



UMEÅ UNIVERSITY

# Opening the black box of mathematics teachers' professional growth

A study of the process of teacher learning

Sara Engvall

Department of Science and Mathematics Education  
Umeå 2019

This work is protected by the Swedish Copyright Legislation (Act 1960:729)  
Dissertation for PhD  
ISBN: 978-91-7855-117-0  
ISSN: 1650-8858  
Series title: Dissertations in Educational Work, Umeå University  
Cover design: Christoffer, the very best brother one could have  
Electronic version available at: <http://umu.diva-portal.org/>  
Printed by: CityPrint i Norr AB  
Umeå, Sweden 2019

*To Benjamin & Milton*

*I will stand by you  
Even when we fall  
I will be the rock, that holds you up  
and lifts you high so you stand tall  
I won't let you go*

(Carissa & Michael Alvarado)



# Table of Contents

<b>Abstract .....</b>	<b>ii</b>
<b>The included papers .....</b>	<b>iii</b>
<b>Enkel sammanfattning på svenska .....</b>	<b>iv</b>
Lärarnas lärandeprocess .....	iv
Faktorer som påverkar lärandeprocessen .....	v
Slutsatser och diskussion .....	vi
<b>1 Introduction.....</b>	<b>1</b>
1.1 Aim of the thesis.....	1
1.2 The role of the papers in the thesis.....	2
<b>2 Background.....</b>	<b>4</b>
2.1 Teacher professional growth.....	4
2.2 Conditions for teacher professional growth.....	7
<b>3 Research design and Methods .....</b>	<b>10</b>
3.1 Research design.....	10
3.2 The professional development program .....	10
3.3 Data collection.....	11
3.4 Data analysis.....	14
3.5 Ethical considerations.....	18
<b>4 Results .....</b>	<b>20</b>
4.1 The process of professional growth .....	20
4.2 Important factors for supporting the professional growth .....	30
<b>5 Discussion.....</b>	<b>34</b>
5.1 The professional growth .....	34
5.2 Important factors for supporting teachers' professional growth .....	35
5.3 Understanding of the process of professional growth .....	37
5.4 Implications for practice.....	38
5.5 Concluding remarks .....	38
<b>6 Acknowledgements .....</b>	<b>40</b>
<b>7 References .....</b>	<b>42</b>

# Abstract

There is a lot of research done on professional development programs for teachers, especially with a focus on different characteristics of the program and whether it makes teachers change their teaching practice to such an extent that it enhances student achievement. However, there is not much research done on the learning process. As long as we do not open the black box of teacher learning it is difficult to say anything about what characteristics in a professional development program actually are important for teachers to learn, develop and grow as professionals.

The aim of the thesis is to better understand the process of teacher learning while participating in a professional development program. The focus is on different aspects of the process of teacher professional growth, as well as on external factors that have an impact on the process of learning. The participants are secondary school teachers that participated in a professional development program in formative assessment. The data have been collected during and after the professional development program took place. Different types of data have been used in this thesis; teacher interviews, classroom observations and questionnaires, and have been collected over a time period of two and a half years. In two of the included papers the studies focus on four mathematics teachers, and the learning process is explored from two different perspectives: how the professional growth can develop, and how their testing of formative assessment activities relates to their understanding of formative assessment. In one of the papers all secondary school teachers are included and a comparison in expectancy of being able to use high quality formative assessment after the professional development program between the mathematics teachers and the other teachers were conducted. In the fourth paper focus is on all mathematics teachers in the study and their motivation are investigated over a time period of two years. The four papers take different perspectives to explore the professional growth for teachers while participating in a professional development program in formative assessment. The results show the complexity of teacher learning and indicate that large-scale implementations risk being inefficient and not reach the intended goals.

# The included papers

The thesis consists of four papers, all still unpublished.

## Paper I

The professional growth of four mathematics teachers participating in a professional development program

Author: Sara Engvall

## Paper II

Mathematics teachers' motivation to change their teaching during and after a professional development program in formative assessment (Submitted)

Auhor: Sara Engvall

## Paper III

The relationship between teachers' understanding and practice of formative assessment within professional development

Author: Sara Engvall

## Paper IV

Do mathematics teachers experience a professional development program in formative assessment any differently than other teachers?

Author: Sara Engvall

# Enkel sammanfattning på svenska

Det finns mycket forskning om kompetensutveckling för lärare, särskilt med fokus på olika egenskaper i fortbildningen och huruvida dessa egenskaper skapar förutsättningar för lärare att förändra sin undervisning i sådan utsträckning att det påverkar elevernas prestationer. Det finns dock inte så mycket forskning som fokuserar på lärarnas lärandeprocess som de går igenom för att kunna förändra sin undervisning. Goldsmith et al. (2014) kallar den lärandeprocessen för den svarta lådan. För att verkligen förstå vilka egenskaper som är viktiga i kompetensutveckling så behöver man också förstå vad det är som skapar bra och mindre bra förutsättningar för lärare att utvecklas och växa i sin profession.

Syftet med den här avhandlingen är att bättre förstå den lärandeprocess som lärarna går igenom när de deltar i en kompetensutveckling. Jag har dels fokuserat på olika aspekter av lärandeprocessen, dels på olika externa faktorer som påverkar lärarnas lärandeprocess. Deltagarna i studien är högstadielärare i en kommun, som under studien deltog i en fortbildning om formativ bedömning. Data har samlats in både under tiden som fortbildningen pågick och efter. Jag har samlat in flera olika sorters data under 2,5 år: lärarintervjuer, klassrumsobservationer och enkäter. I två av de fyra artiklarna som ingår i avhandlingen har jag fokuserat på fyra matematiklärare. I en av artiklarna deltar alla högstadielärare som har besvarat mina enkäter och i den fjärde artikeln är samtliga matematiklärare som besvarat enkäterna i fokus.

## Lärarnas lärandeprocess

Tre av artiklarna rör olika aspekter av lärarnas lärandeprocess. Artikel I och III fokuserar på de fyra matematiklärarna och artikel II handlar om samtliga matematiklärare. I artikel I studerade jag de fyra matematiklärarnas lärandeprocess genom en modell som heter *the Interconnected model of professional growth* (Clarke & Hollingsworth, 2002) och med hjälp av den kunde jag identifiera *change sequences* (förändringssekvenser) hos de enskilda lärarna. Det vill säga, jag kunde se hur lärarna tog till sig ny information (i det här fallet från kompetensutveckling) och hur de sedan hanterade den informationen. Det visade sig att två av lärarna började sina sekvenser med att reflektera över den nya informationen innan de tog ett beslut om huruvida de skulle testa eller inte testa den aktiviteten. De två andra lärarna beskrev inte några särskilda reflektioner kring de moment de skulle prova i sin undervisning. Istället testade de först i undervisningen och reflekterade i efterhand. Alla fyra lärare uttalade sig också om saker som rörde fortbildningen, formativ bedömning och skolkontexten, i samband med att de pratade om sin undervisning. Men utöver denna typ av kommentarer visade det sig att samma två lärare som reflekterade



först också hade en annan typ av uttalanden kring sitt testande. Det var kommentarer som rörde lärarens personlighet, elevernas lärande och olika uttryck för oro. De två lärarna som testade först och reflekterade i efterhand hade inte den typen av uttalanden.

Artikel III fokuserar också på de fyra lärarna, där med fokus på vilka specifika aktiviteter kopplat till formativ bedömning som de testar och hur det relaterar till vilken typ av förståelse de uttrycker för vad formativ bedömning är. Jag har samlat in data vid tre tillfällen, över 2,5 år, och tittar på denna relation och hur den förändras över det tidsspannet. Lärarna testade, till synes sporadiskt, olika aktiviteter kopplat till formativ bedömning, men medianen för antalet aktiviteter som lärarna som grupp testade ökade över tid. Sett till de enskilda lärarna var det två som hade en ökande trend, medan två testade färre aktiviteter vid tredje datainsamlingen än vid första. Lee är den lärare som visar störst samstämmighet mellan testandet och den uttryckta förståelsen av formativ bedömning, medan Kim är den lärare där diskrepansen är störst. Kim uttrycker en god förståelse för vad formativ bedömning är, men har i praktiken knappt testat några aktiviteter kopplade till formativ bedömning.

Artikel II har också fokuserat på lärandeprocessen, men med fokus på motivation att använda formativ bedömning i sin undervisning efter fortbildningen hos samtliga matematiklärare som har deltagit i enkätstudien. Jag har samlat in enkäter vid tre tillfällen över två år och i dessa enkäter har lärarna fått svara på frågor som rör de olika konstrukten som finns i *Expectancy Value Theory of Achievement Motivation* (Wigfield & Eccles 2000), som är en motivationsteori. Modellen innefattar förväntningar (expectancy) på att lyckas och olika värden (values) som belyser olika sorters värden som kan påverka motivationen. En jämförelse av de olika konstruktens medelvärde över tid visar att matematiklärarnas motivation inte förändrades över dessa två år, varken till det bättre eller sämre. Vid en jämförelse med en annan grupp matematiklärare som har gått en annan typ av fortbildning om formativ bedömning har lärarna i den här studien relativt lika motivation som den andra gruppen lärare, trots att de andra lärarna, i enlighet med tidigare forskning, hade bättre förutsättningar i sin fortbildning. Resultaten indikerar att motivationen inte påverkas av egenskaper i fortbildningen, utan snarare av egenskaper hos lärarna, specifikt kopplat till den årskurs som de undervisar i.

## **Faktorer som påverkar lärandeprocessen**

Lärares beskrivning av vilka externa faktorer som påverkar lärprocessen har analyserats i artikel I, II och IV. Sammanfattningsvis tar lärarna upp följande som möjliga hinder i deras lärprocess:

- Avsaknad av möjligheter att arbeta tillsammans med lärare som undervisar i samma ämne (artikel I, artikel IV),
- Avsaknad av tid (artikel I),
- Egenskaper i skolämnet matematik (artikel I, artikel IV),
- För ytliga diskussioner i fortbildningen (artikel I).

I artikel IV tas ett par positiva aspekter med fortbildningen också upp av lärarna: det kollegiala lärandet och de konkreta exemplen som skulle testas i undervisningen.

I artikel II gjordes en jämförelse av motivationen hos lärarna i den här studien och motivationen hos två andra grupper av matematiklärare som gått en annan typ av kompetensutveckling om formativ bedömning. Den typ av motivation som avseddes var motivation att använda formativ bedömning sin undervisning efter fortbildningen. Resultaten visade att egenskaperna i kompetensutvecklingen inte verkar påverka motivationen, utan att det snarare är något annat som påverkar den. En möjlig faktor kan vara att motivationen att använda formativ bedömning i sin undervisning efter kompetensutvecklingen påverkas av vilken årskurs alternativt stadium man undervisar i.

## **Slutsatser och diskussion**

En slutsats man kan dra från den här studien är att lärares lärande är komplext. Det går väldigt kortfattat att sammanfatta i tre punkter:

- Lärare är individer med individuella förutsättningar
- Alla skolämnena är olika och ger olika möjligheter att implementera förändringar
- Olika stadier i skolsystemet ser olika ut och har därmed olika förutsättningar att förändra undervisning

Baserat på dessa punkter kan det vara svårt att designa storskaliga kompetensutvecklingsprogram som ger bra förutsättningar för alla lärare. Den andra och tredje punkten är lätta att adressera genom att skapa kompetensutvecklingsprogram som fokuserar på specifika grupper av lärare. Istället för, som i kompetensutvecklingen som lärarna i den här studien deltog i, där samtliga lärare i grundskolan deltog och var indelade i blandade grupper med lärare från olika ämnen och olika stadier i samma grupp. Den första punkten är dock inte lika lätt att adressera, men ändå väldigt viktig att ta hänsyn till för att kunna skapa goda förutsättningar för alla lärares lärandeprocess.

# 1 Introduction

As the title of the thesis indicates, my interest revolves around the process of teacher learning and professional growth. More specifically, I examine teacher learning through participation in a professional development program (PDP). There is a lot of previous research done on professional development and important characteristics of those, usually with a focus on program effectiveness, that is, on changes in practice and enhanced student learning, and rather few focus on teacher learning (Kennedy, 2016; Desimone, 2009; Goldsmith, 2014). Instead of focusing on results and effects, there is a need to study the process of teacher learning. Because of the lack of research focusing on teacher learning, Goldsmith et al. (2014) even refer to it as a black box, which is what I intend to open in this thesis.

In the title of the thesis I have included both *professional growth* and *teacher learning*, and in the texts I will use them with the same meaning. In this thesis, I have addressed teacher learning by looking at different aspects of the process of learning, as well as important factors that influence that learning process. In this thesis, secondary school teachers that participated in a professional development program in formative assessment (FA) have been included. There are four papers included in this thesis, which in different ways will help answering the two research questions posed in the thesis. In the thesis I intend to answer two research questions, and even though they to a great extent are intertwined with each other, I will present them separately throughout the thesis. In the discussion chapter I will discuss how the research questions relate to each other and how they together paint a picture about the black box of teacher learning.

## 1.1 Aim of the thesis

The aim of the thesis is to better understand the process of teacher professional growth while participating in a professional development program.

The research questions are:

- 1) What can the process of teacher professional growth look like?
- 2) What factors are of importance for the process of teacher professional growth?

## 1.2 The role of the papers in the thesis

In this section, I briefly describe the four papers and how they are used to answer the two research questions. The posed questions will be answered using different types of data, namely teacher interviews, classroom observations and teacher questionnaires. Parts of all four included papers will be used to answer the two questions.

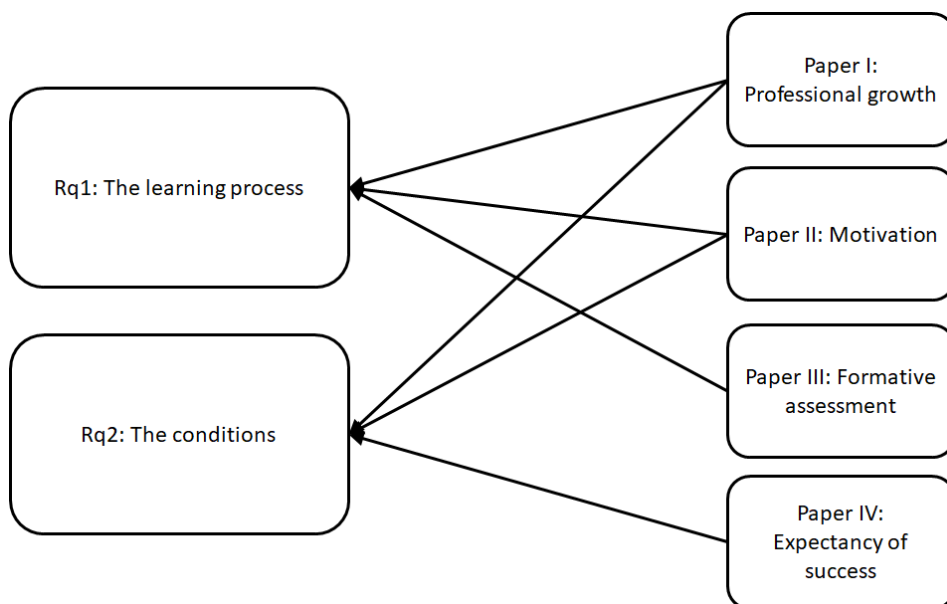


Figure 1: A schematic view of how the four included papers relate to the two research questions posed in the thesis.

**Paper I:** In this paper I have studied how four mathematics teachers process new information received through the PDP. This result will partly answer the first research question. Further, different experienced obstacles connected to the PDP and the school context have been identified as well. Those obstacles will partly answer the second research question.

**Paper II:** In this paper I have studied the mathematics teachers' motivation to use formative assessment in their teaching practice during and after participating in a PDP. The teachers' motivation has been studied over time to be able to see changes. This part of paper II will help answering the first research question. Further, the motivation for the teachers in this study have also been compared to the motivation of another group of mathematics teachers who participated in another PDP about FA. The second part of this study, about the impact of

different characteristics in the two PDPs, will be used to partly answer the second research question.

Paper III: In this paper I have studied the formative assessment activities the four mathematics teachers have tried in their teaching practices. I have also studied the relationship between the teachers' trying and their expressed understanding of formative assessment. These relationships will help answering the first research question.

Paper IV: In this study a construct from *Expectancy Value Theory of Achievement Motivation*, namely *Expectancy of Success*, has been studied and compared between the mathematics teachers and the rest of the teachers in secondary school. Also, different conditions that the teachers experience as supportive or obstructive in their learning process have been studied in this paper. Both of these parts will help answering the second research question.

## 2 Background

The focus in this thesis is to understand more about teacher professional growth. It is a very complex and diverse phenomenon and I have looked at it using several different perspectives, for example, the *Interconnected model of professional growth* (Clarke & Hollingsworth, 2002), *Expectancy value theory of achievement motivation* (Wigfield & Eccles, 2000) and also previous research about teacher professional development. In this chapter, the perspectives I have used are presented as well as previous research concerning the two research questions.

### 2.1 Teacher professional growth

The first research question is about teacher professional growth. Professional growth includes how the teachers process new information, as well as aspects of motivation and how the teachers' expressed understanding of formative assessment relates to the types of formative assessment activities they try in their teaching practice.

There is a lot of research done on how to conduct successful teacher professional development programs (PDPs) with focus on student achievement or changes in practice (e.g. Goldsmith et al., 2014; Kennedy, 2016; Timperley, 2007; Wilkie & Clarke, 2015). Most studies on PDPs try to identify different important features to consider when designing a professional development program. Some of the most commonly discussed characteristics are content knowledge, collective participation, program intensity, and the use of coaches (Kennedy, 2016). However, Kennedy's (2016) review shows that the often-mentioned important characteristics of a successful PDP is not as reliable indications of a successful PDP as has been suggested, but that it is more complex than that. The synthesis by Goldsmith et al. (2014) show that teacher's learning is not as frequently researched as students' achievement, and they argue that it is often treated as a 'black box'. To be able to create good PDPs and enhance student learning, an important aspect to understand is teachers' learning.

Clarke and Hollingsworth's (2002) *Interconnected model of professional growth* is a model that enables studies of teacher learning and change, and it has been used in several studies. The model is developed using three previous Australian studies as foundation. The model consists of four domains: *Personal Domain* (knowledge, attitudes, beliefs), *External Domain* (external input, the PDP), *Domain of Practice* (trying in practice/classroom), and *Domain of Consequence* (perceptions of salient outcomes, for example, consequences from testing or not testing). In addition to the four domains, the *Change Environment* (the school

context) is also included in the model. The domains interact with each other non-linearly through reflection and enaction (see figure 2). Clarke and Hollingsworth (2002) are talking about change sequences and growth networks. The first is a sequence of two or more domains connected through reflection or enaction, where the change does not have to be long-lasting or permanent, while the latter is a sequence of connected domains which is a long-term change.

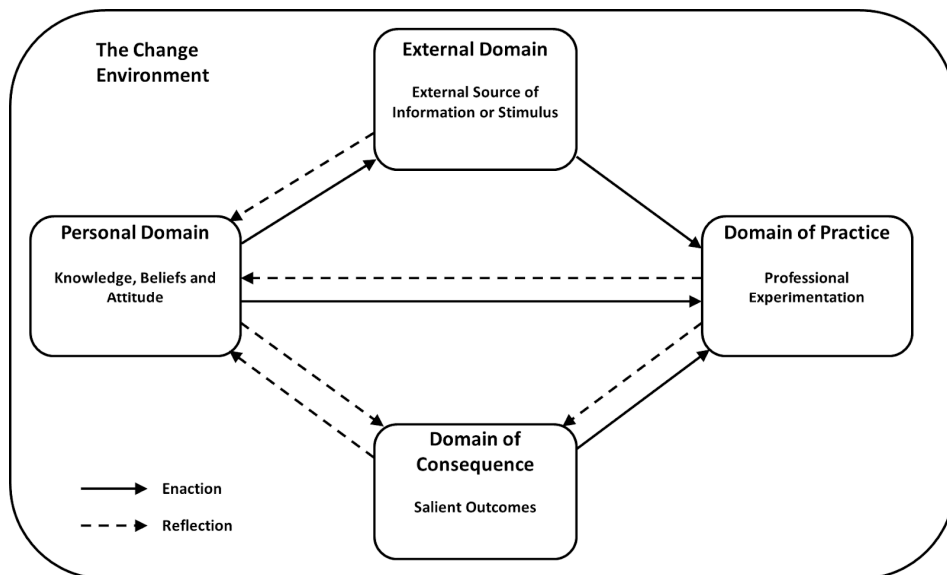


Figure 2: The interconnected model of professional growth (Clarke & Hollingsworth (2002), p. 951).

Teachers’ beliefs are an important part of the process of teacher professional growth. Lebak (2015) used the Interconnected Model of Professional Growth to examine the relationship between one teacher’s beliefs (personal domain) and practice. The teacher participated in a yearlong video-supported reflection process where he videotaped the lessons and used it both for individual reflection and together with colleagues in a peer group. All teachers in the group were science teachers. Through the teacher learning community (TLC) they were supposed to learn how to work with inquiry-based teaching, and the teacher expressed beliefs that comply with that approach to teaching. However, the enacted teaching was not in line with inquiry-based instruction. When the teacher first tried to teach according to inquiry-based teaching he was unsuccessful, but the concrete and honest feedback from the peers on how to improve the videotaped lessons was crucial for the teacher to proceed after the initial failure. Instead of letting the failure reinforce the existing beliefs, the teacher kept trying and managed to change the beliefs. The collaborative dialogue sessions, and especially the feedback from the peers, created cognitive dissonance, which was

a necessity for the teacher to start reflecting on his practice and eventually changing it, as well as his beliefs about inquiry-based instruction. The feedback from the peers would, in the interconnected model of professional growth, be considered as the *External domain*. Fives and Buehl (2014) studied the relationship between teaching ability beliefs and their view of the importance of teaching knowledge. This was done quantitatively through assessment of 443 in-service and pre-service teachers' beliefs about the ability to teach. They concluded that in order to change teachers' beliefs, knowledge and practices, one has to start by acknowledging and working with teachers' beliefs about teaching ability and the importance of teaching knowledge. The greater part of the teachers in the study believed that the teaching ability to a large extent is based on an internal ability. Hence "when devising learning experiences for teachers, teacher educators need to stress how specific coursework and experiences will build on and improve teachers' current tendencies and talents as educators" (Fives & Buehl, 2014, p. 444). As these two studies show, there are different views on how to promote teachers' development and growth. Lebak (2015) shows that change can occur by trying in practice, receiving critical feedback from peers, and reflecting on the lessons and the feedback, while Fives and Buehl (2014) "conclude that only by acknowledging and working with teachers' existing beliefs can teacher educators hope to bring about the intended changes in teachers' beliefs, knowledge, and practices." (p. 446).

Marshall and Drummond (2006) also show the importance of teachers' beliefs when it comes to changing the teaching practice. They studied how teachers engage with Assessment for Learning (AfL), which is the same as formative assessment. Marshall and Drummon (2006) differ between teachers that "embody the 'spirit' of AfL and those that conform to the 'letter'" (p. 147). They conclude that one possible reason that teachers engage differently with AfL is the beliefs the teacher holds about learning. Some beliefs make it easier to do AfL to the spirit, for example that they value pupil autonomy and that they see the classroom also as a place for the teacher to learn. Further, the teachers who did AfL to the spirit had a more flexible approach to teaching. These things gave the teachers a sense of agency, while the teachers who focused on the constraints, such as school culture or the ability of the students, did not.

In summary, there is a lot of research done on teacher professional development and important characteristics of PDPs, usually with a specific focus on student improvement. There is, however, not much research done with a focus on teacher learning and Goldsmith et al. (2014) call it the black box of teacher learning. The interconnected model of professional growth (Clarke & Hollingsworth, 2002) is a model created for studying the professional growth of teachers. In this thesis the professional growth of teachers while participating in a PDP about formative assessment is studied.



## **2.2 Conditions for teacher professional growth**

In the previous section about teacher professional growth, most of the text focused on two of the domains in the interconnected model of professional growth, namely *Personal domain* and *Domain of practice*. However, when studying the process of learning it is also important to include conditions for the learning process to take place, which in the model is the *External domain* and the *Change environment*.

The review by Kennedy (2016) highlights content knowledge, collective participation, program intensity, and the use of coaches as often-mentioned important characteristics for the effectiveness of professional development programs, and these will be described further in the following paragraphs.

One of the most commonly discussed characteristics of PDPs is to have a focus on content knowledge. Kennedy's review shows that a PDP with strict focus on content knowledge has less effect on student learning than if the program has content knowledge as an underlying goal, and focus on a broader goal instead (i.e. to make curriculum content comprehensible for students, control student behaviour, make students participate actively, or expose students' thinking). Furthermore, Timperley's (2007) synthesis about professional learning and mathematics teaching showed that in none of the included studies was it enough to improve students' learning when only focusing on general pedagogic. The "complex relationship between the key elements of teacher subject knowledge, pedagogy, assessment, and how students learn" (Timperley, 2007, p. 92) had to be addressed as well. From the 28 studies included in Timperley's synthesis, four studies were unsuccessful regarding improvements in student learning. The common feature of these four unsuccessful studies was that the focus was only on pedagogy. Even in the PDPs where the focus was on pedagogical principles that could be applied to all subjects, it was not enough to attend to these principles to have an impact on students' achievement in mathematics (Timperley, 2007). These reviews together show that it is not sufficient to focus on either content knowledge or general pedagogic. In order to design PDPs that have an effect on student learning, both content knowledge and more general pedagogic aspects have to be addressed.

Collective participation, or professional learning communities, is another frequently mentioned feature of successful professional development programs. It can for example be done through participation of teachers from the same school or grade (Desimone, 2009). This type of PDP design is sometimes argued to be efficient in enhancing teachers' knowledge and use of formative assessment (William, 2007; Lee & William, 2005; William & Thompson, 2007). However, in Kennedy's (2016) review, the impact from the included studies on collective

participation PDPs differed and Kennedy argues that researchers have to focus on the discussions and the work that is done within the learning communities rather than the learning community per se. Two studies included in the review are Gersten et al. (2010) and Santagata et al. (2010), where the first had a positive outcome and the latter a negative outcome on teacher learning. Gersten et al. (2010) conducted a study where 81 first grade teachers (39 intervention and 42 control) attended a PDP in reading. All teachers attended professional development activities at school and district level, but the teachers in the intervention group also participated in a Teacher Study Group (TSG) where they had 16 meetings, facilitated by persons with plenty of experience regarding research about reading. Four of the five facilitators held a PhD in special education or literacy. In the TSGs the teachers read and discussed research as well as collaborated around lesson planning. The study resulted in significant changes for the teachers in the intervention group, when it came to both reading comprehension and vocabulary. Santagata et al. (2010) designed a PDP responding to the needs of U.S. teachers (according to findings from the 1999 TIMSS). The studied PDP was made mandatory for all sixth-grade mathematics teachers in a district, and 59 teachers (33 intervention and 26 control) participated. The program consisted of three modules: fractions, ratio and proportion, and expressions and equations, and was facilitated by two facilitators with much experience of mathematics and several years of teaching. The goal was to “increase teachers’ content and pedagogical content knowledge in a way that would result in improvements to their instructional practice that would in turn lead to student learning” (p. 17), but they did not manage to reach that goal. Two reasons they give to explain the failure were that teachers had different levels of content knowledge before the PDP and that the fact that it was a mandatory program could have affected the teachers’ engagement and willingness to change their practice. These studies show that it is not enough to focus on whether the PDP is designed as teacher learning communities (TLCs) or not, the important factor is the content they are supposed to learn and how the work within the TLCs is conducted.

Program intensity, which can be referred to in different ways, as the total hours where teachers meet, as the duration over which these contact hours are distributed, or as the volume of information addressed, is yet another frequently mentioned important characteristic of PDPs (Kennedy, 2016; Desimone, 2009). The review by Kennedy (2016) shows that the most intense programs ended up as often in the bottom as in the top in the comparisons. Instead, other variables are important. Intense programs seem to be less efficient for a program with normative, or prescriptive, content (e.g., very detailed descriptions for each lesson) than for programs that provide strategies. Instead of focusing on the specific characteristics of a PDP, it would be better to focus on what is happening

during the program and the complexity of relations between different characteristics.

To use coaches is another common feature to include in PDPs, but Kennedy (2016) shows that the value of coaches varies. Programs where the coaches are collaborating with teachers on lesson planning are more effective than programs where the coaches are observing and evaluating the teachers.

When teachers participate in a PDP, the ultimate goal is usually to improve students' achievement. To accomplish that, the teachers need to change their practice in some way. For teachers to make such changes, it is important that they are motivated, and therefore it is crucial that the PDP supports the teachers' motivation. In expectancy value theory there are two important aspects to take into account; the expectancy of success and the value beliefs. Expectancies "are people's beliefs and judgments about their capabilities to perform a task successfully. [...] Values refer to the beliefs people have about the reasons for why they might engage in a task. In colloquial terms, values answer the question, 'Do I want to do this task and why?'" (Wigfield & Eccles, 2000, p. 44). That is, expectancy of success is about the individual's trust in how well they will be able to perform a specific task. It can be a task to be done now or in the future. The aspect of values has been divided into four different sub categories: attainment value (how important it is to do well on a specific task), intrinsic value (individual's own interest and enjoyment when doing a task), utility value (how useful the task is for future goals; career goals or other), and cost (how much effort, stress, anxiety, fear of failure does the task request) (Wigfield & Eccles, 2000).

## 3 Research design and Methods

This chapter contains information about the empirical aspects of my study, that is, descriptions about the research design, data collection and data analyses.

### 3.1 Research design

I have conducted a longitudinal mixed method study that lasted 2.5 years. I used mixed methods, i.e. collected several different types of data, in order to enable triangulation and make stronger knowledge claims. I used questionnaires to be able to include all secondary school teachers within the municipality and conducted classroom observations and interviews with four mathematics teachers to be able to get more qualitative data about the learning process.

### 3.2 The professional development program

The professional development program (PDP) was planned and conducted by a small municipality in northern Sweden, and participation was mandatory for all teachers in compulsory school. The content of the PDP was formative assessment (FA) and the teachers read a book about Assessment for Learning based on the definition of FA by Black and Wiliam (2009). The definition is:

*Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction, that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited.*

(Black & Wiliam, 2009, p. 9).

The big idea of formative assessment is, put in other words, to know where the student is, where the student is going, and how to get there. As a concretization of the definition, the authors describe five key strategies to work with in order to address the three parts of the big idea: 1) Providing clear learning goals and strive for a common understanding of them; 2) Eliciting information of student learning and understanding, through different tasks and discussions; 3) Feedback that helps the learner forward; 4) Peer assessment and acting as learning resources for each other; and 5) Self-assessment and self-regulation.

The PDP was designed as Teacher Learning Communities (TLCs), where the teachers were working in small groups at the different schools. The guideline from the organizers was for the TLCs to meet once a month for a period of three years, but it has been implemented differently at each school. Between the meetings, teachers read about, and tried, different FA techniques in their teaching practice. The groups consisted of teachers from different school subjects and different school years. One teacher was chosen as coach in each group. In addition

to the meetings, the municipality organized two lectures for all teachers. The first lecture was with a professor from a Swedish university, as a starting point to learn some basics about FA. The second lecture was with two primary school teachers from another Swedish municipality, who had been working with FA for several years, and been a part of a similar PDP. The second lecture was conducted about one year into the PDP.

In the middle of the PDP about formative assessment, all mathematics teachers in secondary school attended another mandatory PDP, the program *Boost for mathematics*, where formative assessment was one of four included didactical perspectives (see Boesen et al. (2015) for more information about the program). All of the four teachers included in this study chose to focus on the mathematics program and did not attend any of the meetings in the PDP about formative assessment during one of the intended three-year program.

### 3.3 Data collection

Different types of data have been collected, which will be described in the following sections. An overview of the conducted data collection is given in figure 3.

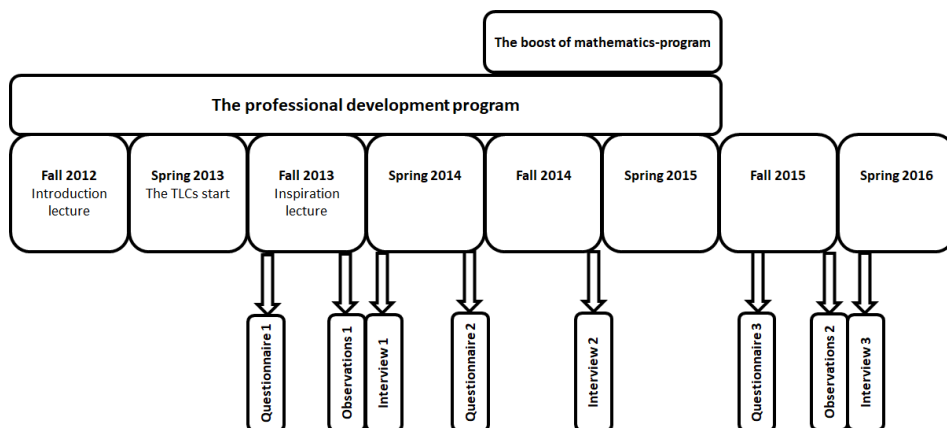


Figure 3: Overview of the conducted data collection.

### **3.3.1 Participants**

Data collection was done in two groups of participants, which will be described in this section.

#### *Survey*

In the survey, all secondary school teachers (school year 7-9) within the municipality where the professional development program was conducted, were invited to participate. All three questionnaires were sent to the same group of teachers, where teachers who quit working between the questionnaires were deleted from the collected data, and teachers who started working in the municipality between the questionnaires were not invited to answer. The questionnaires were distributed through an online survey tool, and the answers were collected anonymously. Questionnaire 1 was answered by 155 teachers, approx. 86%, of which 43 were mathematics teachers and 112 taught other subjects. In questionnaire 2, 142 teachers answered, approx. 73%, of which 35 teachers taught mathematics and 95 other subjects. And finally, questionnaire 3 was answered by 78 teachers, approx. 42%, of which 20 were mathematics teachers, and 58 taught in other subjects.

#### *Case study*

All teachers in the municipality who were going to teach mathematics in grade 7 the following academic year (2013-2014), a total of 26 teachers, attended an information meeting about the planned study. There were two reasons for choosing to focus on those teachers: to make the teachers comparable, and because most of them would teach the same students for the following three years, enabling a longitudinal study. In the study, I wanted to focus on the 'typical' teacher, and therefore teachers were excluded if they were: coaches in the PDP; not teaching in a regular class; not responsible for planning the lessons, evaluations and assessments. A few teachers also chose not to participate. For practical reasons, teachers who were working far away from the city center were excluded. After these selections, there were six remaining teachers. From the six teachers, four were chosen to be the participants in the study. The final selection was done by comparing their answers in the first questionnaire, about their input in the PDP (time spent, what kind of activities they have been doing, and how active they have been in the meetings), in order to strive for variation in their answers. The reason for striving for variation between the teachers was to represent the differences in engagement among the teachers participating in the PDP.

### **3.3.2 Interviews**

The four mathematics teachers were interviewed at three different occasions, spread over a time period of 2 years, during and after participation in the PDP, see figure 2. The first interview focused on the teachers' experiences and descriptions of the beginning of the PDP and their knowledge about FA. The second interview focused more on the different FA techniques that were described in the literature they worked with in the PDP, with a special focus on how the teacher understood, reflected on and used them in their teaching practice. Before the third interview, I wrote a description for each of the teachers based on the data I had gathered until then, where I described my understanding of their teaching and what kind of changes they had done in their practice. The teachers got the descriptions as prompts before the third interview and the interview revolved around the description. During the interview, the teachers explained further, confirmed or rejected different parts of the text. The interview data have been used for paper I and III.

### **3.3.3 Classroom observations**

The classroom observations were conducted in connection to the first and the third interview, December 2013-January 2014 and December 2015-February 2016. During both periods, the observations have been conducted over a two-week period for each of the teachers. The number of observations differ between the teachers, depending on how many mathematics lessons they had over a two-week period, and also depending on other activities in the schools. The total number of observations differ between 9 and 17 for each of the four teachers. During the observations, the whole class instructions, discussions and events were noted. What the teacher and pupils said were noted word for word, as far as possible. After the lessons, as soon as possible, the notes were rewritten and corrected where sentences were incomplete, or words misspelled. Additional comments and explanations were also added after the lessons. Utterances from the teacher or pupils were not changed (only corrected if misspelled) after lessons. The data from the classroom observations have been used in paper I and III.

### **3.3.4 Questionnaires**

The questionnaires were distributed to all secondary school teachers in the municipality, at three different times. All three questionnaires were sent to the same group of teachers, where teachers who quit working between the questionnaires were deleted from the collected data, and teachers who started working in the municipality between the questionnaires were not invited to answer. The questionnaires were distributed through an online survey tool, and the answers were collected anonymously. The four teachers' answers were not anonymous and can therefore be used as additional information for each of the

teachers. The questionnaires included questions about the teachers' perceptions of the PDP, their motivation to engage in it, and questions about their view of formative assessment. Questionnaire 1 was answered by 155 teachers, approx. 86%, of which 43 were mathematics teachers and 112 taught other subjects. In questionnaire 2, 142 teachers answered, approx. 73%, of which 35 teachers taught mathematics and 95 other subjects. And finally, questionnaire 3 were answered by 78 teachers, approx. 42%, of which 20 were mathematics teachers, and 58 taught in other subjects. The questionnaire data have been used in paper II, III and IV.

### **3.4 Data analysis**

Different data analyses have been used for the four papers, depending on the aims of the papers. How the analyses have been conducted in the four papers will be briefly described in this section. The analytic approaches used in the papers are different types of text analyses/coding and statistical analyses.

#### **3.4.1 Text analyses/coding**

In three of the papers (paper I, III and IV), different kinds of text analyses of interview transcripts and text-based questionnaire answers have been conducted and will be briefly described in this section. More elaborated descriptions are available in each paper.

##### *Paper I*

In this paper, different analyses have been conducted. After transcription of the interviews, the data were coded using *The interconnected model of professional growth* (Clarke & Hollingsworth, 2002) as analytic tool. For the analyses, the first step was to define the categories for the predefined parts of the model, namely the four domains and the change environment. Further, a thematic content analysis of the statements in each domain were conducted (cf. Creswell, 2008). The *Personal domain* included themes about teacher's personality, worries, and view of teaching and learning. Other recurrent themes were about perceived obstacles (further described below), and about different FA techniques tried in their teaching practice (not further focused on in this paper).

One part of paper I concerns the process of professional growth, specifically about the relationship between the *Personal Domain* and *Domain of Practice*. I have conducted two different analyses. First, I identified different *Change sequences* for each of the teachers, and secondly, I looked specifically on the statements in *Personal* and what types of themes each of the teachers were talking about in the interviews. The *change sequences* were identified while the data was coded. *Change sequences* and *growth networks* are concepts from Clarke and Hollingsworth's (2002) model of Professional Growth. They define a change



sequence as when two or more domains are connected causally through reflection or enaction. Change in all the domains included in the change sequence, as well as the connection, should be supported by empirical data. In the model, Clarke and Hollingsworth also use growth networks, which is when the data show that the change is not only momentary, but longer lasting. In this study I have only used change sequences, because I do not have data to show whether the changes are long lasting. I have used change sequences in accordance with Clarke and Hollingsworth's definition. The concept of "change" has been defined as when two or more domains affect each other through enaction or reflection, that is, it is considered a change also when trying something in *Practice* triggers reflection that reinforces pre-existing knowledge in *Personal*. When comparing the change sequences for the different teachers I could see some patterns of similarities and differences between them. They related to the *Personal Domain* in different ways, so I decided to look specifically at the types of comments in that domain, namely what themes the different teachers talked about. By combining the change sequences and the types of comments in *Personal domain* I was able to identify patterns showing differences between the teachers, and this combination provides the answer to the first research question, about the teachers' professional growth.

The second part of paper I concerns teachers' experienced obstacles in relation to the PDP and the change environment. To address that, I used the same coding of data as for the first research question. While coding, one of the themes concerned when the teachers talked about obstacles in different ways. It could be expressions like: "I haven't tried that because...", "It was difficult to do, because..." or "I wish I would have been given the opportunity to...". When the coding was done, I went back to all those marked places and looked for patterns among the four teachers' statements. I identified a few recurrent themes across the teachers' answers to gain knowledge about the teachers' experienced obstacles in relation to the PDP and the Change environment.

### *Paper III*

The aim of paper III is to examine teachers' development and understanding of formative assessment activities while participating in a professional development program, and will be studied with two different foci; what kind of activities the teachers try, and the relationship between the teachers' view of formative assessment and the kind of activities they try.

To answer the first part, about what they have tried and how it changes over time, I have analysed the observations and the interviews. I used the table from Boström and Palm (2017, p. 10) for the coding of the data, and to present and summarize what kind of activities the teachers have tested in their teaching practice. To fit my data material, I have removed some of the items in the table

and added a few others. I also added separate columns for each of the points in time when data was collected, to be able to see the changes in activities for the different times.

I coded the interview and observation transcripts, looking for activities the teacher mentioned that they had tried or used. The observations were conducted before interview 1 and 3, so I asked about things I saw during the observations in the interviews. For the analyses I have primarily used the interviews, because they contain more information about the activities and the teacher's thoughts about the activity. The observations have been used to supplement the information from the interviews. For an activity to be coded as something the teacher has tried the teacher had to express that s/he had tried the specific activity in the interview and/or had been observed during the classroom observations.

For the second part of paper III, about how the teachers understanding of formative assessment relate to what kind of activities they have tried, I have used the tables from the first research question and separated the activities for each of the four teachers. I have then used the questionnaire information and information from the interviews where they answered questions about what formative assessment are, how they would describe it. What I was interested in was to see if the teacher's testing could be explained by their understanding of formative assessment. The following questions have been included in the analysis: What do you perceive formative assessment to be? (Questionnaire 1 & 2); What would you say is the core features of a teaching practice based on formative assessment? (Questionnaire 3); How would you explain formative assessment for a teacher who does not know what it is? (Interview 2); and Can you explain what formative assessment is? (Interview 3). I have analyzed the teachers' answers to these five questions by comparing them with the definition of formative assessment, the key strategies and the Adjusted teacher instruction (ATI). If the teachers, for example, answered: "When you clarify for the students what you will assess, and what they should learn", the analysis is that it explains a part of formative assessment (key strategy 1, about goal sharing), but does not address the whole idea. Another example is: "Formative assessment builds on that you know where you are and where you are going. Both as a student and as a teacher in the processes that you have together towards the goals. That is the core, at least for me." In this example the teacher addresses all parts of the idea of formative assessment, namely where you are, where you are going and how you are getting there.

To be able to explore the relationship between the teachers' understanding of FA and the activities s/he has been trying in the teaching practice, I have interpreted and summarized the understanding the teacher expresses through the questions mentioned, and compared to the types of activities the teacher have tried. For

example, the teacher only focuses on the parts of FA that are teacher centered (KS1-3 and ATI) and then in the comparison see that the same teacher only tries activities connected to the same parts of the framework.

#### *Paper IV*

In paper IV, two open questionnaire questions were analyzed through categorization of the teachers' answers. A bottom-up approach was used, that is, the categories developed from the data, through looking at the answers and grouping similar answers together. One set of categories was used for the question about what positive characteristics the teachers experienced that the PDP had, which enabled teachers to use FA in their teaching practice. Another set of categories was developed for the second question, about what features the teachers were missing in the PDP. When the categories were identified, definitions for each of them were written, and the data was analyzed once again, against the categories to make sure that they were in the right category. Answers suitable for several categories were placed in all these categories, and the part belonging in that specific category was highlighted. The proportions of answers in the different categories were used to show differences in the experiences of the PDP between mathematics teachers and other teachers.

#### **3.4.2 Statistical analyses**

Statistical analyses have been used in two of the papers (paper II and IV). They will be described in this section.

#### *Paper II*

In paper, I studied how the teachers' motivational beliefs change over time. It is answered by comparing data collected at three different occasions spread over two years. The survey questions asked about the different constructs of Expectancy Value Theory of Achievement Motivation. I calculated mean values and the standard deviation for the mathematics teachers' values for each of the constructs of the theory and each of the three questionnaires. This enabled me to explore the mathematics teachers' motivation to start using FA in their teaching practice, for the different constructs and over time.

Furthermore, in paper II, I also studied how the teachers' motivational beliefs compare to another group of teachers that has participated in another, more comprehensive, PDP about formative assessment. I compared the mean values for the different constructs for the mathematics teachers in this study with the mean values of year-4 and year-7 mathematics teachers from the other PDP. In the comparison, only mean values were possible to compare, because in the other studies that was the only values presented. In the other PDP, they conducted questionnaire 1 directly after the PDP was finished and the teachers were

supposed to start trying different aspects of FA in their classrooms, and I have compared the mean values from that study with the mean values from questionnaire 2 in my study, which was conducted about two years into the PDP. The reason for that is that the teachers in this study participated in another PDP after the second year, and therefore ended their participation in the PDP about FA. The second comparison has been done between the questionnaire 2 from the other PDP and questionnaire 3 from this study. At that time both PDPs were finished, and they were expected to use FA in their classrooms.

#### *Paper IV*

In paper IV, I also studied the mathematics teachers' expectations of their possibility to use high quality formative assessment in their teaching practice were compared with the expectations of other teachers, using statistical methods. First, the mean value for each of the four questions were calculated, as well as a combined mean value for all four questions, which is suitable because all the questions investigate Expectancy of Success. A T-test was used to see if there was any statistical significance in the differences shown in the mean values, using  $p < 0.05$  as a limit for statistical significance.

### **3.5 Ethical considerations**

The questionnaires were distributed and collected through an online survey tool, and all teachers (except for the four mathematics teachers) answered them anonymously, without possibility for me to see the individual teachers' answers.

The four mathematics teachers gave written informed consent about participation in the study. The consent concerned classroom observations, interviews with audio recordings and answering unanomously on the questionnaires. The teachers were informed that they could end their participation at any time and that they would be anonymous. From the start of data collection, the teachers have been provided with a code instead of using their names. The four teachers in my case study have been given pseudonyms which are gender neutral (Alex, Kim, Lee and Robin), in order to protect their identity and their gender.

The classroom observations were only documented through notetaking, and whenever the teacher called a student by its name, I did not write the name in my notes. In some cases, I wrote "student 1", sometimes the first initial in the name, sometimes x, depending on the situation and amount of information I had to write down quickly.

Before the third interview, I wrote descriptions for each of the four teachers about their teaching practices and their use of formative assessment, based on the data

collected until then. Before the interview, I sent them the text and they could read the descriptions, and during the third interview, the discussions revolved around the descriptions. The teachers could comment, add or remove information from the descriptions, and I could ask where I found the information to be limited or lacking in detail.

My PhD project was partly financed by the same municipality that designed and conducted the PDP that I have been studying. The municipality gave me the frames of the project, that it should revolve around formative assessment and mathematics, but except that, I have been able to design and conduct the study as I wanted. The municipality has been helpful in giving me access to the schools and the teachers, and I was able to contact the four teachers that I have been studying in the case study directly, without first talking to the principals at the different schools.

## 4 Results

The results chapter will be structured according to the two research questions. The first research question is “What can the process of professional growth look like?” and the second is “What factors are of importance for the process of teacher professional growth?”. The first part will address the results regarding the first research question and the second part of the chapter addresses results about the second research question.

### 4.1 The process of professional growth

Included in this part of the results are results from three of the four papers (paper I, II and III). Paper I and III have focused on the individual process of change and the development of the trying of formative assessment activities in relation to the expressed understanding of formative assessment. In paper I and III, the four mathematics teachers have been studied. Paper II focused on changes in the motivation to use formative assessment, for all mathematics teachers. First in this section, results from paper I and III will be presented separately for each of the four teachers. Second, results on group level will be presented (paper II).

#### 4.1.1 The characters of four teachers' growth processes

In paper I, I studied the learning processes using the Interconnected model of professional growth and identified change sequences for each of the teachers. In paper III, I focused on the trying of activities connected to formative assessment and the relations between the teachers' trying and their understanding of formative assessment. Both papers focus on the relationships between *Personal domain* and *Domain of practice* (Clarke & Hollingsworth, 2002), where Paper III has a narrower focus on one specific aspect (i.e. specifically on formative assessment).

#### *Alex*

In paper I, about professional growth, the results show that Alex was satisfied with the teaching as it was before the PDP started and had after one year not made any changes (interview 1). S/he thinks the teacher's way of approaching the students are making them engaged, not whether s/he is using FA or not (int. 2). However, Alex expresses at several occasions that s/he always does what is expected, in this case pages to read and methods to try in the teaching practice. But Alex also says that in the case of the PDP s/he has not done anything more than expected (int. 2).

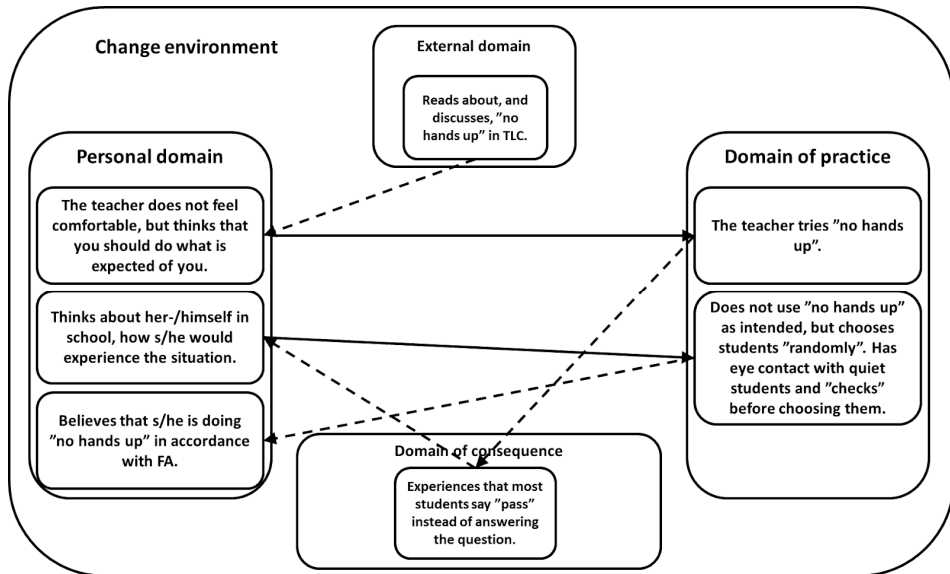


Figure 4: Example of a change sequence identified in Alex's data. Filled arrows are enactions and dotted arrows reflections.

The change sequence illustrated in figure 4 shows a typical sequence, with respect to the relationship between Personal and Practice, for Alex. The sequence starts with new input in the External domain, in this case No hands up. The purpose of the technique No hands up is to make all students participate, because when only a few students engage in the classroom activities the achievement gap increases (William, 2011). When using the technique, the students are not supposed to raise their hands to answer a question, only for asking questions. Instead the teacher lets a random student answer, and to make sure that the distribution of the students' responses is randomized the teacher can use different techniques, for example lollypop sticks with the students' names, or an application (e.g. Names in a hat). The change sequence for Alex starts with the new input in External Domain, which triggers a reflection that creates a change in the Personal Domain. For Alex it is very important to do what is expected, and because of that s/he tries No hands up during a lesson. The consequence that Alex experiences is that most students say pass instead of answering the questions. The experienced outcome made Alex reflect on his/her own time as a student, and how s/he would react in a similar situation and created a reflective link between the Consequence and Personal. This reflection generates an adjustment in the Domain of Practice. Alex says that s/he is using No hands up but chooses "randomly" who will answer. Alex also makes sure to have eye contact and "check" with the quiet students before choosing them.

In paper III, I studied what kind of formative assessment activities the teachers tried. For the first time of data collection Alex had tried 3 activities in total, for the second it had increased to 6, and for the third it was 7 activities. The change between the first and the second was because Alex started testing several different activities connected to peer and self-assessment, and then continued doing so at the third data collection. One example of the types of activities that Alex tries is when the students assess their diagnostic tests and Alex provides an assessment key with all the correct answers, so what the students do is compare their own answer to the key. The teacher also writes down the specific tasks they should practice on depending on what errors they make in the diagnostic tests.

In paper III, I also looked at the relationship between the testing of formative assessment activities and the expressed understanding of the framework. Alex' understanding of formative assessment is very much focused on the importance of clarifying the goals and criterias for success (what will be assessed), across all data gathered. The most important thing is that the students know what will be assessed, that they are aware of what they can do to learn better. It is not clearly expressed what Alex perceives as the role of the teacher in formative assessment but focuses very much on the students. Despite the understanding of formative assessment that Alex expresses, the teacher has not said almost anything about testing or changing connected to key strategy 1 (i.e. clarifying, sharing, and understanding learning intentions and criteria for success). This is only done in interview 3 where Alex talks about using student examples to clarify assessment criteria. In the observations, Alex mainly communicates activity goals (e.g. what pages or tasks they should complete) to the students, and rarely learning goals.

To summarize the results in paper I and III when it comes to Alex, a typical change sequence includes reflections about not being comfortable trying the new activity and a focus on the students' possible experiences of the activity (personal), which leads to adjustments of the activity before trying it in the classroom (practice). This focus on the students is also visible in paper III where Alex to a large extent focuses on the importance of students knowing what they are supposed to do.

### *Kim*

In paper I, Kim expresses a general interest in developing the teaching practice, that it is "boring to have a set of materials that you use year after year. All students are individuals and you always have to think in a new way." (int. 2) The teacher also puts a lot of time and energy on searching for and reading external information about formative assessment, and s/he wants to feel certain about what consequences an activity will render, before trying anything. In interview 1, about one year into the PDP, Kim expresses that the work in the group does not



give as much input as it did in the beginning, that they tend to talk about the same things at every meeting and that it is time for a change.

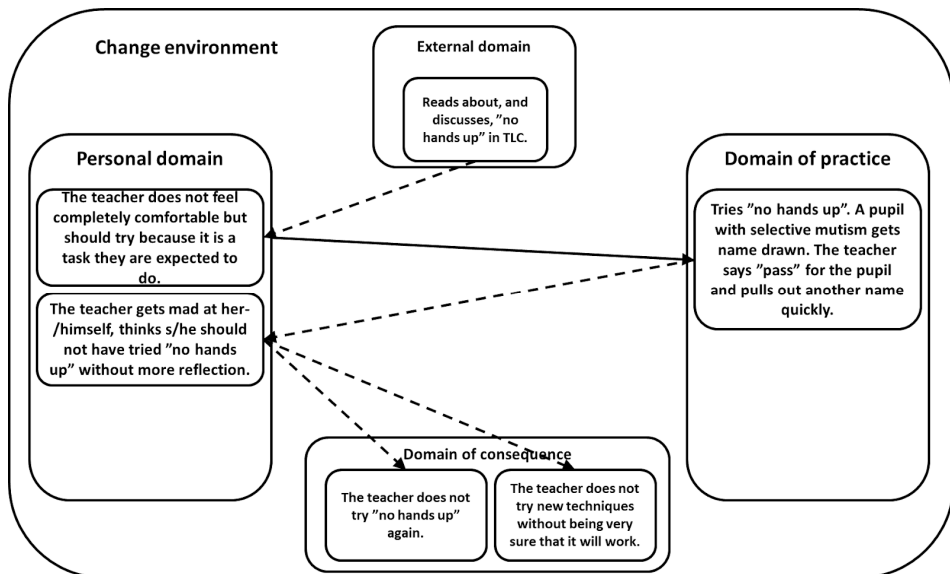


Figure 5: An example of a typical change sequence for Kim.

The example in figure 5 also concerns No hands up, and similar to Alex, the first thing that happens in the sequence is that Kim reflects on the new input creating a reflective link between External and Personal. Kim expressed that s/he did not feel comfortable trying No hands up, but did it anyway, because it was expected. In the class where the teacher chose to try the technique there was a student with selective mutism, and her name was drawn to answer a question. Even though the teacher immediately said “pass” for the student, and drew another name, the event triggered a reflection. The reaction from Kim was to get angry at her/himself that s/he exposed that student to that situation, and that s/he should not have tried No hands up without reflecting more about how to do it. From this sequence, the teacher expressed two consequences: first, that Kim has not tried No hands up again after that, and second that Kim is convinced never to try something without first being sure that it will turn out in a good way, that it will work.

In paper III, the first data collection showed that Kim had tested 4 activities, for the second 5, and for the third only 1. When it comes to testing different activities connected to formative assessment, however, Kim has not tested activities connected to all the key strategies, not to KS1 and KS5. At the third data collection, Kim expressed an understanding incorporating the whole definition of

formative assessment, namely where they are, where they are going, and how they will get there. When Kim describes formative assessment, it is always with a teacher centered perspective and does not focus at all on peer and self-assessment. Kim has put in a lot of work to find information outside of the frames of the PDP, and expressed already in the first interview that the discussions in the TLCs were too shallow and only focused on the different techniques or activities, instead of the core, or the purpose, of formative assessment.

Kim has a good understanding of the definition of formative assessment, in theory, but it is not shown in the teaching practice. Kim has at none of the data collections been testing activities connected to KS1, which is the KS where the teacher clarifies for the students where they are going; the learning goals. At the third data collection, Kim expresses an understanding that covers the whole definition of formative assessment. But when it comes to the testing of different activities, Kim only tests one specific activity, connected to KS3.

To summarize the results from paper I and III for Kim, a typical change sequence, similar to Alex, starts with reflecting on the new activity and focusing on potential difficulties that can occur when trying the activity in practice, before trying some of the activities. In paper III, the understanding of FA and the practice do not match. Kim expresses a good understanding of the purpose of FA but does not use almost any of the activities connected to FA. One reason could be that Kim often gets stuck in the personal domain, when thinking of the potential difficulties that can occur, as shown in paper I, and because of that wants to read some more about the activity before trying.

### *Lee*

Lee showed a quite pragmatic attitude about changing the teaching practice: “Yes, it takes extra time, but I don’t know. I guess that’s why I haven’t made huge changes either, because I don’t have that time. Then you do the things that work, without it taking too much extra time, that you still think give an effect.” (int. 1). However, Lee thought that the PDP gave insights into why one should use formative assessment in the teaching practice, but s/he was not sure whether it provided sufficient conditions to actually be able to use high quality formative assessment (int. 2).

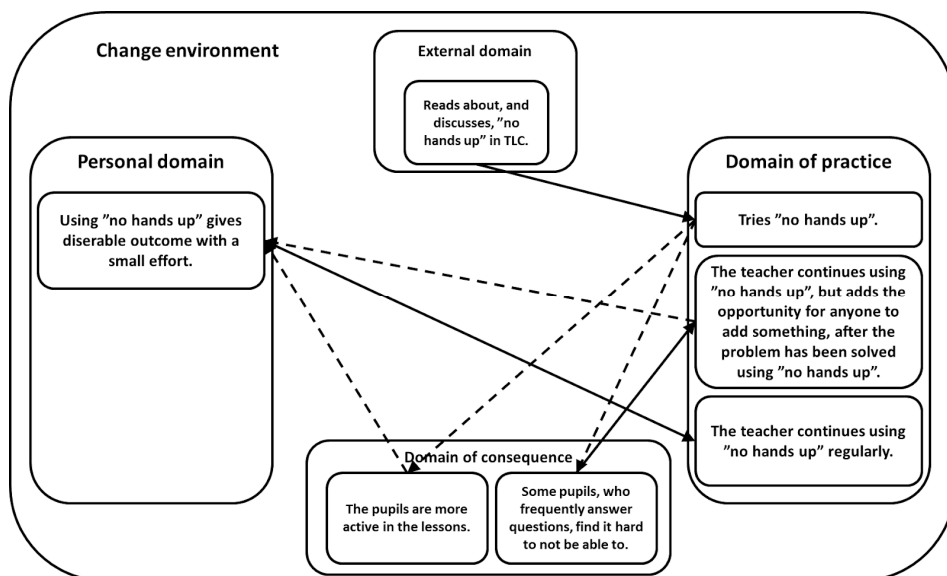


Figure 6: An example of a typical change sequence for Lee.

Unlike Alex and Kim, the first action in a typical change sequence for Lee, see figure 6, is that after learning about No hands up in the TLC (External) s/he tries the technique in Practice. After testing, the teacher expressed that it resulted in two outcomes; that the students are more active in the lessons; and that some students, who used to answer questions frequently, find it hard to not have that opportunity. The first outcome triggers a reflection, that using the technique gives a desirable outcome with little effort, creating a reflective link between Consequence and Personal. The second outcome triggers Lee to make some adjustments in the use of the technique; after using No hands up for answering a question or solving a problem, the teacher gives anyone the opportunity to add something. After implementing the adjustment, Lee again reflects on the fact that the technique gives a desirable outcome with little effort. Lee continues using the technique in the teaching practice.

In Paper III, the first data collection showed that Lee had tried 5 activities, the second data collection 8, and the third 5 activities. Lee has mostly tested activities that are connected to the teacher's acting, while none of the testing has been connected to peer assessment (KS4), and KS5 (self-assessment) was only tested during the first data collection. Lee seems to test a few things and keep using them, especially no hands up and exit pass. The understanding that Lee expresses is teacher centered, and to a large extent focused on the teacher's role in activating and engaging the students. No hands up (KS2) is the one activity that Lee has

been using continuously at all three points of data collection, and the activity Lee expresses the most positive attitude towards. Lee uses No hands up, above all, to make students more active. Lee's understanding of formative assessment is very much focused on the teacher's role. This is visible through the focus on key strategy 1 to 3. The same focus is visible when looking at the key strategies that Lee has tested in the teaching practice. Only at the first data collection, Lee had tested KS4 (peer assessment), and the rest of the testing has focused on KS 1 to 3 and on ATI. All of these have a teacher focus, in the sense that it is the teacher who is active in doing the activities connected to the strategies.

To summarize the results from paper I and III for Lee, a typical change sequence starts with enaction of the activity in practice, and reflections over the activity after trying it. In paper III, the expressed understanding and the trying of activities are in line with each other. Both show that Lee has a teacher centered focus. Results from both papers show that Lee is pragmatic and focuses on the practical implementation of the activities.

### *Robin*

In Paper I, Robin was generally positive about the PDP because "I think this is one of few PDPs that actually has given something that I can use in my teaching practice. Many PDPs have made an impression and given some energy, but this one is something directly usable. That's been good." (int. 1). Robin also enjoyed the design of the PDP, with mixed groups from preschool class to ninth grade, since even if they had tried the same technique, they could have done it in very different ways, which created interesting discussions (int. 3). The teacher expresses that formative assessment is good both for the teacher and the students, and because of that Robin wants to continue trying more things. But at the same time, the teacher has not done anything more than what they were expected to do before the next meeting. Robin has not searched for any information on his/her own (int. 1).

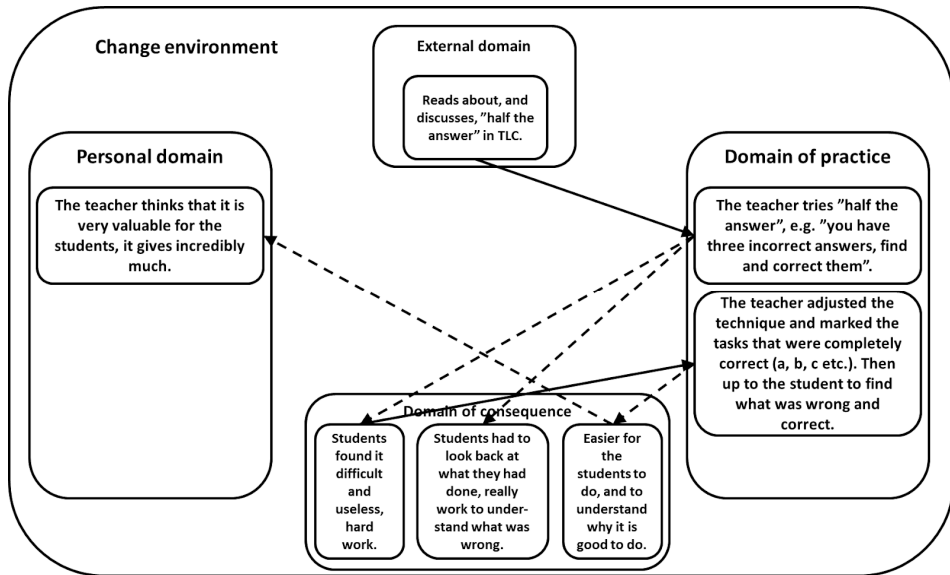


Figure 7: An example of a typical change sequence for Robin.

In the illustration of one of Robin’s change sequences, see figure 7, the teacher learned about a technique called Half the answer. The purpose of this technique is to only provide some of the assessment information to the students, for example, to only say/write how many correct answers there are on a test, instead of marking every task individually. Then the student has to go through the test and find out which ones are wrong, and then try to correct them. Doing this creates an additional opportunity for the students to learn. In this case with Robin, s/he learned about the technique and the first action was to try it in a class. When trying this technique, Robin experienced two different outcomes; the students’ reactions that it was difficult and hard work, and the “enforcement” for the students to actually work with the test, instead of just returning it and then proceed with the next chapter. In order to make it a little easier for the student, Robin adjusted the use of the technique a little, and marked the tasks where all the parts (a, b, c etc.) were completely correct. That adjustment made it easier for the students to manage, and made them more positive about it, which in turn created a reflective link between Consequence and Personal, when Robin expressed that it is very valuable for the students. Robin has change sequences that are similar to Lee’s, where the difference, compared to Alex and Kim, is that they enacted this new information in Practice without any clear reflection. Instead, they reflected on the information after trying in practice.

At the first data collection for Paper III, Robin had tried 2 different activities, for the second 5 and for the third 8 activities. Robin has tested activities connected

to almost all key strategies. When the teacher describes the teaching practice, s/he focuses a lot on self- and peer assessment. Robin is the only teacher who explicitly expresses the three phases of the core of formative assessment, namely: what they know, what they need to improve, and how do we do that. Robin has tested activities connected to all key strategies in the framework, and a lot of focus in the testing has been on peer assessment, but only at the second data collection did Robin mention KS4 and 5 when describing FA.

The results in paper I show that Robin, similar to Lee, try the new activity in *Practice* before reflecting and adapting the activity. In paper III, the activities that Robin tries are connected to almost all key strategies, but a lot of the focus is on activities connected to peer assessment. Robin adapts the activities to make them as good as possible for the students (paper I), but still in accordance with the purpose of formative assessment (paper III).

#### *Summary of the four teachers*

When looking at the examples of the *change sequences* for the four teachers (paper I), you can see that two of the teachers (Lee and Robin) had enactment directly from *External* to *Practice*, while for the other two teachers (Alex and Kim), the input in *External* triggered reflection about the new input, creating a reflective link between *External* and *Personal* before enacting it in *Practice*. These differences in the relationship between the domains made me curious about the comments in *Personal* and whether it differed between the teachers regarding what themes they talked about. *Personal domain* includes themes such as teacher's personality, worries, and view of teaching and learning. When comparing the distribution of the comments for the four teachers, it is possible to divide them in the same way as from the change sequences, namely that Alex and Kim have a similar distribution, and Lee and Robin a similar one. Alex and Kim both have comments connected to their personality (Personality, Worries, Teaching, and Learning and students) while Lee has no comments in those themes and Robin only has one comment in the Teaching category. To summarize, Alex and Kim have change sequences where the "trying in *Practice*" is preceded by some reflection and a decision in the *Personal*, and they both have statements in the sub-categories connected to their personality. On the other hand, Lee and Robin both have enactment arrows directly from *External* to *Practice*, and they both lack statements in the themes connected to the personality.

In Paper III, which investigates the four mathematics teachers' trying of formative assessment activities in relation to their understanding of formative assessment, the results show that the four teachers in this study are different both when it comes to what they have tried in their teaching practice, and when it comes to their expressed understanding of formative assessment. Lee is the one

teacher that seems to have an understanding of formative assessment that is in line with the testing in practice. Kim is the teacher with the biggest difference between the understanding and the testing, since Kim expressed a good understanding of formative assessment, but has tried very few activities in practice. Alex focuses on KS1 when describing formative assessment, but when trying activities connected to that strategy, does not do it in line with the definition of formative assessment. Robin has tried activities connected to all key strategies, but the expressed understanding of formative assessment focuses to a large extent on KS1-3. Most of the activities Robin tried was connected to KS4 (peer assessment), but it was only in the second data collection that Robin mentioned that when describing formative assessment. Two of the teachers tried more activities at the third data collection than at the first, but two teachers tried more activities at the first data collection than at the third. Common to all four teachers is that they are only trying a few different activities.

#### **4.1.2 Changes in motivation to use formative assessment**

Motivation is another important aspect of teacher professional growth. In this thesis, the motivation to use formative assessment in the teaching practice after the PDP is the specific focus.

Paper II explores the motivation among the mathematics teachers that participated in the PDP about formative assessment. To measure their motivation, I used the motivation theory *Expectancy-Value Theory of Achievement Motivation* (Wigfield & Eccles, 2000), which consists of the constructs *Expectancy of success*, *Attainment value*, *Utility value*, *Intrinsic value* and *Cost*. The results show that the motivation was constant over all three questionnaires, where the mean value for the Expectancy of success was lower than for the rest of the constructs (see table 1). About Cost, the scale is reversed concerning positive/negative, so a high value means that the teachers believe that the cost will be high to be able to use FA after the PDP.

*Table 1: Mean values for each of the different constructs of the Expectancy-value theory of achievement motivation over time (Q1-Q3). The scale is 1-5.*

	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>		<b>Q1</b>	<b>Q2</b>	<b>Q3</b>
<b>Expectancy of success</b>	2.8	2.7	2.8	<b>Utility value</b>	3.4	3.5	3.3
<b>Attainment value</b>	3.8	3.7	3.8	<b>Cost</b>	3.4	3.6	3.4
<b>Intrinsic value</b>	3.7	3.6	3.5				

### **4.1.3 Summary of the results**

Two different types of change sequences have been identified for the four teachers. Two of them had change sequences where reflections that connected to aspects of the *Personal domain* occurred before trying the activity in *Practice*, while the other two teachers tried the activity in *Practice* before reflection about it. The same teachers that started with reflections also had another type of comments connected to the *Personal domain*, namely worries, teaching, learning and personality. The other two teachers that started the change sequences with trying in *Practice*, did not have that type of comments. Only one of the teachers (Lee) had an expressed understanding of FA that was in line with the activities tried in practice, while Kim is the teacher with the biggest difference between the expressed understanding of FA and the activities tried in practice. When I look at the motivation for the mathematics teachers, the results show that the motivation was constant over all three questionnaires, where the mean value for the *Expectancy of success* was lower than for the rest of the constructs, and the value for *Cost* were rather high.

## **4.2 Important factors for supporting the professional growth**

In this section, different important factors for supporting professional growth will be presented. The presented factors are based on the teachers' experiences. Parts from three of the papers (paper I, II and IV) are included and will contribute with different types of information about these factors.

In Paper I, about the four teachers' professional growth, the teachers' experienced obstacles to develop their knowledge about, and use of, formative assessment in their teaching practices, were explored. These obstacles will be presented in relation to the four domains and the change environment in the model *The interconnected model of professional growth*. When analyzing the data from the four teachers, I noticed that there were a few themes mentioned in more than one interview. These themes concerned perceived obstacles and were coded in *Change Environment*, *External* and *Personal domain*. The identified themes were:

- Lack of possibilities to work with teachers from the same subject (in the groups the teachers were a part of, it was a mix of teachers from different subjects, and the teachers expressed a need to work with other mathematics teachers instead) (*External domain*);
- Lack of time (the teachers mentioned different types of lack of time, e.g. time to try things in the teaching practice and time to plan and evaluate the activities tested) (*External domain*);



- The characteristics of mathematics education (two of the teachers expressed that it must be easier for primary school teachers to work with formative assessment, and a third teacher thought that it was easier for teachers in other subjects, for example in Swedish) (*Change environment & Personal domain*); and
- Too shallow discussions in the TLCs (two teachers expressed a frustration that the discussions only revolved around the specificities of different activities rather than around the purpose of formative assessment or even the purpose of the specific activity) (*External domain*).

Paper II concerned the motivation of the mathematics teachers, and one part of that paper was to compare the teachers' motivation with the motivation of two other groups of mathematics teachers who participated in another PDP about formative assessment. The other two groups participated in a PDP with a different design than the PDP studied in this thesis. One of these groups taught in secondary school (year-7), the same school level as the teachers in my thesis, and the other group taught in primary school (year-4) (Boström & Palm, 2017; Andersson & Palm, 2018).

The year-7 and year-4 teachers attended PDPs parallel to each other, conducted by the same instructor. The PDP lasted for one term and the group of Year-7 teachers met at the university once a week, for four hours (a total of 96 hours). In addition, the teachers also had 5 hours per week to read, plan how to implement new FA activities in the classroom, and to reflect on the outcomes (a total of 120 hours) (Boström & Palm, 2017). The group of year-4 teachers attended a very similar PDP as the year-7 teachers, with the difference that they were able to have longer meetings at the university. They met for 6 hours every week (a total of 144 hours), and had 3 hours a week for planning, reading and reflecting (a total of 72 hours) (Andersson & Palm, 2017). At the meetings at the university, the instructor had a lecture presenting the theory of FA as well as practical activities for implementation of the theory in practice. Between the meetings, the teachers were supposed to try different activities in the teaching practice, and then during the meetings discuss the experiences with the rest of the teachers. Together they discussed how to overcome obstacles and develop the activities (Andersson & Palm, 2017; Boström & Palm, 2017).

As comparison, the PDP in my study was conducted through teacher learning communities (TLCs), with mixed groups of teachers from different subjects and different school years, and no frequent access to any expert in FA. In the other PDP, where the year-4 and year-7 teachers participated, they met with an expert at every weekly meeting. The PDP consisted of only mathematics teachers

teaching the same school year. In this thesis, the number of participating teachers differed between the three questionnaires. The three questionnaires were answered by 43, 35 and 20 mathematics teachers respectively. In the group of year-7 teachers they were 14 participants and the year-4 teachers were 22.

The teachers in this thesis have lower (or higher for *Cost*) mean values than the year-7 teachers on four of the seven measurements points. The biggest difference is for the *Expectancy of success* where the teachers in this thesis has a mean value that is 0.9 lower than year-7. For *Utility value*, the teachers in this thesis have higher mean values for both comparisons, and for *Cost* the mean values are higher for the teachers in this thesis. In comparison to the year-4 teachers, the teachers in this thesis have lower (higher for *Cost*) mean values on all constructs. In this comparison, the year-4 teachers are the group with the highest mean values for both *Expectancy of Success* and the included values (i.e. *Attainment value* and *Utility value*). For *Cost* one should think reversed, that it is better with a lower value, since the question asks about whether the teachers think that it would take more time to use FA in the teaching practice.

Table 2: Comparison concerning different constructs of motivation between mathematics teachers in this thesis and mathematics teachers from another PDP in formative assessment (Boström & Palm, 2017; Andersson & Palm, 2018).

Construct	After the PDP			One year after the PDP		
	This thesis	Year-7	Year-4	This thesis	Year-7	Year-4
<b>Expectancy of success</b>	2.7	3.6	4.1	/	/	/
<b>Attainment value</b>	3.7	3.7	4.2	3.8	3.9	4.8
<b>Utility value</b>	3.5	3.4	4.1	3.3	2.9	3.8
<b>Cost</b>	3.6	3.3	2.8	3.4	2.8	2.9

Paper IV focuses on one of the constructs in the motivation theory, the *Expectancy of success*, and compares the expectancy to be able to use formative assessment in the teaching practice after the PDP for the mathematics teachers in the study in comparison with the rest of the teachers. The mean values for the mathematics teachers were lower than for the rest of the teachers for all three questionnaires, with a statistically significant difference for the second measurement. Paper IV also compares the two groups, mathematics teachers and other teachers, concerning their positive experiences of the PDP and whether they lacked something in the PDP. Both from the mathematics teachers and the other teachers, most comments mention collegial learning as a positive characteristic of the PDP. The category of collegial learning consists of comments on a general

level about the possibility to discuss, learn and reflect together with colleagues; but the comments can also be more specific, for example, to work with colleagues from different subjects and compare what works for them in their teaching practice. Another category that has a rather big proportion of the answers are examples, which consists of comments specifically about practical examples that can be used in the classroom. When it comes to what the teachers were missing in the PDP, the mathematics teachers had a rather big proportion of answers about different groupings. This meant in general that they wished for groups consisting of mathematics teachers and/or teachers teaching in secondary school, instead of the mixed groups of teachers that they were working in. The other teachers did not seem to have a need of different groupings.

#### **4.2.1 Summary of the results**

Conditions within the *External domain* and the *Change environment* can have an impact on teacher professional growth, and in the previous section I have presented results about that type of conditions. Here is a brief summary of the presented results.

The teachers express the following as possible obstacles in their learning process:

- Lack of possibilities to work with teachers from the same subject (paper I, paper IV),
- Lack of time (paper I)
- The characteristics of mathematics education (paper I, paper IV), and
- Too shallow discussions in the TLCs (paper I).

In paper IV some positive characteristics about the PDP were identified as well. The two things that the mathematics teachers found most positive about the program were collegial learning and the examples in the PDP that could be used concretely in the teaching practice.

In paper II, the results show that despite the different characteristics of the two PDPs that the teachers in this thesis and the year-7 teachers participated in, there is not that big differences between the motivation for the two groups. One thing that differs between the teachers in this thesis and year-7 is the mean value for *Expectancy of success*, where the teachers in this thesis' mean value is 0.9 lower than year-7. *Utility value* and *Cost* also differs, where the teachers in this thesis have higher mean values on both constructs.

## 5 Discussion

In this discussion, the two research questions will be discussed first separately, then in relation to each other and the aim of the thesis. Some implications for the practice will also be discussed.

### 5.1 The professional growth

The results from paper I are valuable in understanding how the process of professional growth can occur for teachers, and how complex teacher learning is. The change sequences identified in paper I show that the four teachers have different ways to change. One conclusion from this is that teachers are different and need different things to be able to change and develop. The results indicate that the teachers' previous experiences and their personalities can have an impact on this diversity.

In paper II, focus was on motivation, which is one aspect of professional growth. When looking at the motivational beliefs for the teachers in this study, it is striking how similar the values are over time. One can assume that when participating in a successful PDP, the motivational beliefs would increase over time, at the same time as the cost would decrease. That is, a PDP that have the sought-after effect on the teachers, teaching and students, would make the participants have increased expectancy to succeed, and have increasing values on how important and interesting formative assessment is to use in the teaching practice. Another aspect to consider is the decreasing number of teachers answering the questionnaires, especially at the third questionnaire. One assumption can be that the teachers most interested in FA are the ones answering the last questionnaire, but still there is no increase in the mean values for the different constructs of the motivation theory. Based on this, it seems that this particular PDP is not very successful, since the mean values for the mathematics teachers are the same over the three questionnaires.

Paper III focuses on the formative assessment (FA) activities the teachers try in relation to the understanding of formative assessment that the teachers express. Two of the teachers tried more activities at the third data collection than at the first, but two teachers tried more activities at the first data collection than at the third. Common to all four teachers is that they are only trying a few different activities. One perspective on the learning process might be that there should be an increase in the number of activities the teacher tries over time. In this case, that would mean that the PDP has enabled "successful" learning processes for two of the four teachers. Another perspective on the learning process might be a development of quality in the specific activities. In this study, I have not focused

on that, but an indication of development in a specific activity could be that a teacher continues to use the activity over time. One of few examples in my study is Lee who tries “no hands up” at all three data collections. In general, however, the testing of different activities seems to be more sporadic. The results also show that the teachers are diverse both when it comes to the activities they try and the understanding of FA. Lee is the only teacher who expresses an understanding of FA that is in line with the activities tried. And Kim is the teacher with the biggest difference between the understanding and the activities tried. Both Alex and Robin have understandings that differ from the types of activities they try. One possible reason for the differences shown for three of the teachers might be that they express understanding for parts of FA, but their beliefs about learning is not in line with the activities of the different key strategies of FA. Marshall and Drummond (2006) showed in their study that some teachers embodied FA to the spirit while other teachers used FA to the letter, and their conclusions were that it was because the teachers held different beliefs that either promoted the use of FA or hindered the teachers from fully incorporating FA in their teaching practice.

## **5.2 Important factors for supporting teachers’ professional growth**

In paper I, the four mathematics teachers expressed different things they experienced as being obstructing in their process of learning. Despite the differences in how they approach the new information, the teachers had similar experiences about potential obstacles in the PDP: a lack of time; the need to work with teachers from the same subject; too shallow discussions in the TLCs; and the frames in terms of the characteristics of the subject itself and/or that they were working in secondary school.

The teachers expressed a need to work with other mathematics teachers, instead of, or as a complement to, the mixed groups they were a part of. Even though formative assessment is not connected to a specific subject, it can put high demands on the subject specific knowledge of the individual teacher to be able to adapt the techniques to work in their subject and context. When working in the mixed groups, it is difficult to have these specific and deep discussions about details in adapting techniques to different subjects. In paper IV, the mathematics teachers expressed a greater need to work with other mathematics teachers than the other teachers did. In the study by Lebak (2015), the critical features of the TLC were that all teachers were teaching the same subject and that the teachers gave honest and critical feedback, which made the teacher proceed, and in the end change the teaching practice, and his existing beliefs about it. Without the feedback, the teacher’s beliefs might have been reinforced, instead of challenged. In paper I, I have not identified any change sequences where the beliefs have been

challenged, and one reason for that might be the composition of the groups with teachers from different subjects.

In paper I, three of the four teachers thought that it was more difficult for them to use formative assessment in their teaching practice, than for other teachers. Two mentioned it in relation to the age of their students (that it would be easier when teaching younger kids), and one in relation to the subject (that it would be easier if you taught Swedish, than mathematics). A study by Hodgen and Marshall (2005) compared a mathematics teacher and an English teacher, who both were working with incorporating FA in their teaching practice. They concluded that due to some characteristics and traditions of the school subject of mathematics, it seems to be more difficult to use FA for a teacher in mathematics, than for a teacher in English. The teachers' experiences presented in paper I, in combination with results from Hodgen and Marshall (2005) and in paper IV, provide a picture that mathematics teachers have a need of other conditions in a PDP to be able to use FA in their teaching practice. It is also in accordance with Tytler et al. (1999) who argued for the need of different PDPs depending on that teachers in different school subjects carry different subject knowledge and confidence in relation to the subject they are teaching.

The PDP about formative assessment was supposed to, according to the plan presented by the municipality, go on for three years. Still, they chose to add another mandatory PDP, the *Boost for mathematics*-program, in the middle of that time period. Most likely, this affected the teachers in a negative way, suddenly being supposed to change their focus to another PDP, and still maintain and develop their teaching practice to contain more formative assessment. It is very likely that it is better and more efficient to keep to one PDP at a time and let the teachers have enough time to learn, implement and incorporate the new things, at least if you want the teachers to grow and for example change their practice.

In paper II, when comparing the teachers in this thesis with the year-7 (Boström & Palm, 2017) and the year-4 teachers (Andersson & Palm, 2018), the motivation for the teachers in this thesis are lower than both groups on a majority of the measurement points. Year-4 teachers have higher mean values than both the teachers in this study and the year-7 teachers. The year-7 teachers and the teachers in this thesis are more comparable since both groups teach in secondary school, and the motivation values are more similar in the comparison. The year-4 and year-7 teachers have had better conditions in their PDP, based on previous research done on professional development programs. But the results in paper II indicate that motivation is not determined by the characteristics of the PDPs, rather by the characteristics of the teachers, specifically regarding the grade they teach.

It is interesting that the teachers in this study had very similar motivation as the year-7 teachers, since the external conditions varied quite a bit between the two PDPs. The common feature between the groups is that they teach mathematics in secondary school. The group of year-4 teachers differs from the other two groups in that they teach mathematics in primary school. One possibility could be that the stage they teach in, or the age of the students, have an impact on the teachers' motivation to implement formative assessment in their teaching practice. Another thing that differs between the year-7 and year-4 teachers is that the latter group spent more time with the instructor. That could possibly explain the difference in motivation between those groups, but not why the teachers in this study have very similar motivation values as the year-7 teachers.

### **5.3 Understanding of the process of professional growth**

Based on the discussions of the two research questions, I will here discuss the results in relation to the aim of the thesis, that is, to better understand the process of teacher professional growth while participating in a professional development program.

An overarching conclusion is that the results in the thesis show the diversity and complexity of teacher learning. This will be elaborated on below.

Some of the external factors that the teachers expressed as missing are known from previous research to be important, for example, more time, focus on the content they will teach, and knowledgeable support. However, the students of the year-7 teachers who had those characteristics fulfilled in their teachers' PDP still did not improve their results (Boström & Palm, 2017b). And in the comparison between the teachers in this thesis and the year-7 teachers, the mean values of motivational beliefs were quite similar between the groups. Hence, the different characteristics of the PDPs do not seem to have an impact of the motivation. However, in paper III, where I studied the number of FA activities that the teachers tried and compared to how many the year-7 teachers had implemented (Boström & Palm, in press), the teachers in this thesis had tried less than the year-7 teachers had implemented. That difference indicates that the characteristics of the PDP still are important for the development of teaching practices in line with FA.

Teachers, just as students and everyone else, are individuals and learn in different ways (Goldsmith, 2014). They have different ways to deal with new information, different experiences, different prerequisites, different types of beliefs about learning, and different interest in the subject the PDP is about. All these things are likely to have an impact on how much the participants in a PDP engage, as

well as how much they change their teaching practice. In school, we are quite good at accounting for students' different needs and different ways of learning. We need to be better at that when it comes to professional development programs for teachers too, both when planning and conducting one. The results show that the four teachers have two different ways to handle new information, and even though it is not possible to generalize, it is not unlikely that other teachers approach new information in similar ways as these teachers. In addition, it is likely that there are even more ways to handle new input. To make PDPs more efficient, this is an important aspect to take into account, meaning that large-scale implementations risk being inefficient and not reach the intended goals. Even though I question the efficiency of large-scale PDPs, like the one studied in this thesis, there are some characteristics that can improve the possibilities to be successful. For example, there seems to be differences between what works for teachers in different school years and for teachers in different subjects. But there is still the issue of individual teachers' differences to take into account for a PDP to be supportive for every teacher in their process of professional growth.

#### **5.4 Implications for practice**

My thesis has studied teacher learning from different perspectives and one conclusion is that the process of teacher learning is complex and diverse. Some of the aspects that makes it difficult are:

- Teachers are individuals with individual preconditions
- The school subjects are different and give different possibilities to incorporate change
- Different stages in school have different conditions to change

Based on these things, I would argue that it is difficult to design large-scale professional development programs that support teacher learning for all participants. The second and third point are easily addressed through focusing on specific groups of teachers, instead of, as in the PDP is this thesis, to include all teachers in compulsory school, when designing PDPs. The first point, however, is not as easily addressed, but still very important in order to support all teachers in their learning process.

#### **5.5 Concluding remarks**

In this thesis I decided to include several different perspectives to study the learning process of teachers. I have also used several different methods for data collection. Both of these decisions have their strengths, for example that the results provide understanding of the diversity and complexity of the learning process. However, if I could redo this study, but with the knowledge I have gained



until now, I would probably focus on gaining a deeper understanding of the individual processes for the four mathematics teachers. More specifically, I would have focused on what is Paper I and Paper III in this thesis. In the data I have, I did three data collections, but if I had been able to spend more time with each teacher, I could get a better picture of the process, not just at three different points in time. I could also in a better way study the quality of the formative assessment activities they tried or used in their teaching practices. For the data collection, I would have spent much more time with the teachers in their classrooms, in order to get a fuller picture of their actual teaching practices. I would also have put in the work in getting permissions from the legal guardians of the students, to be able to audio or video record the lessons. In order to better understand the teachers' learning processes, I would also have been observing the meetings the teachers participated in within the PDP.

With that said, the results I have provide an important addition to the understanding of the process of teacher learning. And even though there is still a lot more to explore, I have, as the title said, opened the black box of teacher professional growth.

## 6 Acknowledgements

Det är lite drygt sju år sedan som jag gjorde min första dag som doktorand på NMD. Jag minns min första lunch i fikarummet och hur jag fascinerat och skräckslaget förstörde förstå vad det pratades om. Fullständigt obegripliga begrepp slängdes runt och bollades nonchalant med och jag tänkte att det här klarar jag aldrig. Men sju år senare står jag ändå här, med en alldeles egen avhandling. Att skriva den har varit en av de största utmaningarna jag har ställts inför, men doktorandtiden har också varit en av de mest fantastiska perioderna hittills i livet. Det finns så många som har varit del i att hjälpa mig att orka och som bidragit till att det varit så fantastiskt roligt och givande.

Först av allt vill jag tacka mina handledare. Magnus, du är min hjälte och jag vet inte hur jag ska kunna uttrycka hur tacksam jag är för allt du har gjort för mig. Jag är så tacksam för att du är så lyhörd, strukturerad och trygg. Det är fantastiskt att i panik gå in till dig och komma ut helt lugn. Chrissan, tack för att du har dykt ner med mig i träsket av kvalitativ data och tillsammans med mig kämpat tills gyttjan blivit mer lättforcerad. Och Björn, tack för att du alltid har tagit dig tid att hjälpa mig när jag kört fast eller inte begripit vad jag hållit på med. Och tack för alla diskussioner om formativ bedömning, fortbildning och motivation.

Torulf, tack för allt du lärt mig om formativ bedömning och forskning, att när jag tyckte att jag var noggrann och detaljerad, så lärde du mig att så inte var fallet. Det visade sig att det fanns en helt annan nivå av detaljer som man behövde ta ställning till. Manya, tack för alla dina skarpa frågor som tvingade mig att vara på tå. Och för dina omtänksamma frågor om hur jag mårde.

Fritte, vad jag är tacksam för att jag har fått slutspurta tillsammans med dig. Även om vi inte fick avsluta exakt samtidigt har jag fått dela slutet med dig. All oro, stress, panik och glädje. Jag är så glad att vi har lärt känna varandra så bra den senaste tiden, och jag är glad över allt vi har upplevt tillsammans.

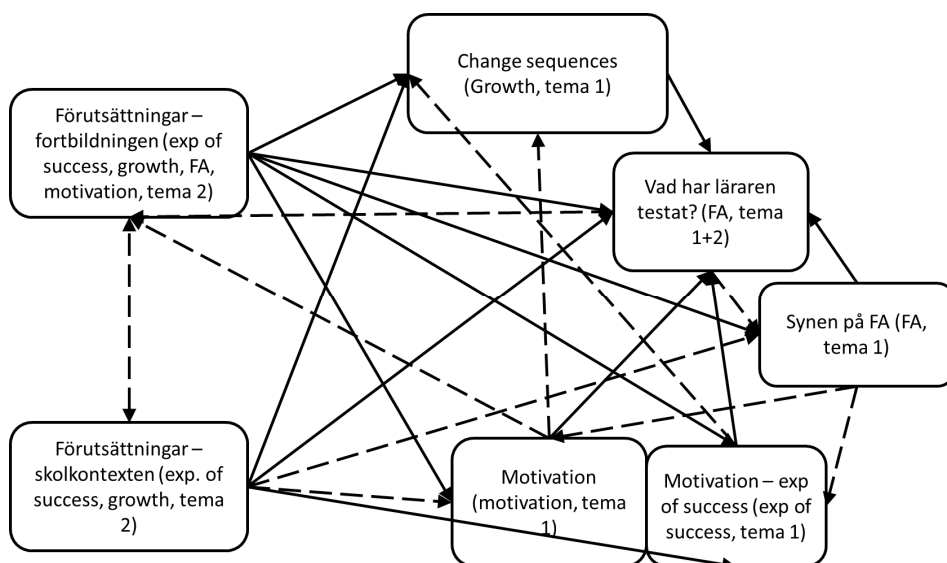
När man håller på så länge som jag har gjort hinner man ha en hel del doktorandkollegor, alla fantastiska på olika vis. Jag är så glad över att ha fått lära känna er allihop. Tack och stort lycka till i framtiden.

Alla ni som finns och har funnits på NMD, tack för allt stöd, all kärlek och omtanke, alla kramar och uppmuntrande ord. Tack för alla skratt, alla roliga och allvarsamma samtal. Tack för after works, danser, skidåkning, beachvolleyboll, löpning och promenader. Jag har älskat att vara en del av NMD.

Jag vill också tacka den kommun och lärarhögskolan på Umeå universitet som har gjort det här möjligt genom att finansiera mitt projekt. Och tack till alla lärare som har ägnat tid åt att besvara enkäter. Och framförallt, tack till de fyra lärare som jag har fått lära känna genom intervjuer, observationer och samtal.

Utöver den fina jobbfamiljen jag har fått vara en del av, har jag förstås också en familj utanför jobbet. Min familj. Världens bästa familj. Benjamin och Milton, tack för all kärlek ni ger mig och för att ni visar vad som är viktigt här i livet.

Tack mamma för att du hjälpte mig att verkligen förstå vad min avhandling handlar om, kappan hade inte blivit så bra som den blev utan ditt tålamod, dina frågor och ditt intresse för vad jag har gjort. Och tack för hjälpen med den fantastiska modellen som visar precis vad jag håller på med och hur allt hänger ihop.



Pappa, tack för all omtanke och för all hjälp med praktiska saker. Tack Lennart, Rebecka, Kajsa, Lovisa, Erik och Carl för påhejning och tron på att jag skulle klara det. Och ett alldeles särskilt tack till min bror, Christoffer, som har hjälpt mig att skapa exakt den framsida jag drömde om till min avhandling.

Utän alla er hade den här boken aldrig blivit. Tack!

## 7 References

Andersson, C. & Palm, T. (2017). Characteristics of improved formative assessment practice. *Education Inquiry*, 8:2, 104-122

Andersson, C. & Palm, T. (2018). Reasons for teachers' successful development of a formative assessment practice through professional development - a motivational perspective. *Assessment in Education: Principles, Policy & Practice*, 25:6, 576-597.

Black, P. & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, 21:1, 5-31.

Boesen, J., Helenius, O. & Johansson, B. (2015) National-scale professional development in Sweden. theory, policy, practice. *ZDM Mathematics Education*, 47, 129-141

Boström, E. & Palm T. (2017). Motivational beliefs as an explanation for the effect of professional development programmes in formative assessment on teacher practice. In E. Boström, *Formativ bedömning: En enkel match eller en svår utmaning? Effekter av en kompetensutvecklingsåtgärdsatsning på lärarnas praktik och på elevernas prestationer i matematik*. Doctoral thesis, Umeå university, 2017.

Boström, E. & Palm, T. (2017b). The impact of a specific formative assessment practice on student achievement in mathematics. In E. Boström, *Formativ bedömning: En enkel match eller en svår utmaning? Effekter av en kompetensutvecklingsåtgärdsatsning på lärarnas praktik och på elevernas prestationer i matematik*. Doctoral thesis, Umeå university, 2017.

Boström, E. & Palm, T. (In press). Teachers' formative assessment practices: Changes after a professional development programme and important conditions for change. *Assessment matters*.

Creswell, J.W. (2008). *Educational Research. Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. Upper Saddle River, NJ: Pearson Education International.

Clarke, D. & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and teacher education*, 18, 947-967

Desimone, L.M. (2009). Improving Impact Studies of Teachers' Professional Development: Toward Better Conceptualizations and Measures. *Educational Researcher*, 38:3, 181-199

Gersten, R. et. al. (2010). Teacher Study Group: Impact of the Professional Development Model on Reading Instruction and Student Outcomes in First Grade Classrooms. *American Educational Research Journal*, 47:3, 694-739

Goldsmith, L.T., Doerr, H.M. & Lewis, C.C. (2014). Mathematics teachers' learning: a conceptual framework and synthesis of research. *Journal of Mathematics Teacher Education*, 17, 5-36.

Hodgen, J. & Marshall, B. (2005). Assessment for learning in English and mathematics: a comparison. *The Curriculum Journal*, 16(2), 153-176.

Kennedy, M.M. (2016). *How Does Professional Development Improve Teaching? Review of Educational Research*, 86:4, 945-980

Lee, C. & Wiliam, D. (2005). Studying Changes in the Practice of Two Teachers Developing Assessment for Learning. *Teacher Development*, 9:2, 265-283

Marshall, B. & Drummond, M.J. (2006). How teachers engage wit Assessment for Learning: lessons from the classroom. *Research Papers in Education*, 21:2, 133-149.

Santagata, R., Kersting, N., Gvvin, K.B. & Stigler, J.W. (2011). Problem Implementation as a Lever for Change: An Experimental Study of the Effect of a Professional Development program on Students' Mathematics Learning. *Journal of Research on Educational Effectiveness*, 4:1, 1-24.

Schneider, M. C. & Randel, B. (2010). Research on Characteristics of Effective Professional Development Programs for Enhancing Educators' Skills in Formative Assessment. In H. L. Andrade & G. J. Cizek (Eds.), *Handbook of formative assessment*, pp. 251-276.

Timperley, H. et. Al (2007). *Teacher Professional Learning and Development. Best Evidence Synthesis Iteration (BES)*, 65-98

Tytler, R., Smith, R., Grover, P. & Brown, S. (1999). A Comparison of Professional Development Models for Teachers of Primary Mathematics and Science. *Asia-Pacific Journal of Teacher Education*, 27:3, 193-214. New York, NY: Routledge.

Wigfield, A. & Eccles, S.E. (2000). Expectancy-Value Theory of Achievement Motivation. *Contemporary Educational Psychology*, 25, 68-81

Wiliam, D. (2007). Content Then Process: Teacher learning Communities in the Service of Formative Assessment. In: D. Reeves (ed.) *Ahead of the curve. The power of assessment to transform teaching and learning* (pp. 183-204). Bloomington, IN: Solution Tree.

Wiliam, D. & Thompson, M. (2007). Integrating Assessment with Learning: What Will It Take To Make It Work? In: carol Anne Dwyer (ed.) *The future of assessment: Shaping Teaching and Learning* (pp. 53-82). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Wilkie, K.J. & Clarke, D. (2015). Pathways to Professional Growth: Investigating Upper Primary School Teachers' Perspectives on Learning to Teach Algebra. *Australian Journal of Teacher Education*, 40:4, 87-118