in this book extends these priority actions by helping to highlight through an international comparison, systemic-related differences in what counts as out-of-field teaching, difficulties in conducting comparisons of incidence due to differences in the qualification requirements of an in-field teacher (see Chaps. 3 and 10), and variation in how broad subject categories are regarded (see Chaps. 3 and 6). Different countries, states and jurisdictions recognise out-of-field teaching to different degrees, as pointed out in Chap. 1, attracting the attention of administration and prompting action in different ways, from simply ignoring the issue, to providing funding for professional development when data shows unreasonable levels of out-of-field teaching (see Chap. 11), to regulating mandatory requalification for out-of-field teachers (see Chap. 1). Mandating teacher mentoring for beginning teachers is different to simply providing the option for additional time and mentoring as set out in government policy, which may or may not be actioned by a principal (see Chap. 9). Also, cultural variation in what is regarded as a quality teacher and quality teaching means that there are different requirements for teacher registration and certification (see Chaps. 5 and 10). For example, state tests for certification to teach particular subjects exist in some jurisdictions while others use teacher education entry requirements to allocate and monitor specialisations. This variation in certification and registration processes leads to differences in the types of data being maintained within the system, with registration and verification bodies keeping records on the numbers of teachers entering the system, or the number of 'types' of teachers.

12.3 Recommendations

In order to set an agenda for research and action, a set of recommendation have been developed that draw on insights from the previous chapters. Why is it important to take action on out-of-field teaching? At a fundamental level, limiting out-of-field teaching means that teachers are more likely to have the disciplinary background matching their teaching assignments. This, of course, does not guarantee quality teaching, but it does provide a sound basis for ensuring teachers have adequate content and pedagogical content knowledge, at least in principle. Actions here mean *reducing*, *improving* and *preparing*: reducing the need for, improving quality teaching in the face of, and preparing teachers adequately to meet the system demands for, out-of-field teaching. The following recommendations are written as a set of needs, paying attention to the various stakeholders who have some responsibility for or are affected by out-of-field teaching, and what actions should be considered when responding. Each recommendation begins with a question that frames the ideal and elaborates on the issues that the recommendation is attending to.

Recommendation 1. There is a need to understand the supply and demands issues that lead to the necessity for out-of-field teaching.

A. What would a system look like where the supply and demand of teachers was adequately monitored and informing of teacher recruitment and improvement approaches?

B. What 'tolerance threshold' is suitable, what evidence is used to establish this threshold, and what variables and systems should be measured?

Where teaching positions cannot be filled with appropriately specialised teachers, a principal must assign out-of-field teachers—this may mean recruiting teachers for out-of-field positions, or assigning current staff who may be out-of-field. The underlying problem is an undersupply of teachers, whether it is due to a lack of qualified teachers, unequal distribution of teachers or recruitment practices that give preference to qualities other than teacher specialisations (as discussed in Chap. 1). Teaching out-of-field is a solution to a problem that inadvertently masks the extent of teacher shortages. A system that has an accurate record of the supply and demand of teachers needs adequate data that quantifies the 'real' teacher shortage in terms of location, subject, school types and levels, and then provides an accurate accounting of the extent of out-of-field teaching. A complication of the out-of-field phenomenon is that out-of-field teaching continues to persist even in areas where there are adequate records of teacher certification or where teachers obtain formal approval to teach. The problem of teacher shortages, for whatever reason, therefore remains an ongoing issue.

Data that shows the real extent of out-of-field teaching is needed so that approaches used to address the issues that arise are informed by a sound empirical base. In Chap. 2, Ingersoll emphasises that decisions about what to measure influence the estimates of out-of-field teaching. Different measures enable researchers to look at the same phenomenon in different ways. Therefore, researchers need to choose the measures carefully and explicitly acknowledge exactly what is being measured. Also Chaps. 1 and 8 highlighted the fact that there are different groups of teachers that make up the out-of-field teaching population, such as teachers who are permanently out-of-field and others short term. These different groups have different needs, but the lack of data is preventing opportunities for systemic response to support these different groups. Chapter 8 provides some recommendations for policy that need to be informed by data:

- Recruitment initiatives require ongoing support mechanisms;
- There needs to be succession planning that forecasts teacher attrition; and
- Improved working conditions of teachers are needed to entice 'the best and brightest' university graduates and professionals into teaching.

Data should not be restricted to incidence, but include other measurements and representation (quantitative and qualitative) of the effects of out-of-field teaching, the reason teachers teach out-of-field, the approaches that work in maintaining teaching quality, and how initial teacher education might contribute to the problem and be part of the response. Complications exist in ascertaining and representing these effects, however, as this book has shown, as the effects are complex and dependent on many factors, including teachers' personal resources, the effect of school context, governmental direction or intervention, etc. Chaps. 2 and 7, for example, showed that the relationships between student achievement and teachers' specialisations, qualifications, certification and background is not clearly established in the literature. The variables are many and the different methodologies that can be available (for example, single point in time versus longitudinal methods) provide different data. Other variables such as teacher experience has also been shown to be correlated with student achievement, for example one TIMSS[1] analysis of Australian data showed that mathematics teacher qualifications affected student mathematical achievement, but in science the teacher's experience was more strongly correlated to student achievement (Thomas et al. 2017).

Such data might inform a cost–benefit analysis that takes into account the costs and benefits associated with teachers teaching out-of-field, against the costs and benefits of seriously attending (and not attending) to both the issues associated with out-of-field as well as the mechanisms that lead to the need for it. Further attention needs to be given to consider how such an analysis might usefully inform action in response to the out-of-field phenomenon.

A 'Tolerance Threshold' could be used in this instance to identify at what point an education system is negatively impacted by out-of-field teaching, and up to which point it would be regarded that, on a system level, the impact of out-of-field teaching is not detrimental. When establishing such a threshold it would be important to decide on:

- What does negative impact mean?;
- What positive impacts might arise?;
- Who is impacted?;
- Which parts of the education system might be considered, e.g. school, universities?; and
- How should impacts be measured?

A threshold would need to be deemed culturally acceptable and must be informed by a realistic understanding of the variety of causes, effects and responses possible within the system. Such a threshold would need reliable data on incidences, also reliable and rich data on the effects of out-of-field teaching on teachers, student learning and attitudes and other key stakeholders. There would need to be some accounting of the possible learning trajectories of teachers, such as professional development uptake and cultures of support within schools. Or at least identify the approaches that might be taken to reduce negative impacts when teacher shortages reach a certain point.

Such a threshold is culturally determined by what a society is willing to tolerate. An example of a low threshold can be seen in South Korea where a policy of

[1] Trends in Mathematics and Science Survey.

limited school autonomy was introduced where principals had some control over teacher recruitment, rather than relying solely on teachers being allocated to schools depending on need. When this policy was introduced, there was a small percentage of out-of-field teaching recorded, which was deemed unacceptable, and at which point the policy was changed (Kim 2014).

Such thresholds may be used to introduce or change policy, as illustrated above. Thresholds may also be used to map approaches that might be taken at different points leading up to the threshold, and at the threshold. For example, the 2013 Staff in Australia's Schools (SiAS) survey data showed that 37% of Years 7-10 teachers in the Australian state of Tasmania were out-of-field (Weldon 2016). The state government was prompted to act and funded the professional learning programme outlined in Chap. 11. Up to this point, the government had remained silent on the issue. Obviously, there are a number of political mechanisms that determine whether there is action on issues such as these. But clearly, 27% was beyond the threshold of what was deemed tolerable.

Recommendation 2. There is a need for explicit attention to teacher learning that is tailored, systematic, recognised and remunerated, and embedded.

What would a system look like that

- expected teachers to be qualified or specialised or certified for the subjects that they teach? and
- ensured teachers and schools were supported to maintain teachers' professional knowledge through funded re-specialisation?

SYSTEMATIC: Chapter 8 raised concerns about the unsystematic approaches to teacher learning inherent in the case studies from Australia and United Kingdom. Teachers were seen to be winging it, 'having a go', finding their own way 'at the mercy of almost random opportunities to develop new skills that are congruent with system needs' (Chap. 8). Localised and personal action is the only resort when there is no systemic acknowledgement of the phenomenon, nor adequate means for teachers to be supported in their response. There is a need for recognition of the out-of-field teaching as a challenge that teachers more often than not must face at some point in their career. Also recognition that it can problematic for teachers, but that is does not have to be. There is then a need to expect that adequate support will be provided to teachers, at a school and system level.

RECOGNISED and REMUNERATED: Under such a regime, out-of-field teachers could be expected to upgrade to gain additional qualifications. If we believe teacher background and exposure to the disciplines is important for effective teaching, then requalifying or specialising should be rewarded or at least respected by the profession. Further, there is a need to recognise the value of qualifications and to remunerate teachers to undertake ongoing teacher education. For those 'just filling in', it may not be important, but for those pursuing an interest or wanting to improve their practice, they should be supported (with funding) to undertake additional courses to obtain additional subject specialisations. Where teachers are expected and funded to undertake further studies in areas they are teaching out-of-field (see Chap. 1), the incidences of out-of-field teaching may be more likely to be reduced. Research is needed, however, that examines whether there are relationships between teacher requalification and the drop in incidences of out-of-field teaching by more experienced teachers—are there fewer experienced teachers teaching out-of-field simply because they have requalified to teach the out-of-field subject?

TAILORED: While PD might be one solution, what constitutes PD suitable for out-of-field teaching must be considered; professional learning in schools as well as respecialising through funded programmes are two ways. Professional development needs of out-of-field teachers are different to in-field teachers as there are identity issues that come to bear on a teachers' willingness to undertake PD but also in their belief in their capacity to learn (see Chap. 11). Also there are long-term out-of-field teachers who have developed immense capacity to be effective teachers in these out-of-field areas who quite rightfully do not see the point in formally upgrading their qualifications by undertaking expensive professional development (a Graduate Certificate qualification on Australia, for example, can cost $10,000).

Chapter 11 provided a useful framework for effective professional development programmes for out-of-field teachers. Content tailored specifically for out-of-field teachers can mean going back to basic ideas and relationships between content across the curriculum, with a focus on discipline and pedagogical knowledge, as well as specific attention to teacher identity development. School-based support should follow so that teachers have the time, space and support needed to trial new approaches and apply new knowledge. The best models for the professional development are longitudinal and extended rather than one-off events with cycles of learning-implementation-reporting. The authors also reinforced the requirement that the PD be professionally recognised as additional qualifications, such as Masters or Graduate Certificates.

EMBEDDED: Chapter 9 concluded that school culture was an important factor in determining the effects of teaching out-of-field. First there is a need for a *culture of recognition* of the broad-reaching effects of out-of-field teaching on teachers, students, other staff in the school and the broader school community. This means supporting teachers to navigate the difficult challenges that they face, such as negotiating the teacher–student–parent relationships, especially where criticisms of the teacher arise due to teachers being unprepared to teach the out-of-field subject. The principal is a significant player in creating a constructive environment where the difficulties that teachers can face is not underestimated. Second, where there exists a *culture of support*, sharing and collegiality, all staff stand to benefit rather than the flow of knowledge (and blame) being directed only at the out-of-field teacher. Under such a regime, teacher learning is normalised and valued, and practices such as peer observation, teacher reflection and collaboration are embedded in the normal operation of the school, such as through timetable allowance and funding provision for professional learning. This may be as simple as preferring that teachers reteach subjects and year levels. This respects the value of reteaching to develop teacher confidence and expertise, more coherent knowledge of curriculum, and better collaboration within teaching teams. Third, under such a regime, a *culture of respect* for teachers, what they know and what they can do may be exhibited as that teachers being given some agency or at least being consulted in what and how they teach; also that there is respect for teachers' subject-specific knowledge and attitudes when appointing and allocating teachers to positions and roles, and when establishing communities within the school, such as in organisation of staffrooms, establishing professional learning communities or mentoring relationships.

Research is needed into the experiences that lead to confident and competent teachers. How can these be resourced, institutionalised and systematised to ensure such experiences and processes are part of the normal functioning of schools?

Recommendation 3. There is a need for distributed responsibility

What would it look like if all stakeholders seriously paid attention to dealing with out-of-field teaching?

Given that our systems (Government, University, Schools) are unlikely to change overnight, the locus of change needs to be distributed so that we respond with complex solutions to this complex issue facing many schools. It is wildly unfair to place the locus of change only on teachers.

POLICY MAKERS need to be made aware of the incidences and effects, and to seek out and distribute a range of approaches that acknowledge the many reasons that teachers teach out-of-field and the variation in support needs of teachers, school leaders and other staff. This needs to be translated into policy that explicitly acknowledges, provides for and mandates some action in response to out-of-field teaching.

SCHOOL LEADERS. School governance is constrained by the system. Basically, out-of-field teaching is the least of their problems—the overemphasis on school accountability and reporting at present is stifling good governance. But also, Chap. 9 showed that sometimes school leaders fail to recognise the difficulties that some out-of-field teachers can face (Du Plessis et al. 2015). School leaders need professional development in knowing how to adequately support these teachers: out-of-field teachers need time for learning, collegiate support, continued links with their in-field area and some input into their load in order to maintain staff morale. School leaders make decisions about staffing—sometimes staffing decisions are restricted to appointing new teachers who do not fully fit the subject profile needed, simply because of a lack of suitable applicants. But sometimes the decisions are driven by timetabling to a point that in a school you may find a PE teacher assigned to mathematics, while the mathematics teacher teaches PE simply because of the way the timetable falls. Also, student subject choice can also influence subjects being offered, and therefore the teacher specialisations needed. School autonomy is part of this problem—school leaders have to work with the staff they have. In other countries (such as South Korea), teachers are placed in schools as needed to get the right mix of teachers (Kim 2014).

UNIVERSITIES in the first instance, particularly in teacher education, need to acknowledge, as part of their programmes, the realities that their graduates will face, that is, most likely teaching out-of-field. Chap. 10 has offered suggestions on preparing their students—from raising awareness, to specifically focusing on adaptability and the need to have a flexible mindset, to giving students the necessary 'tools' to continue learning and researching their practice.

In addition, universities need to take seriously their teacher education remit and go beyond initial teacher education, and work with schools to tailor professional development that is informed by theory, and further education opportunities for obtaining certification in a new subject. Whether teachers take up these courses and opportunities, however, is contingent on whether they feel they 'need' additional training, whether they are 'required' to requalify or seek additional training, and whether they can afford it (if unfunded). For example, a suite of funded retraining initiatives offered in the state of Victoria in the early 2000s for teachers from hard-to-staff schools had limited uptake by teachers wanting to requalify as mathematics teachers, despite the incidence of out-of-field mathematics teachers being at about 20% (Harris and Jensz 2006), and as a result the mathematics initiative was the first to cease. So, while the universities may work with governments to offer funded placements, they can only be offered when there is the demand. Demand will not address the real shortage of appropriately specialised teachers unless there is some expectation that teachers are formally specialised.

Out-of-field teaching needs to be understood in the context of the broader issues facing schools. There is therefore a need for a mindset change:

- By teachers and schools to value upgrading qualifications (which would mean a change in the perceived value of the tertiary sector by Governments and Schools);
- By Governments who must respect the need for funding and remuneration of teachers and that additional policies need to be put in place that explicitly address how schools can usefully maintain teaching quality when out-of-field teaching is needed; and
- By the university sector (which should be funded appropriately) to appreciate the importance of responding to the profession through producing the right number of teachers in the right subject areas (rather than churning out teachers who may struggle to find employment) and in working closer with schools to offer retraining courses in areas of need.

Finally, the teaching profession needs to be prepared to reconsider the role of the 'subject' in schools. This is important as schools are exploring new curricular arrangements. In particular STEM is offering new curriculum models and teacher collaborations leading to teachers teaching unfamiliar subjects, but also working with and learning from colleagues in exciting ways. This does not mean abandoning subjects, but recognising the learning and teaching potentials associated with alternative curriculum structures.

Also, the teaching profession needs to be clear and honest about what it values and what assumptions underpin 'quality teaching'—if knowledge of content and how to teach it is considered fundamental to good teaching, then out-of-field teaching without an expectation for supported, formalised and remunerated teacher learning should be deemed unacceptable.

Recommendation 4. There is a need to reconsider the 'out-of-field initiation' of beginning teachers

What would it look like if only teachers with more than two year's experience were ALLOWED to teach outside of their specialised areas? What would be the consequences?

The majority of out-of-field teaching in Australia is assigned to teachers in their first few years of teaching (Weldon 2016); this pattern appears to be common in other countries (see Chap. 3). While this seems counter-intuitive, this practice has become part of the cultural initiation of new teachers into the profession, a rite of passage so to speak. New teachers 'do their time' teaching out-of-field and hopefully will teach into their preferred subject as they gain more experience. The upside of this is that teachers who teach out-of-field in their first few years, if they survive, can sometimes assume positions of leadership. Some evidence from the field shows that early career teachers are 'cheaper' and potentially more malleable due to less experience and bargaining power, also they are more desperate and appreciative of simply securing a position in the first place. As was shown in Chap. 1, some principals will select less experienced out-of-field teachers over more experienced in-field teachers.

In our research into out-of-field teaching (Hobbs et al 2018), we are finding that some beginning teachers actually benefit from teaching out-of-field in their first few years by having a greater appreciation for how students behave in multiple subjects and finding links between subjects that may not otherwise have been apparent. There is some anecdotal evidence to show that where the out-of-field teacher is assertive, dedicated to their professional development and learning, they may be a given greater levels of responsibility early in their career (Selvakumaran, in prep). Balanced against these benefits though is research showing high levels of teacher attrition (estimates of up to 50%) in the first few years as a result of increased stress and 'increasing complexity of teachers' work' (AITSL 2016, p. 12). What determines which way the pendulum swings? A culture of support and collegiality, innovation and trust are needed for new teachers to find their feet. Chap. 9 highlighted the importance of mentoring for beginning teachers, for example, especially when they are teaching out-of-field, and the need for subject-related mentors. There also needs to be greater sharing of what works to support these teachers and make this an opportunity for learning. Another approach can be workload reductions for new teachers and out-of-field teachers to combat teacher 'churn' in hard-to-staff areas (see Chap. 8). This would require funding for additional training and an expectation that teachers gain professional learning or further training in their out-of-field subjects.

Recommendation 5. There is a need for international collaboration

What would it look like if there was international recognition of the out-of-field phenomenon and world-wide action to limit its effects?

Chapter 1 provided a justification for examining the out-of-field phenomenon from a cross-national perspective. What the preceding chapters have shown is that an agenda for research and action presents the locus of change as sitting not only with the teachers, but also with those responsible for school governance structures, systemic and societal change, and initial and continuing teacher education. A goal for such research should be to develop an international, coordinated, culturally sensitive and multifaceted approach to responding to the out-of-field phenomenon. Such an international examination of the phenomenon would aid international comparison. In this era of international comparison tests, understanding this cultural variation is vital given that policy decisions are often influenced by such findings, especially in the case of PISA[2] and TIMSS.

A programme of research can build on the chapters hereby focusing on describing the experiences of different 'types of out-of-field teachers', paying closer attention to impact on student achievement and engagement and on the broader school community, continuing professional development requirements and in-school support mechanisms suitable for different groups of teachers.

International research is needed to examine how the systems create the conditions for the need for out-of-field teaching, as well as the capacity of the various systems to respond. Such analysis can focus on: what can be done at the individual school level within the constraints of current policy; how certification and registration bodies recognise (or do not) teacher specialisations and how they relate to formal teacher education; the role of university accreditation processes in restricting or enabling the depth and breadth of the specialisations that teachers can be trained in; and the tolerance thresholds that are evident through government action.

Ultimately there need to be national and international conversations about what the education systems are willing to accept, and how out-of-field teaching can be so tolerated on the one hand, but on the other hand, teacher preparation and standards and competencies continue to be restricted to knowledge within subject domains.

12.4 Conclusion

Here are some realities. In many countries teachers are assigned subjects outside their area of expertise for a number of reasons, sometimes through choice in order to improve career advancement or explore interests, but mainly because teachers are needed in front of a class (Hobbs 2013). Out-of-field teaching can render an effective teacher ineffective, but with the right support, access to adequate professional development, and appropriate governance practices (such as provision of time), quality teaching can be maintained. Some teachers, over time, assume the out-of-field subject as part of their teaching repertoire, while others continue to feel out-of-field and are not fully committed to teaching the subject and it remains a short-term arrangement. How committed a teacher feels to the subject can influence their willingness to

[2]Programme for International Student Assessment.

undertake professional development—being upskilled in a new area could mean they become the specialised teacher and they can risk being moved out of their preferred area, for example.

This chapter has provided a number of recommendations for how to move forward in responding to the challenges associated with teaching out-of-field. How we respond as individual teachers, as a school, as a state or nation, and internationally, will depend on what we regard as important for the teaching profession to which we aspire. In our response, there needs to be acknowledgement, honesty and respect, and a clear plan that is multifaceted, involves the various stakeholders, and is informed by data that captures the various nuances of this phenomenon. The challenge is to reduce the need for out-of-field teaching, but where it exists, or is in fact desired, then normalising a regime of supported and resourced teacher learning is needed to turn a potentially destructive situation into a learning opportunity.

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