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Investigating mathematics teachers' changes in practice during a professional development initiative

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Abstract

The constant educational reforms, pedagogical innovations, and new technologies place teachers capacity for change as a necessary attribute to the profession. Professional development initiatives (PDI) have been tackling this issue with some success and research is now able to provide features that foster an effective intervention. However, many studies focus on PDI to implement reform, and not on change motivated by local school-based issues. The focus on reform might cloud essential features influencing teacher change and relationships between them for instance, the PDI are usually mandatory, top-down and neglect local characteristics of teachers and students. Therefore, the existing theoretical frameworks for teacher change developed based on these PDI are partial at best.

This thesis reports on a study which investigated change in mathematics teachers' practice with low achieving students. Acknowledging the complexity of teacher change in classroom practice, I sustained a long period of data collection to investigate change of three mathematics teachers. The overarching research question was: How do secondary mathematics teachers change within the context of a professional development initiative to innovate in their classroom practices?

I developed and run a PDI to discuss lesson plans about fractions focused on visual representations. Over the period of one year, the teachers in a secondary school in England chose one low-set group to teach these collectively planned lessons. Before the new lessons began, I was already observing their regular lessons, and we were having meetings to discuss the initial ideas for the lesson plans. These allowed us to align our goals regarding the new approach the teachers were going to use during the collectively planned lessons.

The nature of the study was exploratory, and the data collection methods reflected this stance: semi-structured interviews (3 with each

teacher), informal conversations, many lesson observations (more than 250 hours), and 8 meetings with the teachers. The prolonged period with the teachers allowed me to build trust and rapport with the participants, which contributed to the in-depth view of the process of change and the influences affecting it, adopting a close-to-practice approach to research.

Data from the lesson observations also allowed me to identify changes in practice during the project lessons for all the three teachers. I analysed the interviews, the notes from informal conversations and the meetings using grounded-theory techniques (Strauss and Corbin, 1998). The categories developed lead me to suggest influences affecting participants change coming from the PDI and the teachers' professional characteristics. I was also able to build explanations using the data that indicated how these influences were related to and building on to each other.

The major finding of this study is a set of components that influenced the teachers participating in my research to change their classroom practices. More importantly than the set itself, my findings include a thorough discussion of the relationships between them and how they influenced the process of change. This set is divided into three parts. An initial part apparently neglected in other studies, is composed of the teachers' professional characteristics: ‘commitment to the job’, ‘curiosity’ and ‘classroom management’. These characteristics are important to maintain teachers' engagement with the project, but also as initial requisite so teachers can begin implementing changes in practice.

The second part is the cycle of experimentation of the change process, and it is formed by a sequence of ‘follow the lesson plan’ and have a ‘positive experience’, these are mentioned in many studies about teacher change, and it also revealed as relevant in mine.

The third and final part are features of the PDI, namely: ‘time’, ‘trust’, ‘support’, ‘familiarity’, ‘congruence’, ‘discussion’, ‘reflection’, ‘consistency’, and ‘agency’. Some of these features were embedded in the PDI design, and others emerged from my role in the project.

Lastly, as a practical implication of my findings, I suggest the role of school-based designer, a person in the mathematics department with a role focused on supporting teachers and designing materials to tackle local problems within the school.

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The whole PhD process has been so much more than just producing this document and I have so many people that I am thankful to for making this journey so incredible and memorable. In so many ways I am not the same person that started this journey, but the most important thing I learned was that all that really matters are the people on the way. So, if our ways crossed, as brief as it might have been, thank you and I assure you that I kept something good from our encounter.

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If someone had told me previously I wouldn’t have believed it, but the title of PhD is lower down in the list of important things this journey has provided. At the top of the list are the friends I will carry in my heart from now on. I am not going to name them all here, because I know that I am so privileged that the list is too long. But I still want to say thank you to all the wonderful new friends I have now, who have helped me in so many ways and have transformed this journey into a period of my life that I will remember with tenderness and love. I am sure we will keep in touch.

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Chapter 1 Introduction

1.1. Presenting the researcher

I am a mathematics teacher from Brazil, but the idea of one day introducing myself as a teacher was not something I anticipated when I was deciding which undergraduate degree to pursue. The teaching profession is not highly valued in the Brazil, and none of my mathematics teachers at school trained to be a teacher. Only since 2014 has it become mandatory to have an appropriate qualification to be able to teach, and at present only 74.2% do (MEC, 2018). The goal is to reach 100% by 2024[1], therefore in the meantime schools have to hire temporary (and unqualified) teachers.

Although the country has many people graduating with a teaching degree, Rezende Pinto (2014) showed that many end up in areas unrelated to teaching. He also showed in his study that there is a deficit in Brazilian schools of 170,000 mathematics, physics and chemistry teachers. The most common reasons for this were low pay, the poor infrastructure of schools and the lack of social prestige of the profession (Leme, 2012; Louzano et al., 2010).

As a successful student in a private school I did not perceive teaching as an attractive career and chose to study mathematics as my undergraduate degree. I was accepted in one of the top three universities in the country, Unicamp. I struggled in the initial courses at university and soon noticed that my school and the university had different approaches to teaching. At school I was used to spoon-feeding with a lot of guidance from the teachers, while the university courses demanded that students used more initiative and were less reliant on the lectures.

1 http://www.observatoriodopne.org.br/metas-pne/15-formacao-professores/indicadores

Nevertheless, I completed my degree successfully. Towards the end I was not enthusiastic about it, but I enjoyed the experience of being a tutor for my younger colleagues and that was when I began to consider teaching as an option for me.

In Brazil, to become a mathematics teacher, it is necessary to complete an undergraduate degree of three to four years. Having finished studying mathematics I only needed another year and a half to be fully qualified, so I did that. As soon as I announced my decision to move to teaching I was offered a teaching job. Even after staying at this first school for only six months, I was hooked.

I came to Nottingham after teaching mathematics in Brazil for nine years. I had also worked in Brazil on several projects for teacher development: on-line courses, initial training and workshops. Throughout these experiences, the ones that affected me the most were all related to the comprehensive school system in Brazil. Teaching for ten months in a comprehensive school in a poor area in Brazil was truly striking, because of the number of problems the teachers had to face. Working with teachers from comprehensive schools, I found it disturbing to observe how dedicated but ill-prepared most of them were. Teaching advanced mathematics to students from comprehensive schools who had been awarded in mathematics Olympiads was heart-touching, seeing how grateful the children were and how devoted to teaching their teachers were. From these experiences came my desire and motivation to pursue a PhD in education.

1.2. Motivation and research interest

The experiences described above were the main origins of my research interests, but it was also the poor situation of students' attainment in mathematics in Brazil. Internationally, 70% of students fail to achieve the most basic level of proficiency in mathematics in PISA (OECD, 2016) and nationally, fewer than 20% of 15 year-old students

learn what is expected at their level (Todos, 2017). Additionally, there is evidence pointing to the lack of quality in many teacher training courses in the country (do Rosário and Diniz, 2009; Gatti, 2013; Louzano et al., 2010).

Considering the wonderful teachers I encountered in Brazil, my desire was (and still is) to participate more effectively in the search for feasible strategies to deal with the endeavour of supporting mathematics teachers to be better prepared for the challenges they have to face in their daily practices.

After my masters degree in teaching and learning mathematics, I started a company that offered courses for continuing professional development of mathematics teachers. The company developed many courses for different audiences (on-line, one day seminars, weekly meetings, etc). During the three years of work I had the opportunity to learn more about what possibilities were available to teachers and who was providing opportunities for teacher further development. Although the company had some projects, I decided that a career in the academy would put me in a better position to influence the development of mathematics teachers in Brazil. Therefore, the next step would have to be a PhD degree in the area.

Although Brazil has universities internationally renowned for postgraduate programmes in education, a degree from a foreign university is highly valued when one is applying for a position in a top Brazilian university. My search for prominent universities in mathematics education around the world led me to the University of Nottingham. Also, a partnership between this University and a Brazilian agency facilitated funding.

Initially, my plan was to conduct my data collection in Brazil, but after the first few months in the UK, I found out about numerous continuing professional development initiatives, including the possibility of working inside a British school with teachers or with prospective teachers. In addition, many UK schools have the practice of grouping

students according to their previous attainment (Francis et al., 2015). The students' profiles (background and attainment) in the low-sets are similar to the majority of the Brazilian population studying in comprehensive schools, thus perhaps making it more viable to transfer some of the findings between countries notwithstanding the cultural and political differences.

Additionally, knowing the Brazilian context, I was aware of the challenges of organising a research project involving comprehensive schools in Brazil. Facing this challenge while being away from the country seemed too risky.

Therefore, I decided to conduct all my research in the UK. I believe that my overall experience at the University of Nottingham allowed me to become involved with a wide range of projects and have contact with more people in my research area. The period of the PhD was not long enough to lose sight of Brazilian initiatives, but it was sufficient to attend conferences in Europe and to create an academic network. Above all, staying in the UK allowed me to have more support from my supervisors.

1.3. Defining the research context

In this section I describe in more detail the messy process of establishing the research: deciding to stay in the UK, defining my research focus and choosing the school for data collection.

The three paragraphs above provide the clean and short version of why I decided to stay in the UK for the data collection. I struggled a lot to commit to that choice. At first, I wanted to collect data in my own country because I was going back there after the PhD and because I wanted my research to contribute as much as possible to my country. Also, I was not confident enough that I would be able to run my data collection in the UK, solely due to not knowing what to expect and the possible challenges I would face, while I had a fairly clear idea about the challenges I would face in Brazil. In order to have more information to

consider both options, my supervisor took me to a school in the UK. That is how I began to visit Purple Valley[2] regularly.

After three months, the visits to Purple Valley were very interesting from the perspective of my research interests (Chapter 2), which helped me to decide to carry out my data collection in the UK. During this period, I also contacted some people in Brazil, and I did not have the access I was expecting. Moreover, I became less worried about access in the UK, both my supervisors had contacts in schools and offered me support in case I wanted to approach a school they did not know.

Around that time we had the first meeting in Purple Valley, in which we formalised what we were planning to do. Up to that point, we had been observing lessons and having informal talks with some teachers. This meeting was the first time we all sat together to talk. I discuss this initial period at length in Chapter 2. However, that chapter is also a cleaned up version of the messy process of developing a study inside a school and close to teachers.

My initial aim with these visits was to get a sense of the context. My main supervisor was running a project in the school, and I was "going in to look at what was happening": a group of teachers was getting together to talk about lessons for their low-set groups, the focus they had at the time was on visual representations in general and fractions in particular.

For this period, I did not have any defined research question. Nevertheless, it was an excellent opportunity to investigate how teachers dealt with an intervention suggesting change in their practice. So even without a structured research project, I was able to collect data (Section 2.2) and analyse it as examining possibilities for the main study (Sections 2.3 and 2.4). Towards the end of that period, another important decision had to be made — the location of the data collection for the main study.

2 Purple Valley is a pseudonym for the name of the school. Also, all teachers and students mentioned throughout this document have been given pseudonyms.

As this issue began to emerge, one of the teachers in Purple Valley was planning and teaching the lessons we had discussed and the other teacher would come to observe the lesson. The group was getting along very well, the academic year was close to the end, and the teachers indicated they wanted to keep the meetings going in the next year.

My plans for the main study had developed, and I wanted to focus my investigation towards influences on teacher change in practice. The opportunity to continue to follow the teachers in Purple Valley seemed too good to waste. My supervisor and I began to consider other schools, but moving to a different school meant that I had to hope for another head of school agreeing with the study, other teachers willing to participate, and not necessarily being able to implement an intervention explicitly focused on fostering teachers to change.

Being already in a school which agreed with an intervention and the presence of researchers, with teachers willing to participate in the intervention as I was proposing and also prepared to work closely with the research was, mostly, serendipity, and it seemed unwise to disregard. I considered looking for another school and keep two schools for the main study, but it would mean less time in each, more time with commuting and it did not agree with my wishes to have in-depth close contact with the teachers and their lessons.

My decision was to focus solely on Purple Valley and look at the teachers while they were participating in an intervention about teaching fractions with a visual approach to low-set students. The school agreed to accommodate two simultaneous studies: I was looking at teacher change in practice while the other PhD student was looking at students learning. In order to do so, an intervention was put in place, a professional development initiative to discuss lessons and tasks about teaching fractions with a visual approach.

The study reported in this begins with the period just before the data collection (Chapter 2) and moves to the main study for the rest of

the thesis. Although it might read as a smooth and straightforward process, with the initial period morphing into the main study, there were many uncertainties and difficult decisions that had to be done, and since this is a PhD thesis, it all worked out fine in the end.

1.4. Some differences between Brazil and UK

The first time I visited a secondary school in England it was a cold day in November, and all the students had their blazers on, giving me a very serious business-like first impression. Also, seeing teachers in full suits set my initial impression to the school. I later learned that this was quite usual in most British schools, but it just made the gap bigger in relation to comprehensive schools in Brazil, where it is common to have a school t-shirt as mandatory uniform, if there were any mandatory uniform at all.

Of course, coming from Brazil just two months earlier, I was easily impressed by the cultural differences in the two countries, so these differences naturally came to my attention. When I was told that I was going to visit a comprehensive school that was below average in terms of attainment, I painted a version that was very different from the truth. In my head I was going to visit a school with infrastructure problems, lack of materials, such as books and chalk, and not well maintained. My experience in Brazil suggested that there would be visible issues that anyone who entered the school could perceive. The infrastructure of Purple Valley was really impressive, with a library, laboratories, sports facilities and an auditorium. All buildings were modern, spacious and well maintained. I came to know that Purple Valley and many other schools in the UK had been rebuilt as a result of the previous Labour government's commitment to improving the inner cities.

As these first impressions settled, I learned of more differences in relation to the English and Brazilian schools and their educational systems. In Brazil there is no regulatory government agency acting as Ofsted (Office for Standards in Education, Children's Services and Skills). Brazilian schools are monitored by their IDEB[3], an index calculated considering some census factors and students' attainment in national examinations. With this index the federal government delineates goals for municipalities and/or states, although there is no direct interference in any specific school. Only municipalities or states are responsible for their schools' administration and can interfere in a particular school, which is quite unusual in my personal experience.

There are national examinations, similar to GCSE (General Certificate of Secondary Education) and A-levels (specific subject-based qualification at "Advanced level"), in Brazil, but they are centrally administered and marked by the federal government. The last (pre-university) qualification a Brazilian student takes in called ENEM[4] and it can give access to universities that are funded by the federal government and do not charge any fees. There are more than 70 of these types of universities all around the country and the students' grades at ENEM are the only method of admission. Generally speaking, these government funded universities are better classified compared to other private institutions in the country (S.Paulo, 2018).

Coming back to basic education, textbooks are largely used in Brazil, which is different from Purple Valley, where out of around 200 lesson observations I did not observe any lesson with a textbook. The Brazilian government provides pre-approved textbooks to schools and each student gets the collection of textbooks for the whole academic year.

3 Portuguese acronym for Development Index for Basic Education

4 Portuguese acronym for National Examination for Further Education

Students in Brazil can be retained to repeat the school year if they do not achieve a minimum level in all subjects. Retention rates are used to compile indexes about schools, such as IDEB, mentioned before. Together with drop-out rates, retention rates are higher among economically disadvantaged students in the country (Silva Filho and Araújo, 2017).

These differences in the educational system increased my desire to stay in England to have the opportunity to learn more about another reality than the one I was used to in Brazil. The next section is about grouping students by ability, to me the most astonishing aspect of the British educational system.

1.4.1. Ability setting

In many countries, such as England, Australia and the USA, schools have the option of grouping students within the same year group according to academic performance (OECD, 2012). Some features regarding the criteria that a school follows when grouping students vary from one country to another, or even among schools in the same country, but in the UK, 99% of students aged 15 years were in schools that group by 'ability', according to an OECD report on equity and quality in education (OECD, 2012).

In Purple Valley, students were placed in 'ability' sets according to prior attainment, and usually each year group was split into six sets. The highest 'ability' students were in set one, or the top set and the lowest 'ability' students were in set six, or the bottom set. In general, it is argued by proponents of 'ability' grouping that this allows schools to provide a better environment for the high-set students, where they do not need to "wait" for their peers, and also to allow teachers of the lower sets to deal with topics that students should have learnt previously, but for some reason did not (Boylan and Povey, 2014, p.7; Dixon et al., 2002, p.7; OECD, 2012, p.5, 2005, p.399). In that sense, both groups of

students, from higher to lower sets, would be treated according to their learning needs.

Unfortunately, that is not what this practice is achieving in many mathematics lessons in the UK. In fact, grouping students is controversial; for instance, Finland abolished ability grouping in 1985 (OECD, 2012) and Dunne et al. (2011) argue against setting on political grounds as:

> social class was a significant predictor of set placement, such that pupils from lower socio-economic backgrounds had a higher probability of being placed in lower sets irrespective of prior attainment (Dunne et al., 2011, p.506)

Consequences of using 'ability' grouping are reported in many studies. Among the many problems with this practice, researchers have reported that students in low-sets have poorer progress than their colleagues in higher sets and that the practice of grouping by 'ability' reinforces social inequality due to the over-representation of students from disadvantaged backgrounds in these groups (e.g. Boaler, 2005; Francis et al., 2015; Gates and Noyes, 2014; Jorgensen et al., 2014; Marks, 2014).

A summary of the possible explanations for the poor outcomes of students in the lower-sets were presented by Francis et al. (2015) in their study investigating the low impact research findings have on 'ability' grouping in England. Francis et al. (2015) pointed to the following problems reported in research on the failure of 'ability' grouping:

- placing students in the wrong 'ability' grouping;
- lack of mobility between sets over the years;
- quality of teaching for different groups;
- teacher expectations of students;
- pedagogy, curriculum and assessment applied to different groups;
- students' perceptions and experiences of 'ability' grouping, and impact on their learner identities;

- the different factors above, working together to cause a self-fulfilling prophecy. (Francis et al., 2015, p.4)

Francis et al. (2015) suggested that the practice still prevails because the:

> interpolation of segregational practices as symbolic of academic 'standards' and hierarchies that appeal both to longstanding phantasies of natural order, and to contemporary middle-class desire and habitus. Hence discursive practices and policy narratives reflect and (re)produce historic, naturalised assumptions of distinction, fixed/essential 'ability' and the benefits of social segregation (Francis et al., 2015, p.12)

The idea of 'fixed ability' was also pointed out by other authors as one of the major factors contributing to the perpetuation of 'ability' grouping in schools, such as Dixon et al. (2002) and Boylan and Povey (2014). I agree with Dixon et al. (2002) when they claim that:

> teaching cannot be guided by predictive labels, because if the future is being created in the present, then to make pedagogical decisions in the present on the basis of such categorisations is indeed to create those futures-as-predicted. There is nothing fixed or unalterable about existing patterns of achievement and response. Indeed, the pedagogical task is to stimulate – and make possible – growth, development and change, to create classroom conditions that will release learning from the limits that create and are reflected in existing patterns (Dixon et al., 2002, p.9).

From now on I will use the expressions low-set and high-set to talk about the 'ability' groups in Purple Valley. My main reason for choosing these terms is because of my personal rejection of the idea of fixed 'ability' (and I am not alone, as shown above) and because these were the terms that teachers in Purple Valley frequently used.

I was intrigued by this practice of grouping students even with the research results, mentioned above, suggesting otherwise. Considering the Brazilian reality, students in low-sets in England are comparable to most students in comprehensive schools in Brazil, so understanding how teachers can change their practices in the low-sets became one of my

research interests. Investigating this reality was personally more relevant to my own beliefs and personal desire to contribute to an under considered population, as when it comes to research in mathematics education, as pointed out by Skovsmose (2011), "90% of research in mathematics education concentrates on the 10% of the most affluent classroom environments in the world" (Skovsmose, 2011, p.18).

An implication for my study was that I chose to focus on teachers teaching the low-sets. I mostly observed lower-sets, but I also observed some lessons from other higher-set groups in order to explore which practices were specific to low-set groups and which were general for all groups. Although the aim of my study was not to compare the different groups, it seemed important to have at least an idea of how different teachers' practices were with different sets.

1.5. Structure of the thesis

Chapter 2 describes my initial period of visiting a school in the UK. During that period I was able to familiarize myself with the English educational system, and also investigate one teacher changing her practices. This preliminary work led to a tentative model to explain her changes. This period was mainly important because it allowed me to focus my research interests.

Only after knowing the context was I able to propose a research question, which I present in Chapter 3, which also includes a discussion of the relevant topics related to the justification and the aims of the study.

In Chapter 4 I focus on the study design, considering the professional development initiative (PDI) developed and the methods for data collection. After presenting the proposal of the study, in Chapter 5 I present the participants, describe the data collection process, and I finish this chapter with a thick description of the analysis process, which was for me the most time-consuming and demanding period of the PhD.

Chapters 6 and 7 have similar structures, since both focus on the analysis of two participants, Julia and Alice. These chapters consider their changes and discuss possible influences on the change process. They reflect my attempts to make sense of all the data collected during my research project.

I finally bring together the discussion of influences on change in practice from Julia and Alice in Chapter 8, where I develop and discuss my proposal to explain the change process. The discussion is strengthened and refined with data from the third teacher, David.

The final chapter presents the conclusions this study has to offer. I also develop a practical implication of my findings and discuss the limitations of the study.

Chapter 2 The Reconnaissance Period

This chapter is about the period when I was visiting Purple Valley, a secondary school in England, before the main phase of data collection for my PhD study. This period was important as reconnaissance, to delineate my research, setting the boundaries of what would be possible in terms of involvement with the school and the teachers for my main data collection. As mentioned in Hammersley and Atkinson (2007), such a period is part of the research design as a pre-fieldwork phase and they argue that one of the goals "is to turn the foreshadowed problems into a set of questions to which an answer could be given" (Hammersley and Atkinson, 2007, p.24). This is a great definition of what this period meant to my study, hence the name "Reconnaissance Period" (RP).

From November 2014 until the end of the academic year in July 2015, I visited Purple Valley with Dr. Peter Gates, my main supervisor. Another goal was to develop familiarity with the school system in this country. Coming from Brazil with no experiences in any other educational systems, this was necessary for me to develop a feasible research plan. Moreover, Purple Valley was one of the schools that might participate in my main study.

In this chapter I describe the school, classrooms, teachers and comment on the lessons I observed. During this period, Dr. Gates, another PhD researcher (Leonardo Barichello) and I were working with four mathematics teachers in the school on a study focused on the use of visual aids to teach low-set students (Gates, 2015). I comment on the data I collected during this period: lesson observations, meetings with the teachers and one interview. Finally, I explain how I analysed this data and discuss an attempt to develop a model to explain the changes I observed in one of the teachers. Parts of this text have been previously published in conference proceedings (Guimaraes, 2015).

By the end of this period of visiting Purple Valley school, I began to focus my study and was able to develop the research questions that I considered interesting and feasible. However, in this chapter, I describe only the Reconnaissance Period (RP), while the research questions for my main study are presented in Chapter 3.

2.1. Purple Valley

2.1.1. The school and the students

Purple Valley is a secondary school (11-16 years) with approximately 1,000 students, located in a working-class area in England. According to the national regulation agency for education, its cohort was not ethnically diverse, but largely (80%) "white working class", and the number of students who were eligible for free school meals was above the national average. This suggests that the families in the neighbourhood were in an economically disadvantaged situation. Student achievement was also below the national average, and this was one of the reasons why the school had been 'under special measures'[5] for more than one year by the time I started the visits.

As mentioned previously, in Section 1.4.1, students in Purple Valley were grouped by previous attainment since their first day in the school. The lower the set, the fewer students in the classroom, with numbers varying from ten in a lowest set up to 32 students in a highest set.

2.1.2. The teachers and their lessons

Purple Valley had seven mathematics teachers when I started visiting the school, but only four were participating in the project. The initial interactions with the teachers were all accompanied by my

5 'Under special measures' is the label given to schools that are ranked low according to the criteria established by the national regulation agency for education in the UK, called OFSTED – Office for Standards in Education, Children's Services and Skills.

supervisor. This was also the case for lesson observations, although this arrangement naturally evolved to observing lessons alone, since we developed our rapport with the teachers and there were three researchers and four teachers.

The four teachers in the project were David, head of the mathematics department, and the one who initiated contact with Dr. Gates and invited all the other teachers; Julia, the second in charge in the mathematics department with around 10 years of experience; Otto, new at the school, but with experience in other schools; and Omar, in his initial years of teaching. They were all very receptive to having research undertaken in their lessons, frequently open for an informal talk before or after a lesson, and apparently comfortable with our presence in their classrooms.

Most of my lesson observations during the RP were in low-set groups, but I also observed some teachers teaching top-sets and these comments are valid for both. The lessons were one hour long and teachers had to take the register every lesson. Almost every lesson had a *starter*, which was a task covering a topic that students probably already knew and was meant to be a 'warm up' to the lesson as well as a settling activity, until every student was inside the classroom. After the *starter*, the teacher moved to the main topic of the lessons, normally showing the expected learning outcomes. As is usual in England, teachers had fixed rooms and students had to change classroom every lesson, one reason for a *starter* as a settle down activity.

So far I have described Purple Valley school. The following sections continue to focus on this RP, but now the focus narrows to my data collection during this period. Although this preceded the main study, it was fundamental in helping me delineate the issues around teachers' practices in the classroom that I wanted to investigate.

2.2. Data collection in the Reconnaissance Period

I began to visit Purple Valley while my supervisor was working on a research project with David, the head of the mathematics department. They were working together for some time, and their project was called "Supporting Disadvantaged Learners of Mathematics Through Visual and Spatial Imagery". Dr. Gates was observing some of David's lessons in low-set groups, and they were discussing possible approaches that David could use with his groups.

After I received the Disclosure and Barring Service[6] clearance, I began to visit Purple Valley with my supervisor on a weekly basis. David and the other teachers agreed that another PhD researcher, Leonardo Barichello, and I would observe some of their lessons. After some visits, I finally decided on the focus I would have during this period. I decided to look at teachers' professional development, and more specifically, how the teachers could change their practice with low-set students, as a result of Dr. Gates' project.

Dr. Gates was running meetings with the teachers, in which we discussed ideas for lessons about fractions. My main study began just after this project with my supervisor had ended. After the RP, although Dr. Gates visited Purple Valley a couple of times and attended some of the initial meetings, he was not running his project any more. Therefore, after the RP there were two other studies happening at the same time in Purple Valley: mine, looking at professional development of mathematics teachers and focused on teachers' change in practice with low-set groups; and the project of another PhD researcher, focused on how low-set students learn fractions with a visual approach (see more on Section 4.2.2).

6 The Disclosure and Barring Service is a government organization that can issue certificates to help employers "prevent[ing] unsuitable people from working with vulnerable groups, including children." (UK, 2018)

The data collection during the RP was aimed at refining my research aim and to clarify the possibilities for my main study. The research questions for the main study are presented in Chapter 3. This process of collecting data was also useful for my personal development as a researcher, since I had the opportunity to actually collect data and consider analytical methods for the main study, on which I comment in the sub-sections.

2.2.1. Lesson observations

Lesson observations were the first activity I was involved with during my initial visits to Purple Valley. I was curious to observe a lesson in a school in England, and particularly after my supervisor told me about Purple Valley's condition of being 'under special measures' by Ofsted.

During the RP I observed 22 lessons in total. My aim with these lesson observations was to get to know the participants and their teaching styles. Since I was expecting that these teachers would be my participants in the following year, I wanted to foster a good rapport with them, not only for our daily contact, but also to improve my access to data, i.e. make it easier to schedule interviews and gain access to their lessons. As well as improving our rapport, the development of trust between the researcher and the participants might improve the trustworthiness of the study in terms of the internal validity of the data (Shenton, 2004). With this goal in mind, I adopted some of Shenton's (2004) suggestions that improve the *credibility* of the research such as:

- adopting well-established research methods;
- developing an early familiarity with the culture of participating organisations;
- iterative questioning;
- frequent debriefing sessions between the researchers.

The table below summarizes the lesson observations undertaken during the nine months of the RP:

	Year 7		Year 8	
Teacher	**Set, out of 5**	**Number of lesson observations**	**Set, out of 6**	**Number of lesson observations**
Julia	Set 4	9	Set 3	1
David	-	0	Set 6	3
Otto	Set 3	4	Set 1	3
Omar	Set 1	1	Set 2	1

Table 2.1: Lesson observations with each teacher during the RP.

Initially I was unsure about what I should focus on during the lesson observations. Since this was not my main data collection, I was free to explore and develop observation schedules for the forthcoming year. Other than building rapport with the teachers, I adopted a stance of participant-observer (Wragg, 1999, p.15), and with the teacher's consent, I helped students and circulated around the classroom at moments during the lesson when I felt I would cause less disturbance. This was in order to get a sense of the culture of the setting, and to familiarise myself with accepted norms and expectations.

One aspect that quickly became salient was the nature of the mathematical tasks and how teachers enacted them. This was due to my perception that the teachers used the term 'task' to refer to a unit of what they would do in a lesson. The 'task' was usually a written text (with pictures, drawings and/or formulae) that I could have a copy of for my records. Additionally, 'task' is a common unit in research on mathematics education in general (e.g. Mason and Johnston-Wilder, 2006; Swan, 2014).

For this study, after observing some lessons from the teachers in Purple Valley, I decide to structure my observations around the following three aspects of the lesson:

- the *task*: the written text with the instructions and items for students to read;
- the *enactment* of the task in the classroom: how teachers presented the written text, or the activities as Mason (2008) calls them and how students were supposed to act on it; and
- the *closure*: how the teacher followed up on the tasks (e.g. showing the answers or asking for students' feedback).

At the time I was not aware of the definition of what is a *task* and what is an *activity* as suggested by Christiansen and Walther (1986), but I developed an observation schedule based on what seemed feasible to record during the lesson observation and what attracted my attention as a teacher and teacher educator. During the RP I changed the format and the items on the observation schedule until I reached the version shown in Appendix 1, which is the version I used during the main study.

From now on I provide a general comment on some aspects of the lessons (not only the tasks) that seemed important at the time. I selected these aspects of teachers' practice because I perceived they might be susceptible to change in my project. To organize these comments I used the three dimensions suggested in Artzt's and Armour-Thomas' (1999) study: the tasks used; the learning environment, especially related to opportunities of students' participation; and discourse, focusing on teachers' language. These were topics that seemed important to me at the time and they served as the drive to my readings.

Tasks

Tasks were central to all the teachers' lessons. Most of the lessons centred around the tasks the teachers had prepared in a similar sequence:

1) Teacher explained how to solve one item of the task;
2) Students solved the other items of the task individually or in groups;

3) Teacher asked for feedback on the answers for the items of the task.

This sequence is structurally similar to the initiation-response-feedback (IRF) discourse loop in Sinclair and Coulthard (1975). The IRF sequences tend to be short, focused on closed questions, and do not produce conceptual understanding (Kyriacou and Issitt, 2007).

Considering this sequence, the type of task defined the type of mathematics the students would engage with – practising procedures, solving problems, etc. However, I observed mainly tasks in which the goal was to "develop factual knowledge and procedural fluency", and that focused on repeated practice and memorization (Swan, 2014), and I only observed a few lessons in which the teacher addressed different goals.

While students were solving items from the task, item (2) above, teachers usually circulated around the room. It was not common to see students talking to each other, even when teachers asked them to do so.

The closure, item (3), was the only moment when teachers asked students to speak in a whole class situation in the lesson. Teachers usually began to show the answers of the items from a task before everybody had finished, but sometimes teachers asked students to solve something on the board. The most common closure practice was for teachers to take many answers from different students and start a discussion about which one was right.

Learning environment

All the teachers encouraged students to contribute in the lesson in some way and the most common approach was with students saying their answers when the teacher was checking the solutions to a task on the board. Sometimes students were invited to go to the board or to show their notebooks under the visualiser[7]. Those interactions varied

7 Visualiser is a device equipped with a video camera and an image projector. Teachers normally use it to project a worksheet so the whole class can see it. Since it uses a camera, it is also useful to show objects and someone's writing in real time.

from just saying the final answer to explanations about how they obtained the answer.

The arrangement of students in the classroom was also diverse, and some teachers kept students' seated in pairs or groups of three and four, while none of the classrooms were arranged in individual rows. In general, students were quiet when the teacher was talking and a few students (usually the same ones every time) were willing to engage (mostly by raising their hands) when the teacher asked for them to participate. The teachers had many strategies to foster participation, such as choosing a student at random to give the answer, asking students who had finished to help others, and sometimes proposing short competitions regarding speed and accuracy.

The teachers were attentive to the management of the classroom, and any misbehaviour, such as off-topic conversations, a student standing up for no apparent reason, or any abrupt disruption of the course of the lesson was promptly dealt with, sometimes with the support of the senior staff member responsible for behaviour management. There was a list of consequences in every classroom reminding students and teachers of what the procedures were in case of misbehaviour.

Discourse

I was intrigued by the emphasis the teachers had on memorization of procedures to solve a task. They emphasised how to perform one single fixed procedure to solve one specific type of task, rather than explore possible ways to solve a task or how to use and adapt a procedure for different tasks. The teachers were constantly warning students of the importance of 'remembering' and 'memorizing' something because they would use it for the examinations and they constantly created lists of steps to solve certain types of tasks. My impression was that the lessons were normally focused on instrumental understanding (Skemp, 1978).

In general, the lesson observations provided a lot of primary data on teachers' practices (rather than secondary accounts from the teacher about a lesson). Other than developing the observation schedule, after the RP I decided that I would need to record the lessons. I had some experience using video cameras, which were demanding to set up and caused more disturbance in the classrooms. I decided to audio-record the lessons with a small audio-recorder placed on the teacher's table or at the back of the classroom.

2.2.2. The meetings and the lessons planned collaboratively

In conversations with the teachers, we agreed to focus on the topic of fractions. We believed that concentrating on one topic would help us during our meetings with the teachers to focus on specific aspects of the teaching practices, rather than having a different topic for each teacher and probably limiting the talks teachers could have with each other. The project then was about teaching fractions to low-set students using a visual approach, with my focus being on how teachers engaged in the project and how they might change their practices in the classroom.

During the RP there were six meetings with the teachers and the researchers, each about one hour long and audio recorded. The table below shows the dates and the main topic discussed in each one of them.

	Date	Topic
Meeting 1	10/02/2015	Introduction of the project; issues observed in the school; planning lessons about fraction
Meeting 2	03/03/2015	Discussion of examples of lesson plans about fractions
Meeting 3	31/03/2015	Discussion of examples of lesson plans about fractions
Meeting 4	08/05/2015	Discussion of Julia's initial ideas for the first lesson
Lesson 1	15/05/2015	Visualising fractions, silent animation adding up to one with cut-outs of 1/2, 1/4, 1/8 and 1/16
Meeting 5	12/06/2015	Comments about the first lesson and initial plans for the second lesson
Meeting 6	06/07/2015	Discussion about the second lesson, finalising the lesson plan
Lesson 2	10/07/2017	Adding fractions with cut-outs of 1/2, 1/4, 1/8 and 1/16
Lesson 3	17/07/2015	Representing and adding thirds, sixths and ninths

Table 2.2: Date and topic of the meetings with the teachers and the lessons about fractions during the RP.

Three lessons to teach fractions were discussed in these meetings and Julia taught these lessons to her Year 7 set 4. I will now discuss the meetings and these lessons.

In the first meeting we talked broadly about the interests of each one of the researchers, professional development (for me), students' learning (for Barichello) and the use of visual representations (Gates, 2015) in low-set groups (for Dr. Gates). It was agreed that the whole group would focus on planning lessons together to teach fractions to low-set groups. We established that the lessons would be designed by everyone involved and they would not be 'ready-to-use' lesson plans, mainly because we all wanted the lesson to be specific to each teacher and flexible in terms of structure and time.

For the second and third meetings Dr. Gates prepared handouts with lesson plans and tasks about fractions. He presented several styles

of tasks, expecting to hear the teachers' opinions and that the discussion would initiate the development of a common goal among the group: to teach addition and subtraction of fractions using a visual approach and without focusing on the procedures to simply obtain the final sum. We discussed the items, commenting on how they might work in the classroom. At the end of the third meeting, it was agreed that Julia would sketch out the first lesson plan to be discussed in the next meeting.

The fourth meeting was the last one of planning for the first lesson about fractions. Julia prepared a slide animation to introduce the rectangular area model for fractions. We watched the animation, giving suggestions and discussing the tasks that students would be asked to solve afterwards.

During the first lesson, Julia showed an animation with a square being cut in 2 halves, 4 quarters and so on up to sixteenths, accompanied by their corresponding symbolic representations. The last part of the animation displayed three fraction sums equal to one. Then the students were given a set of cut-outs of the shapes they had seen in the animation. They were supposed to use these cut-outs to solve three tasks: 1) write some sums equal to one; 2) identify two equivalent fractions; and 3) explain what 'equivalent' means. After the lesson we had a short meeting to talk about it, and everybody was excited about how well the students coped with this lesson. David came to observe the lesson and also stayed for this meeting.

This first lesson was very different from how Julia usually taught her lessons. Julia was used to producing very structured slides, which enabled her to control the flow of the lesson. But to ensure this control, Julia also relied on frequent verbal explanations (see Section 5.1.1 for further description of her regular lessons). For this lesson about fractions, planned collaboratively, Julia was able to not talk during the slide animation. I discuss this change in her practice in Section 2.3.1.

For the two following meetings (fifth and sixth), the group included only two teachers, David and Julia, as Otto was no longer attending the meetings and we were not observing his lessons (ethical issues about this are discussed in Section 4.4 and further analysis in Section 8.1.2.d). The remaining group discussed the most appropriate topic for the second lesson. We talked about what the students had achieved and what we were expecting them to achieve after all the lessons in general, and after this second lesson in particular. To inform our decisions, we looked through collected students' responses from the first lesson and our field notes.

The second lesson was about adding fractions, and Julia began the lesson with one half and one sixteenth shaded in a square and asked students to find out how much of the shape was shaded altogether. The students used the same cut-outs from the previous lesson to solve several similar questions and also questions where the fractions were written down, but the diagrams were not provided. Again, we spent some time talking after the lesson. We discussed positive and negative aspects of the lesson, but this post-lesson talk focused mainly on what to do next, and how we could move towards more abstract ways of adding fractions. Although we came up only with ideas, not a complete lesson plan, Julia agreed to teach a third lesson about fractions, and this time the students would be asked to add thirds, sixths and ninths.

In the third lesson, the students did not have the cut-outs. They were encouraged to draw diagrams for thirds, sixths and ninths. Julia did not show how she expected them to draw the fractions and students had more ideas than we anticipated. The discussion of these ideas took a lot of time from the main task of the lesson. Eventually, the students moved on to the next activity, a matching card activity to recognize the fractions, with the last task being about adding fractions. During the post-lesson meeting we commented on problems of not imposing a single way to represent the fractions. David had given an extra sum for one of the students and we spent a long time discussing his solution, because he

seemed to have grasped a lot from the visual representation and was able to attempt a different question using the diagrams (Barichello, 2015).

During these meetings to plan and talk about the lessons, the group (teachers and researchers) interacted a lot, solving mathematical tasks, discussing preferences and expectations, sharing experiences, etc. The group seemed comfortable discussing issues about teaching practices. The relaxed atmosphere seemed important to allow teachers and researchers to talk freely. Teachers could talk about their fears and justify their choices, and researchers could suggest different strategies and further question teachers' reasons and intentions. I was intrigued by what had helped the development of that atmosphere.

Additionally, the tasks we solved brought up possible misunderstandings that students could have and allowed us to discuss the topic of fractions in general: what prior knowledge students should already have, what would be the best order to present the topics, and what were the connections within the topic that we needed to advance. These discussions seemed to also strengthen the content knowledge of the group at the same time as we considered students' issues. The idea of using the students' task to foster the teachers' curiosity seemed to be fruitful in that context.

Julia followed her lesson plans developed during the meetings collaboratively for the two first lessons, and by following them, she taught differently from her usual style. Apparently we achieved an appropriate balance between support (helping during the planning and during the lesson) and perturbation or challenge (suggesting different approaches and asking about her lessons). This led me to ask, what were the factors enabling Julia to act the way she did?

The experience of using the tasks we planned and seeing them working as expected seemed to be powerful in motivating Julia to keep trying the different tasks we were discussing during the meetings.

Julia agreed to follow a lesson plan she did not help to develop. This was unexpected, since she said during the meetings that she needed to plan her lesson herself in order to be able to teach it, and that she did not feel comfortable following a lesson plan she did not develop herself. I was interested in identifying the features of this situation that enabled Julia to change her mind and become comfortable in teaching someone else's lesson plan.

The planning, the teaching and the talk seemed to work as a powerful combination to discuss teacher practice that could eventually lead to teacher change in practice. But I still did not understand why Julia followed this sequence, and that was the main reason I wanted to interview her.

2.2.3. The interview

After the third lesson I interviewed Julia. My aim was to gather more information about her impressions of the whole experience we had shared (the meetings, the planning and teaching of the lessons) and the reasons that might have encouraged her to engage with it, considering that she changed her practice in the classroom during these three lessons.

The interview schedule began with some background information about Julia. Then I moved to the main topic: how did Julia perceive the experience with the different lessons. As I commented near the end of Section 2.2.2, I was looking for how Julia accounted for teaching differently-styled lessons and how she felt during the experience. I also asked her what might have influenced her to plan those lessons, and if she thought she had changed something in her teaching practices since the project began.

Julia and I talked for one hour, during which she seemed to me to be relaxed and willing to talk about her teaching and the project. Julia appeared to enjoy talking about her job. During these nine months we had developed a good rapport and Julia had shown willingness to talk and

reflect. Those characteristics would facilitate my main study the next year if she agreed to be a participant.

The following section explains how I analysed the data collected during the RP through the lesson observations, the meetings, informal talks, and the interview with Julia. I tried to formulate an initial hypothesis about teacher engagement in the project and about features that might foster teacher change in practices.

2.3. Analysis

The data I collected during the nine months of the RP helped to delineate the focus of my main study. Towards the end of the academic year I began to analyse the data I had from the RP focusing on how Julia had changed her practice during those three lessons, how she planned and taught the fraction lessons and how the project had influenced her. This section is about that tentative analysis.

During the RP, I was constantly going back to the data I was collecting. Alongside this ongoing process I analysed the data in an iterative and multi-faceted way:

- I wrote some accounts *of* and *for* the lessons I had observed (Mason, 2002) and discussed some of them with Barichello and Dr. Gates;
- I transcribed and analysed the interview with Julia following an open-ended coding approach (Newby, 2010, p.493);
- I listened to some of the meetings and talks I had with Julia to try to confirm the themes I found in the interview.

Newby (2010) described the phases of Grounded Theory approach to data analysis as (1) open coding: tagging line-by-line of the data; (2) axial coding: grouping the codes from phase one; and (3) selective coding: building an explanation that brings the axial codes together. During all the phases, Newby argued, the researcher is constantly

comparing data and writing about her impressions and ideas, a process called "memoing" (Newby, 2010, p.498).

At the time, I was not confident that I performed all the phases and processes above properly, but the experience of trying brought up the importance of constant comparison and memoing for my main data collection. I felt the need to be constantly keeping notes of what had happened and my ideas at the time. Also, I needed to be organized with the data to be able to easily find the lesson or the conversation I wanted to revisit.

The next sub-sections present the codes I developed during the analysis, followed by a tentative discussion of the findings from the RP.

2.3.1. Julia's changes

I identified many differences between Julia's regular practices and the three lessons about fractions that she taught. From my lesson observations, interview and informal talks with Julia, I identified the following five themes in Julia's adaptation of her practice:

- **Doing less talking**: In the first lesson, in addition to the animation being silent, Julia did not give further instructions for the students. Their only guidance was two questions presented on the slide. Also, during the second and third lessons, Julia had other silent animations and her comments were only repeating what they were showing.
- **Not using fixed methods**: There was no list of steps to be followed, which was the rule in her regular lessons. Also there were always multiple ways of representing or arriving at the correct answer. This situation, of Julia not showing fixed methods to solve a task happened in all three lessons. Julia trusted that students would be able to solve the items without being taught a method beforehand. Julia said: "I think perhaps prior to doing this [the

meetings and the lessons] I would have done the example first." (Interview RP, 20min 09s)

- **More investigative type of task**: due to the previous point, the tasks acquired an investigative component and the concepts were built from the tasks instead of the tasks being solved by repeating a known procedure. This changed the nature of the tasks Julia would normally use in her lessons.
- **Using cut-outs and diagrams to foster students' engagement**: Julia felt that the cut-outs and the diagrams were beneficial for her students, and the way she used these resources in her lessons was helping students to have a different experience with fractions. Julia saw this as a new strategy for her lessons that allowed students to engage with the topic of fractions in a different way from how they did before. Julia said:

> The idea of them having some tangible resource and creating different fractions and being able to lay things out in front of them [the students] that is completely new (Interview RP, 21min 55s).

- **Reinforcing the perception that low-set students can be successful**: Julia did not show signs that she believed in fixed ability, on the contrary, she seemed dedicated to help low-set groups develop further than the minimum expected from them. However, her participation in the project pushed her perceptions further. In Julia's words:

> [the meeting and the lessons] kind of opened me up to the fact that actually lower ability classes probably know perhaps more than you perceive, sometimes (Interview RP, 21min).

These were the five changes and how I interpreted them soon after the RP. This initial analysis was an inspiration for my main study and it is presented here, three years before the writing up of this thesis. With the five changes mentioned above, I moved on to consider the reasons that fostered or constrained Julia to plan and teach the different lessons.

2.3.2. Reasons behind the changes

Now I present the themes I created that related to what might have encouraged Julia towards planning and trying the different fraction lessons, according to my analysis.

- **Being reflective**: Julia often said she had time to think more about the lessons due to our discussions in the meetings. The researcher was bringing new ideas and fostering discussion about planning and teaching the fraction lessons.
- **Collaboration**: Julia said that the non-judgemental environment in the meetings had a positive effect on her willingness to try out the lessons. The group (teachers and researchers) supported the planning and the teaching, helping Julia through this process.
- **Motivation**: Julia was already motivated by low retention levels presented by her students regarding fractions, and she wanted her students to do better.
- **Immediate results**: Julia's first impression was that "they understood!" meaning that the new approach, with all the features that differed from how she normally teaches, presented a positive response from the students. Julia had a productive experience in teaching the fraction lessons.

These four themes seemed to be positive influences in helping Julia to plan and teach the lessons. Initially, Julia recognised that the silent animations were really different from what she would normally do, presenting a challenge for her teaching. I felt at the time that the level of the "challenge", and the surrounding context seemed to be in a positive balance for Julia.

A first constraint in implementing this strategy for other topics was that the group took a long time to develop only three lesson plans. However, there was a possibility that this might get faster once the group established a routine, making it feasible as a long-term initiative.

A second constraint was related to the fact that only Julia taught the lessons. David participated in the planning and attended all the lessons Julia was teaching, but he did not try them in his own groups. This was discussed during our last meeting, and we all agreed to continue with the project for the next academic year, with David also teaching the lessons we would plan.

2.4. Discussion about the RP

The analysis showed that Julia changed the way she taught during the lessons about fractions (see Section 2.3.1), and suggested some reasons why she was able to plan and teach lessons so differently from how she usually did. I was curious to investigate further what may have enabled her to change.

2.4.1. Literature review for the RP

During the meetings with the teacher I was implementing many features already established in the literature as positive influences on teacher change. These features included the items suggested in the report from De Geest et al. (2009), who used questionnaires, observations and interviews with teachers, and the core features identified by Desimone (2009), who summarised research results. They cover the main features influencing Julia with reference to the project we were running in this period: Researchers providing ideas and leading discussions; the group of teachers discussing their practices; careful planning of lessons; experimentation in the classroom; support during the planning and the teaching of the innovation; and allocated time away from the classroom to engage in the project.

These were the pushes from the design of the project during the RP that may have supported Julia to plan and teach the different lessons. As mentioned before, there were also pushes against Julia's use of the lesson plans. It was possible to notice that there were some risks and

concerns involved when Julia was planning and teaching the different lessons: Julia was unsure if the lessons would work; some tasks were really different from her common practice; and the planning of three lessons took a long time. Despite these negative pushes, Julia felt capable and motivated enough to continue with the project.

Edwards (1994) and Anthony, Hunter and Thompson (2014) found the opportunity for risk-taking was beneficial for changing in mathematics teachers' practice. Penteado (2001) and Penteado and Skovsmose (2009) used the terms 'comfort zone' and 'risk zone' to characterise practices involving the use of new technologies. The authors suggested that teachers in the comfort zone take predictable actions, and do not try innovation even when unsatisfied with their practices and with student learning, while teachers in the risk zone are exposed to unexpected and unfamiliar situations that may develop into new practices. According to the authors, to provide new learning opportunities to students, teachers need to operate in their risk zone, changing their practices. The authors suggest that peer collaboration represents vital support required for teachers to "ensur[e] that risks become not destructive, but rather entrances to new educational possibilities" (Penteado and Skovsmose, 2009, p.225).

Considering the analysis of the changes (Section 2.3.1), I perceived that, on one hand, Julia maintained some of her regular practices when teaching the different fraction lessons, such as using worksheets and slides, keeping students in the same positions in the classroom and having a backup plan in case the fraction lesson did not work (an extra worksheet or a slide presentation with something else for students to work on). On the other hand, there were changes that would characterise Julia as acting in her "risk zone", such as talking less and trusting that students would be able to solve the tasks after only watching a silent animation. She said that these approaches and the use of tangible resources to promote independent thinking were all new and challenging to her.

The “comfort zone”, as characterised by Penteado and Skovsmose (2009), does not seem fully appropriate to explain Julia's situation during the lessons. Thus, I would argue that Julia was acting in both risk and comfort zones simultaneously during these lessons. Apparently, a transitory zone seems more appropriate to describe her situation. Based on that, I propose a different model composed of three zones: confidence, risk and innovation (see Figure 2.1).

2.4.2. The Zone Model

Figure 2.1 below illustrates the idea of an intermediate area between the risk and the comfort zone that I term the **Innovation Zone**. Taking risks can be seen as necessary for teacher change, as mentioned before, but research also found undesirable emotional outcomes from adopting innovation in practices (Nolder, 1990). As Reio (2005) points out:

> emotions are a key component in school reform and teacher change. Teachers' emotional experiences of reform influence their risk taking. Change can affect teacher development by creating an environment of uncertainty. (p.856)

The results from the RP in relation to Julia’s changes suggest that there could be a middle ground that would avoid too many undesirable emotional outcomes when teachers are taking risks.

The Confidence Zone: is the space encompassing the practices usually implemented by teachers. From my point of view, acting inside your Confidence Zone has many positive aspects. The teachers are comfortable and control the type of practice they are using in the classroom. Acting in the Confidence Zone develops automaticity, professional agency, and is less demanding for the teacher, allowing recovery time. However, if the Confidence Zone is too narrow a range of strategies, the teachers may have problems creating opportunities for all students to learn. Hence, the wider range of strategies in the Confidence Zone of a teacher, the more flexible and diverse their practices will be.

Teachers empowered with more practices have options to choose judiciously what they want to use, thus enhancing the learning opportunities for students (Borko et al., 1990).

The Risk Zone: is the space composed of the practices teachers are not comfortable using. It is possible that a teacher will not use certain practices due to not knowing about them, not recognizing any advantage in teaching that way, apprehension and anxiety in relation to the unknown, or because of unsuccessful previous experiences.

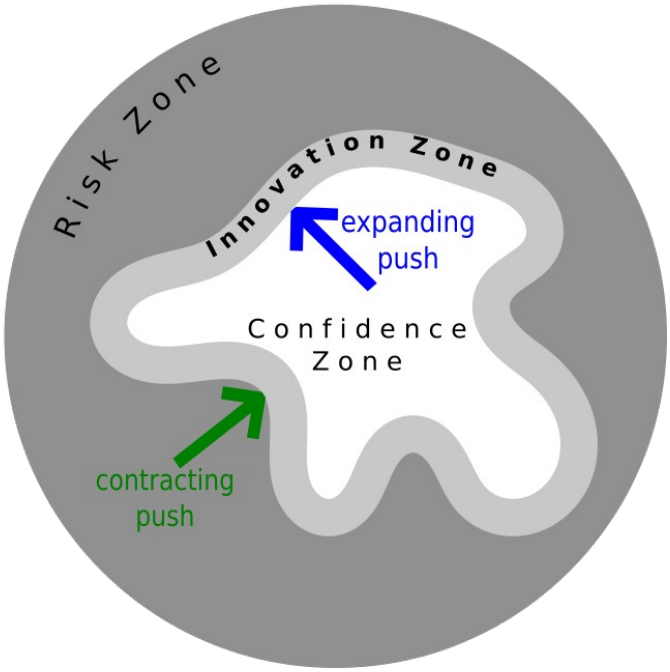


Figure 2.1: Schematic representation of the Risk, Confidence and Innovation Zones.

The Innovation Zone: is a transition zone, combining elements from the Risk and Confidence Zones in such a balance that it allows the teachers to feel confident enough to deliver the lesson, and at the same time, incorporate some new elements. The practices in this zone are not yet consolidated as part of their Confidence Zone, but if an experience with them is successful, it has the potential to be aggregated to the Confidence Zone, thus expanding it.

The Innovation Zone can be the focus of initiatives with different aims, from implementation of a reform to the adoption of new tools, such as the use of computers (Penteado, 2001) and strategies, such as considering cognitively demanding mathematical tasks (Stein et al., 2008).

The Innovation Zone is a helpful concept to understand what Julia did during the RP. With this modification, the Zone Model seems useful to think about other teachers' continuing professional development, and because of that, it has become central to my research.

2.4.3. Focusing the research interest

The changes observed in Julia's practices were largely encouraged by many "perturbations" (Shaw et al., 1991; Wheatley, 2002; Wood et al., 1991) from the initiative. For Shaw et al. (1991), perturbation is a mental dissonance needed to influence teacher change, and the quality of these perturbations is key in fostering commitment to change. In my project, these perturbations are described in the analysis of the reasons why Julia changed elements of her practice (Section 2.3.2) and they suggest that the initiative was creating some level of confidence and control that prompted Julia to act differently.

Considering the findings obtained in the RP, I conjectured that a similar initiative might also move other teachers towards their Innovation Zone. My interest therefore, was to investigate:

- why teachers would go toward their Innovation Zone;
- why they stay in or leave their Innovation Zone.

In order to have information that might help me investigate these issues, I designed the main study to consist of an investigation of teachers' changing teaching practices with low-set groups, through an initiative designed to support them moving towards their Innovation Zones. This includes the recognition that not all teachers are the same

and the balance between novelty and common practices would be different for each teacher.

It was important to investigate what changes in teaching each teacher implemented in their practices and the features influencing (fostering or hindering) the changes.

My starting point was to expect that teachers could change if they had a suitable balance between risk and confidence, together with some support from the initiative. Features of the teachers' personality and the school context would be likely to influence the changes, so these aspects were also relevant to my main study. Although I had developed the Zone Model to illustrate the general movement and represent the zones where teachers might act, it was already evident for me that the phenomena under investigation is messy and I should not seek to offer simple models of complex behaviour.

The next chapter summarizes research results of relevance to defining the research question (so far, I have only presented research interests). I also consider previous results of research that might be relevant for understanding the contribution of the main study.

Chapter 3 Developing the Project

In this chapter I define the research question for the main project of my thesis. I consider the 'main project' to be the period following the Reconnaissance Period (RP), see Chapter 2. As mentioned before, the RP set some boundaries related to the possibilities for the study and also helped me to develop some initial hypothesis about the influences on teachers trying an innovation in practice in the context of my investigation. Additionally, the RP helped me to familiarise and acclimatise to the setting where my study would take place.

In the next sections, before presenting the research question, I summarize relevant literature focused on justifying my choices, and state the results already known in the field that have influenced my decisions during this period. Research results that support my conclusions are presented in the final chapters of this thesis along with the discussion of the findings (Chapter 8 and Chapter 9).

Following the RP, the approach during the main project was still exploratory in nature, meaning that the initial goal of the study was refined during the research process (Hammersley, 2018). My initial general goal with the PhD study was to investigate the phenomena of teachers changing their practices with low-set groups as openly as I could, allowing unforeseen issues to emerge.

3.1. Change in teaching

Teaching demands teachers be adaptable to change in many situations, to adopt new curricula, to use new technology, to accommodate new textbooks, new cohorts of students, and different examination boards, etc (Jaworski, 1989; Lampert, 2010). Although some of these changes are a natural part of a teacher's job, others might not be as natural, such as change in teachers' practices that do not seem to come easily (Hiebert, 2013; Wood et al., 1990).

Teaching is a complex task, which is highly influenced by different types of knowledge and beliefs (Ball et al., 2008; Shulman, 1986; Wilson and Cooney, 2002), has a constant need for instant decisions while interacting with a group of children (Ball, 1993), and has pressures from different sources (Hargreaves, 1994). This all increases the difficulty of understanding the barriers to the changes that are not integrated into the job description, such as changes in classroom practices.

Additionally, in many situations in the school context, the actions taken to improve students' learning are directly related to improving the quality of teaching (Hiebert, 2013). This is the case for the majority of aspects of the changes in schools' curriculum, or reform. Research in teacher development has paid a lot of attention to the reform context. The scenario in mathematics education is the same, with the focus on teacher change in practice largely dominated by the context of reform (Adler et al., 2005).

Richardson (1990) argued that the focus of the literature on teacher change in practice is mainly on whether teachers are able or not to implement the new program under investigation. She showed that the studies moved from the acceptance of the new program or not by the teachers to examining features influencing implementation of the new program, but at least one similarity persisted: the fact that the innovation was brought from an outsider and was not under the control of the teachers who had to change their practices. Studies looking at changes

imposed upon teachers are the norm, this approach leaves a gap related to issues of teacher change in a non-imposing situation. This issue is known for some time now, and Richardson (1990) suggested that teacher personal attributes and autonomy should be considered when research is undertaken in a context of teacher change.

Therefore, instead of focusing on a reform context, my particular focus on this issue of changing teaching practice is towards providing teachers with more agency in terms of approaches to use in the classroom, enabling them to develop a large repertoire of teaching strategies to choose from when they are teaching.

One reason for the need of this large repertoire of practices comes from Lambert's (1985) and Ball's (1993) examples of daily dilemmas that mathematics teachers face in the classroom: deciding what and how to teach in their classrooms, and finding a balance between pressures of time, performance, their own teaching skills and the outcomes for students' learning, etc. Lambert and Ball both portray the teaching job as one of constantly making decisions to cope with challenges. Coping and managing dilemmas in the classroom, they argue, is and always will be, a major part of the job for teachers (Ball, 1993; Lampert, 1985). If teachers have more options to use while teaching, they will be better prepared to face these daily choices in their classrooms.

A teacher who tries a new strategy in the classroom is testing it, and possibly incorporating it to her repertoire of strategies to use in the classroom. Beyond that, as Clarke and Peter (1993) suggest:

> Teacher experimentation is the principal operationalized consequence of the changes in knowledge and beliefs, as well as being a principal stimulus for reflection. From this perspective the role of teacher classroom experimentation within professional growth is a central one (Clarke and Peter, 1993, p.173).

This conclusion is aligned with the results I obtained in the RP. Considering addition and subtraction of fractions, Julia chose to teach her Year 9 the mnemonics of the procedures, which in her opinion, would be

sufficient for her students to do well in the examination questions about this topic. On the other hand, the project during the RP created the opportunity for Julia to plan and teach different lessons from the ones she taught her Year 9. During these different lessons she perceived that students had learnt more about fractions than just the mnemonics for adding and subtracting. This experience led her to rethink her own teaching for that low-set group, as discussed in Sections 2.3 and 2.4.

Some research suggests that space to take risks is one of the ingredients to foundational change, which "involves a change in orientation of self (identity) and practice (actions)" (Chapman and Heater, 2010, p.456). Anthony, Hunter and Thompson (2014) investigated one teacher's self-reported experience of participating in a professional development initiative and the authors concluded that:

> the provision of both space for collective and individual learning, the provision of a space to take risks, and the prompts and support for him to experience and attend to tensions involving self and practice have enabled [...] 'foundational change' (Anthony et al., 2014, p.288)

But experimenting with different practices in the classroom can be too great a risk (Penteado and Skovsmose, 2009; Smith et al., 2005) and teachers can suffer from diverse emotional and professional setbacks (Nolder, 1990; Reio, 2005). To deal with these issues, many studies of professional development initiatives mention the importance of support and collegiality as means to foster teachers engagement with new practices (Goldsmith et al., 2014, p.15). For instance, Penteado (2001) found that collaboration among her participants was enhancing their use of new technologies. Penteado (2001) used an analogy with risk when teachers were implementing novelty, and with comfort when teachers kept using old practices and did not create opportunities for developing their pedagogical strategies.

My approach to this issue is the Innovation Zone. As I discussed in Section 2.4.2, Julia's experimentation of an innovation in her classroom balanced novel and old practices, facilitating the expansion of Julia's

repertoire of strategies and placing her in a privileged position when making choices for future lessons (Ball, 1993; Borko et al., 1990).

This claim was limited to the specific context and to only one teacher during the RP. The main project investigated three teachers over one academic year in the same context who were involved in a profession development initiative (PDI) similar to Julia's, and focused on features influencing the teachers to teach in their Innovation Zone. The details of the main project are presented in Chapter 4.

In summary, I agree with Zaslavsky and Sullivan (2011) that teacher development includes facilitating teacher change from:

> novice possibly uncritical perspectives on teaching and learning to more knowledgeable, adaptable, judicious, insightful, resourceful, reflective and competent professionals ready to address the challenges of teaching (Zaslavsky and Sullivan, 2011, p.1)

The initial aim of this project was to investigate change in practice, considering it to be beneficial mainly for improving teachers' adaptability and resourcefulness in the classroom. The results, discussed in Chapter 8 and Chapter 9, suggest that the focus on trying an innovation in practice also encouraged the participant teachers to develop their knowledge (about teaching fractions and about low-set students) and their decision-making skills for planning and teaching lessons.

The next section focuses on positioning this study as considering teacher change as learning. I also explain why I chose to study change in teacher practice, and after that I turn to review some PDIs that also focus on the adoption of innovations in practice.

3.2. Teacher change as learning

In educational research it is common to come across studies about:

1) students' learning, most commonly referring to children in the school in relation to a subject;
2) teachers' perceptions of students' learning, as studies about teachers' beliefs regarding students and about the subjects they teach;
3) teachers' learning about teaching, which is more commonly known as teacher development (initial or continuing), but in general people learning about the job of teaching.

My study focused on the third area, more specifically on teachers' learning about teaching practices. The statement "teachers learning about teaching" is already a widely accepted assumption and a declaration of a belief that teaching can be learned (Goldsmith et al., 2014; Hiebert, 2013; Lampert, 2010; Shulman, 1986).

Shulman (1986) proposed different types of knowledge that teachers need in their jobs, implying that it is possible to learn the job of teaching. Another example of learning the job of teaching is the discussion about teacher development and teaching practice in Lampert (2010). Lampert's article is a discussion of this topic, and assuming that "learning [to teach] is whatever one does to get better at that work" (p.21), she suggested the use of the term 'learning teaching' as a way to allow the possibility that teachers also learn while they are teaching. Lampert's approach also indicates that she agrees that teaching can be learned. These are only two examples, but as I said earlier, the assumption that teaching is not a "gift" one is born with, but rather a profession that can be learnt, is well accepted.

Although the two studies mentioned above do not have the same specific topic, Shulman's and Lambert's views on teacher development suggest that there are different approaches to the issue of learning to teach. While Shulman's ideas suggest an emphasis on the processes by which teachers might get to know things (understand, explain, representations, analogies, demonstrations) that will supposedly help

them teach, Lampert's emphasis is on teacher-student relationships, on the possibility of learning about teaching while teaching, and on the context where teachers might learn.

As these two examples suggest, different theoretical approaches to teacher learning reflect different views on what learning is and how it occurs, and there is no clear consensus about which view would be more appropriate for investigating different issues (Cobb and Bowers, 1999; Greeno, 1997).

The theory I consider from now on has helped to establish my definition of what might be considered learning in the context of teacher development. This definition is relevant because it has informed decisions about the format of the PDI in the project and the choices I made regarding data collection methods and focus for data analysis.

It is important to highlight that my PhD project was not focused on developing the philosophical aspect of what learning is for teachers, rather my contributions are related to the influences on how learning can occur.

My study considered that the context, the interactions and the communities teachers were engaged in are relevant when investigating teacher development, coherently with Wenger's (1998) views. Below, I discuss other studies that supported my view of how teacher learning can be seen as teacher change.

Putnam and Borko (2000) presented a discussion of recent research on teacher learning and after considering research on staff development in which learning experiences were situated in practices, they concluded that:

> the most appropriate staff development site depends on the specific goals for teachers' learning. […] Experiences situated in the teachers' own classrooms may be better suited to facilitating teachers' enactment of specific instructional practices (Putnam and Borko, 2000, p.7)

"Enactment of specific instructional practices" is a learning experience that can be seen as change in teachers' classroom practices.

Since teacher practice in the classroom and learning are apparently intertwined, I come back to the arguments from Clarke and Peter (1993). They claimed that "classroom experimentation should be seen as the contextual catalyst for professional growth, and the outward evidence of teacher change" (Clarke and Peter, 1993, p.174).

As suggested by the excerpt above, the terms *change, development, growth* and *learning* are frequently used interchangeably in research literature about teachers' practice. Clarke and Hollingsworth (1994) offered a differentiation of the three first in relation to learning:

> "**development**" when referring to in-service programs […] "**change**" when referring to a process, an observable phenomenon, or a set of behaviours; and, "**growth**" where the intention is to encompass both a change process and to invoke a notion of learning. (Clarke and Hollingsworth, 1994, p.154, emphasis added)

Clarke and Hollingsworth (1994) continued the discussion of different perspectives on changes. They argued for a need to reconceptualize teacher change in order to have clarity on the aims of in-service programs for teachers. They advocated for the education research community to focus on the perspective of *growth* and they criticise the "professional development programs based on deficit-training-mastery models" (p.160), where teachers are seen as lacking skills or implementing inefficient practices.

Although I agree with Clarke and Hollingsworth's (1994) distinction, I have not talked about *growth* in this thesis. Instead, my focus will be on change in teachers' practices. This choice was made to emphasize my interest on observable phenomenon as main data sources for my study. Therefore, not only is my research focus on what fostered or constrained changes in practice, but the PDI from which my data collection took place was focused on teachers experimenting in their classrooms.

Clarke and Hollingsworth (2002) also developed a model of teacher change (see Figure 3.1), or of teacher growth networks, as they called a change sequence that is not momentary and leads the teacher to professional growth (Clarke and Hollingsworth, 2002, p.958). Their model contains previous suggestions, such as the model of teacher change from Guskey (1986), who argued that change in teacher practice came *before* change in beliefs. But Clarke and Hollingsworth included important differences, such as the cyclic possibility of changes (not having a fixed order of occurrence) and the complexity that a growth network can have, travelling through the different domains (see Figure 3.1) in any order, even repeatedly, to build an accurate description of the change (Clarke and Hollingsworth, 2002, p.951).

Their model has also been highly accepted by the research in mathematics education community, being used in different studies to investigate teacher change, (Golding, 2017; Hartnett, 2011; Justi and van Driel, 2006; Voogt et al., 2011) and even to categorize studies in a synthesis of recent research about mathematics teacher learning from Goldsmith, Doerr and Lewis (2014). But the model does not contribute to explaining the reasons and the influences behind the changes it describes.

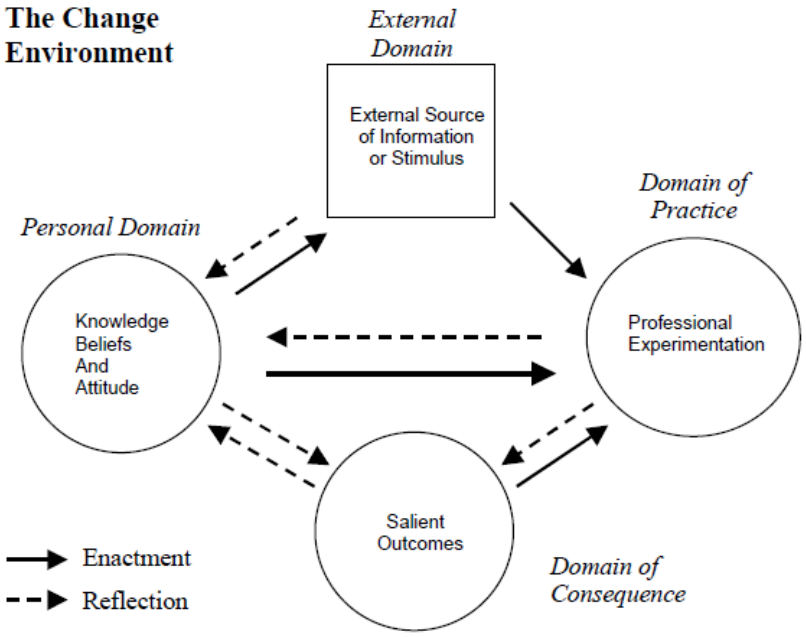


Figure 3.1: Clarke and Hollingsworth (2002, p.951) the Interconnected Model of professional growth.

Based on the ideas of Clarke and Hollingsworth (2002), it is consistent to consider change in the *domain of practice* as professional experimentation can lead, through enactment or reflection, to change in the *personal domain*, where one of the options is change in knowledge. Therefore, according to the authors, it is consistent to consider change in practice as one of the ways to foster teacher learning and I am adopting this view in this study.

Lampert (2010) suggests that there is a gap in the relationship between teaching strategies (component practices) and experimenting in the classroom (practising):

> A strong congruence seems to exist between the notions that teaching is made of component *practices* and that teaching can be learned by *practicing*, though there are several aspects of this link that could be clarified. (Lampert, 2010, p.31, emphasis in the original)

The aspects I investigated were factors that might affect teachers' willingness to experiment with a new strategy in their classroom. This change in practice can be seen as learning, as Lampert defined learning

as "whatever one does to get better at [their] work" (Lampert, 2010, p.21).

In a systematic review of the literature focused on professional development for teachers, Vangrieken, Meredith, Packer and Kyndt (2017) investigated results from empirical research on learning communities (LC) and communities of practice (CoP), which they argue are not always clearly differentiable in the literature. They used "teacher communities" as a general term to address the shared results of the studies with either theoretical approaches, LC or CoP.

The concept of teacher community considers that teacher learning happens through collaboration, which includes discussion, sharing practices and support. According to Wenger (1998), a community of practice is continually learning, and one of the ways to account for learning is change in practice, "what they [participants in the CoP] learn *is* their practice" (p.95).

However, even if one assumes teachers form a Community of Practice, this may not be enough for the demands of the profession. As Jaworski (2008) pointed out, in a community of practice

> participants align themselves with the normal desirable state. However, the normal desirable state does not necessarily foster the kinds of mathematical achievement didacticians, and society more broadly, would like to see (p.313)

Jaworski (2008, 2005) suggests the concept of inquiry community in order to "challenge the normal (desirable) state and question what it is achieving" (p.313). Her argument is that for teachers seeking to improve education, it is necessary a community that questions and re-thinks its practices as an integral part of their activity.

Vangrieken et al. (2017) found that in order to be successful members of the teacher community, teachers have to be in a safe environment to experiment with new ideas, being able to share failures and discuss uncertainties (Vangrieken et al. 2017, p.55). The authors concluded that successful teacher communities need trust and respect;

alignment of goals and a balance of the following aspects: leadership and participants' agency; top-down and bottom-up influences; safety and challenge.

This section revisited research results on the topic of teacher change in practice. It seems widely accepted that teacher change in practice can be seen as learning and that one way to promote teacher learning about teaching is experimenting with innovations. My study is based on these findings, and claims the importance of understanding what influences teachers to experiment with innovation in their practices: in other words, what influences teachers to move to their Innovation Zone.

3.2.1. Why I am not talking about beliefs?

The focus on the practice and beliefs of mathematics teachers is a common combination in educational research (e.g. Clarke and Hollingsworth, 2002; Smith et al., 2005). Due to my interest in low-set groups, the issue of teachers' beliefs in relation to many aspects of teaching and learning mathematics involving low-achieving students emerged as a potentially relevant aspect. However, I consciously decided not to focus on beliefs and I explain the reasons for this decision in this section.

As a teacher myself, and considering all of the choices teachers have to make daily in their lessons (Ball, 1993; Lampert, 1985), I personally consider that my beliefs (about teaching and learning) influence my lessons in many different and intertwined ways, from the clothes I choose to wear to go to work and the lesson plans I develop to the comments I make in class. Additionally, other broader aspects, such as beliefs about my profession (arguably related to identity) also have an impact on my lessons.

Nevertheless, considering my day-to-day teaching practices, in one day I would easily move from doing discussion and group work, to

lecturing and individual work if I thought that this combination was better for the students after considering the topic, the students' moods, the time and resources available and so on. These changes in teaching practices could be interpreted as a move from a *collaborative* to a *transmission* orientation view of mathematics and teaching (Swan, 2006), but in my opinion these changes can be better explained by the imminent circumstances than by a reflection of some sort of philosophical stance of the teacher. Therefore, changes in teachers that are sometimes regarded as a change in beliefs might just be a manifestation of the complexity of practices and the shifting strategies teachers may use.

My suggestion is that if teachers can experiment with practices that are outside their usual repertoire, and if they perceive it is better for students, then this is enough to change their practices despite any possible philosophical alignment. This is coherent with one of the major principles identified by Clarke (1994) for designing a professional development initiative:

> Recognise that changes in teachers' beliefs about teaching and learning are derived largely from classroom practice; as a result, such changes will follow the opportunity to validate, through observing positive student learning (Clarke, 1994, p.6)

Forgasz and Leder (2008) agree with this view when presenting six conclusions from a literature review on mathematics teachers' beliefs:

> The beliefs about the teaching and learning of mathematics of teachers at all levels are affected by a range of factors and can be context and student dependent (Forgasz and Leder, 2008, p.187)

Guskey (2002, 1986), who proposed one of the first models for change in teacher professional development, advocated specifically for change in practice coming before change in beliefs.

The onion model (Figure 3.2) for teacher education proposed by Korthagen (2004), also suggests that *beliefs* are a layer far inside, harder

to affect, while *environment* followed by *behaviour* and *competencies* are the most external layers that can actually be affected.

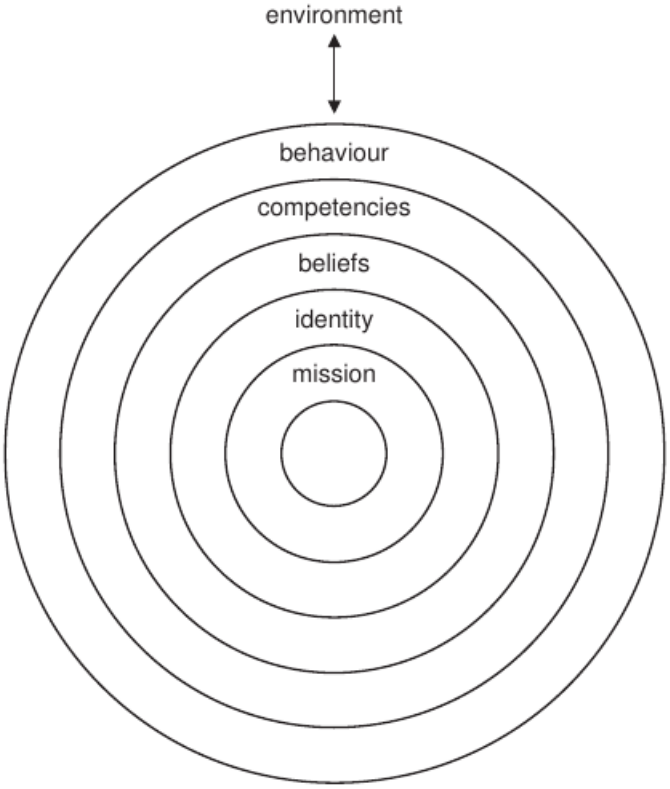


Figure 3.2: The onion: a model of levels of change (Korthagen, 2004, p.80).

In terms of this model, my study aims at investigating the layers called environment, behaviour and competencies.

Moreover, Clarke and Hollingsworth's (2002) model for teacher growth does not separate beliefs as an isolated construct. The authors consider that teacher *personal domain* is composed of knowledge, beliefs and attitudes, suggesting that these three features are not easily isolated and even that they do not have to be considered separately when investigating teacher change. Clarke and Hollingsworth's model of teacher change considers many possible paths for teacher change, with one possibility being that change in teacher practice is followed by change in teacher beliefs (personal domain which includes knowledge,

beliefs and attitudes, see Figure 3.1). Their empirical results showed that this is indeed a path for change in teaching.

In fact, as I will discuss in my data analysis, throughout the project, Alice and Julia showed elements that could be interpreted as signs of differing beliefs from each other. These were related to teaching and learning of low-set groups, but their beliefs did not seem to prevent them from changing their practice with those groups.

According to the literature reviewed by Wilson and Cooney (2002) on studies about mathematics teachers' beliefs and change, the authors remarked that:

> These studies illustrate how reflection on beliefs allows teachers to connect their thoughts and actions, to recognize and perhaps confront contradictory or otherwise problematic beliefs, and, particularly, to change their teaching behavior. (Wilson and Cooney, 2002, p.142)

Teachers' practices ought to have implications for teachers' beliefs about teaching and learning mathematics, but the focus of this study is in how we can develop and sustain a PDI that encourages and supports teachers in changing their practices.

On top of the criticisms presented so far, there are also serious methodological questions regarding the concept of belief (Watson, 2014). There is no consensus regarding how to define, identify and measure it, how it is affected by context and practical issues and how they are enacted. Mason (2003) gets to the point about the uncertainty surrounding the concept when he states that "it is not clear to me that beliefs exist, or that people actually even hold 'beliefs'" (Mason, 2003, p.288).

In my study I assume that beliefs related to teaching and learning might be flexible, highly related to practice and to the perception of good results in the classroom. I am not claiming that change in beliefs will not happen during my study, but as I have stated earlier, that is not my focus.

3.3. Professional development initiatives

In this section I review some of the literature on professional development initiatives (PDI) for mathematics teachers, focusing on those that also focus on teachers' change in practice.

There are many studies that identify features that influence the general outcomes of PDI, for example Clarke (1994), Garet et al. (2001), Borko (2004) and De Geest et al. (2009). Some of these studies were based on teacher perspectives and others on large reviews of the literature, but they all suggest very similar influencing features. The fact that we have these similar features being reported from different studies is highly promising in allowing the development of PDI that fulfil their intentions.

Even though these lists are useful suggestions for planning a PDI, they normally lack solid results directly linking the specific features of the PDI to teacher change. These relationships might be more complex to establish, but some studies have shed light on this issue.

For instance, small-scale studies often try to establish causal relationships between PDI features and teacher change, but they normally link specific aspects of a particular initiative, making it difficult to extrapolate to different contexts (e.g. Anthony et al., 2014). Large-scale studies have to simplify complex constructs, such as teacher learning, that are hard to accurately isolate and measure (e.g. Smylie, 1988). Others focus on self-reporting of teachers, and might be weakened by the lack of consensus regarding the meaning of key terms, like problem solving, and the difficulty in establishing the intensity of key events, such as change in practice (Kaasila et al., 2008).

Even with a plethora of influences on mathematics teachers participating in a PDI, the research community is finding ways around it. One path is to focus on teacher *knowledge* (Ball et al., 2008). Although it is an important endeavour, even if we do achieve a consensus on what

mathematics teachers have to know, we are still left with the issues of how teachers would learn it and how this knowledge would transfer to practice.

Another approach is to look at models to describe teacher change. These models normally suggest the path that has to be followed in order to achieve teachers' change, taking into account factors from the PDI and beyond. This, in my view, is a benefit from this kind of approach: context and social aspects are more likely to be considered in relation to the features of the initiative.

Guskey (2002, 1986) proposed one of the first models of teacher professional development to advocate specifically for change in practice coming before change in beliefs. Based on empirical evidence from other studies, Guskey advocated that there were two crucial factors contributing to a good PDI: "(1) what motivates teachers to engage in professional development, and (2) the process by which change in teachers typically occurs" (Guskey, 2002, p.382). Guskey (1986, 2002) discussed teachers being motivated by success and that they perceived success in terms of their students' behaviour and activities. Guskey then presented his model and suggested that the teachers had to have an "experience of successful implementation" (Guskey, 2002, p.383) in order to change their beliefs. Guskey claimed that this experience could only happen if the teachers tried the new feature in their lessons.

Focusing only on developing individual teachers, not related to reform implementation or district innovations, Smylie (1988) found that teachers' *self-efficacy* played a big part in the process of teachers changing practices. His model considered aspects of the schools' context, classroom characteristics and teachers' psychological factors as influencing teacher changes in practice. Smylie's results in this quantitative study showed that teachers' self-perceptions had more influence on change than any other factor. This was unexpected, but Smylie attributed it to the lack of pressure for curriculum implementation in the context of his study.

Other models, such as the ones by Shaw, Davis and McCarty (1991) and by Cobb, Wood and Yackel (1990), included a perturbation phase. These are inspired by Lewin's (1947) ideas of unfreezing, changing or moving and freezing. The argument is that teachers needed to feel the need for change, or at least the awareness that something in their practices would lead to cognitive dissonance. The perturbation works as a trigger for teacher change. However, Shaw et al. (1991) and Cobb et al. (1990) also included in their arguments that teachers have to see an alternative in order to actually change.

Nolder (1992) considered the personal and the institutional environments as external influences in her model, but the focus of Nolder's model was on accelerated change and she was interested in describing the stages related to teachers' concerns while implementing the changes. Nolder also considered rejection as a possible outcome at any stage of her change process.

So far, these studies presented do not bring features of the PDI into their models, but mainly investigate phases that teachers might go through when implementing change. Borko (2004), in mapping the terrain of PDI of mathematics teachers, suggested that the elements of a professional development system are as shown in Figure 3.3:

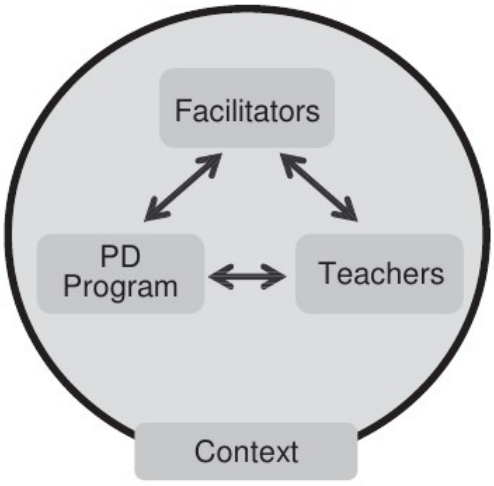


Figure 3.3: Elements of the professional development system (Borko, 2004, p.4).

Borko included not only the PD program, but also the influence of the facilitators and of the context as major elements in her model. While this is just a general representation and most of the models mentioned so far describe features related to their PDI and the context (even if they did not enter the model), it was not common to have features of the facilitator as influence.

Borko's (2004) goal with her literature review was to discuss how research in professional development and teacher learning should move forward. This is similar to what Desimone (2009) attempted when she identified five features that should be considered in order to have an adequate starting point for comparisons among different initiatives, see Figure 3.4.

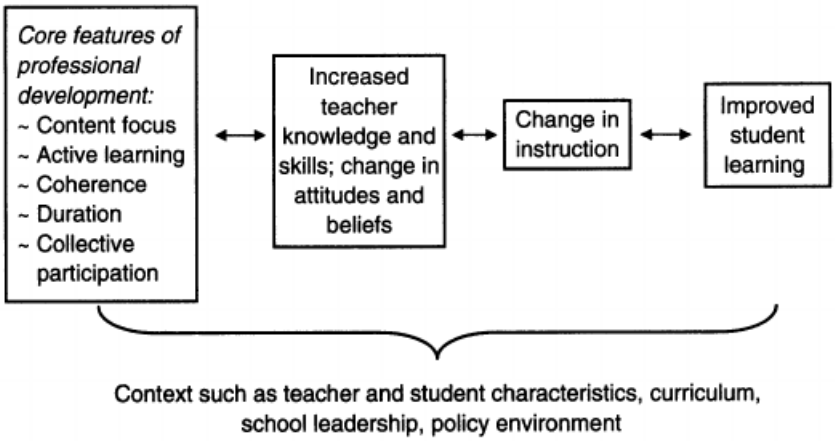


Figure 3.4: Conceptual framework for reporting studies in PDI (Desimone, 2009, p.185).

It has been acknowledged by Desimone (2009), and by many others, that teaches can introduce change in their practices by following a number of different routes. The model from Clarke and Hollingsworth (2002) represents that possibility. Many different "change sequences" are possible for explaining teacher change. Clarke and Hollingsworth's model has been adopted by other researchers who used their model as a framework for their studies (e.g. Golding, 2017; Goldsmith et al., 2014; Justi and van Driel, 2006; Voogt et al., 2011; Wilkie, 2017). Although useful in describing teachers' possible paths to change, Clarke and Hollingsworth's (2002) model focuses closely on teachers, not considering the PDI features and other influences from the context.

The work of Smith, Smith and Williams (2005) suggested a different perspective for such investigations. The authors followed a group of 13 elementary teachers, concluding that:

> variations in change among participants can be explained by variations in their levels of engagement in particular elements of the change model by the learning activities of the […] course (Smith et al., 2005, p.1)

The authors presented three cases to represent the different levels of engagement the participants had during the study. Smith, Smith and

Williams (2005) found out that teachers' "Initial Interest" in change was related to the outcomes of the initiative, which brought my attention to the initial conditions of participants in my study.

As discussed before, many of the studies mentioned in this section are focused on interventions designed to implement a new curriculum, or the implementation of a system-wide reform. These are probably scenarios in which teachers are under greater pressure to change their practices. This might imply differences in relation to my study, as I focus on how teachers try to change their regular practices, not because of such external pressures, but aiming at increasing their repertoire of strategies for them to use in the classroom more freely.

The studies presented above were relevant to my study for two main reasons. Firstly, they informed the design of the PDI that was carried out for my main data collection, as described in detail in Section 4.2. Secondly, they provide possible influences on teacher change that I can consider when analysing my data. Although I am not committing to any one of them, their results will certainly influence my awareness.

My study considered teacher change during a PDI focused on engaging teachers in trying an innovation in their classroom. In my analysis I consider that teachers might change through many possible paths (Clarke and Hollingsworth, 2002) depending on their personal disposition when the project started (Smith et al., 2005), the influences that the researcher had on the process (Borko, 2004), and their experiences throughout the process. The gap my study focus on is particularly related to investigating teacher change in a context where the participant teachers are seen as active agents in defining and evaluating the innovations they try (Castle and Aichele, 1994). In other words, the PDI is designed to investigate teacher change when teachers are changing themselves.

3.4. The research questions

The RP described in Chapter 2 culminated in a tentative conjecture for the changes observed in the teacher's practices: Julia was able to experiment with innovations in her practice with low-set groups, because the experience was neither too overwhelming nor too risky, i.e. Julia acted in her Innovation Zone during the lessons about fractions.

This combination was apparently effective in stimulating Julia to rethink some deeply entrenched aspects of her practice and to engage in teaching differently during the lessons about fractions. Considering that, I decided to focus my research on understanding what had influenced Julia to act this way.

The sections above are aimed at theorizing this issue. Teachers are constantly requested to change their practices in the classroom. This is sometimes forced by changes in the school, such as the adoption of a new curriculum, technology, etc., and at other times by their own perception of what would be better for their students. If the teachers have a big repertoire of strategies, they will be better prepared to deal with changes in practices. In order to acquire more teaching strategies, teachers need to try some innovation in their lessons. That way they are potentially learning that new strategy, and rethinking their usual ways of teaching. Previous research on teacher change in practice provides insights into what features make a PDI effective, but they rarely investigate the relationships between these characteristics and how they are related to teachers' personal characteristics. Additionally, most studies focused on imposing pre-defined changes into teachers practice, not many research focused on teacher changing themselves.

Based on that, I define my general research question as:

1. How do secondary mathematics teachers change within the context of a professional development initiative to innovate in their classroom practices?

2. What are the influences affecting teachers when they try to change their practice?

Because I am not investigating a reform context, in order to encourage change, a PDI was developed to present and discuss options that might stimulate teachers' curiosity. Similar to the RP, I wanted teachers to experiment and innovate in their practices. The specific aspects of the PDI are discussed in Section 4.2.1.a, and the aspects of the lesson plans we developed with the teachers are discussed in Section 4.2.2.

Looking at the research questions with the Innovation Zone in mind (Section 2.4.2) and considering the results obtained in the RP, I expected that a similar PDI would also enable teachers to act within their Innovation Zones. My interest therefore was to investigate:

- whether it is possible to reach the balance between risk and confidence that characterizes the Innovation Zone for other teachers;
- why teachers would be open to going into their Innovation Zone;
- what would prevent teachers from going to their Innovation Zone.

My conjecture, considering the literature mentioned here and the findings during the RP, was that through participating in a PDI considering teachers' context in its design, they would be stimulated to rethink their practices while engaging in discussion about practice and teaching the lesson plans we developed collaboratively.

The methods I used to investigate this scenario, and the research questions are explained in Section 4.3. But due to my own experience as a teacher and to the experiences during the RP, I was aware of the many complexities of investigating teachers' classrooms. Therefore, I adopted diverse strategies from well-established methodologies in order to develop a substantial data set. A discussion of their advantages and disadvantages to the study is presented over the next two chapters.

Chapter 4 The study

In this chapter I describe the plans for tackling the research questions presented in Section 3.4. Initially, I comment on the nature of this research, followed by the features of the professional development initiative (PDI) developed, then I describe and justify the methods of data collection. Lastly, I end this chapter discussing the ethical issues of the study.

4.1. The nature of the research

The aim of this study is exploratory in nature, my intention being to study teachers experiencing change in practice and the features affecting this process. My own background, which includes being a teacher, led me to consider the perception of the teachers as of utmost importance in investigating this topic. Seeing reality as a human construct, approaches that fit my stance are going to be interpretative rather than positivist (Wellington, 2000), focused on meaning, aiming at deep understanding and detailed descriptions of the phenomena.

Before moving on to explain how this stance translates to the design of the research, it might be worth exploring the nature of the constructs under investigation. Considering my research questions (Section 3.4), "teacher change" is a central element, but it is a loose concept, and hard to capture using instruments, such as surveys. My approach to this issue is to combine different sources of qualitative data, such as observations and teachers' accounts.

At the same time, after the RP, an opportunity to study "teacher change" in a context where teachers were invited to take part in a PDI opened up. Taking on this opportunity determined the setting and the cases I was going to investigate. As Hammersley and Atkinson (2007) called, I was studying a 'natural experiment', in which

> the setting itself came first – an opportunity arises to investigate an interesting situation or group of people; and foreshadowed problems spring from the nature of that setting (Hammersley and Atkinson, 2007, p.28)

This approach places my study as a case-study with ethnographic methods. The cases are the participant teachers, I planned to collect data during their lessons, in informal talks and during meetings. Gathering information to build an in-depth account of each one of them and how they were engaging with the process as a whole. I was exploring the change process in a non imposing situation. As Newby (2010) suggests:

> We can use a case study to find out what is going on, to throw light on something that we have never met before or do not understand. This is exploration. We start by not knowing and we use the case study to establish understanding. (Newby, 2010, p.54)

The ethnographic approach, as Hammersley and Atkinson (2007) present, includes:

> the study of people's actions and accounts in everyday contexts; data comes from a range of sources, but particularly from participant observation and informal conversation; flexible and unstructured data collection and; the focus is on a few cases only (Hammersley and Atkinson, 2007, p.3).

For analysing the data, I planned to follow a grounded theory approach, which is aligned with ethnographic studies, similarly to what was done in the RP. I wanted to continue with the process of constant coming back to the data, since it enabled me to follow up on topics that seemed to be relevant for my study. I described the data analysis process in more details in Section 5.3.

I did not expect this study to be neat and straight forward, mainly because it dealt with very complex phenomena of the human behaviour with which I was familiar enough to be aware of the intricacies. Therefore, I did not seek to offer simple models that can describe and explain teacher change, rather I hoped to shed light on hidden influences that affect teachers trying to change their practices.

According to a research report from British Research Association (BERA), developing better links between research and practice is an international trend in educational policy (Wyse et al., 2018):

> Close-to-practice research focusses on issues defined by practitioners as relevant to their practice, and involves collaboration between people whose main expertise is research, practice, or both. (Wyse et al., 2018, p. 34)

My study has the main characteristics BERA suggests for close-to-practice research. The term "close-to-practice" is not new, and it has been used in health sector as well as in education. The focus on issues coming from teachers, being relevant to teacher practice, and promoting involvement of and collaboration with practitioners fit the approach I wanted to follow in this research.

Since I am proposing an intervention, any results will definitely be connected to the characteristics of that intervention. This necessitates a careful, in-depth description of its characteristics. It is also beneficial to have some control over the intervention in order to be able to adapt in case new opportunities or unforeseen obstacles emerge (Hammersley and Atkinson, 2007).

As argued in Chapter 3, this study takes a position of seeing teacher learning as a social activity that develops in a given context. Since I am interested in investigating the teachers in their natural context, the influences of the setting also have an impact on any results, so need to be thoroughly understood, in order to increase the explanatory power of the study.

As the previous paragraphs suggest, the research design of this study has some flexibility in terms of specific aspects of the data collection. As highlighted by Hammersley (2018), this approach is valid as long as the modifications are reasoned by the researcher, who considers any advantages and disadvantages. Moreover, I designed this study to have a mixture of well-established and non-contradictory approaches to data collection, as discussed above. These design choice

allowed me to get familiar with the methods, e.g. through courses, books and seminars, and to gather data that added to each other strengthening the validity of my conclusions (see Section 4.3.3).

The next section is about the intervention (or perturbation) planned as the PDI teachers were taking part. Considering what was relevant in terms of format (e.g. not imposing change on teachers) and what was circumstantial (e.g. about fractions).

4.2. Design of the intervention

My aim is to look at change in the context of bringing teachers to their Innovation Zone (Section 2.4.2), where they still have some level of control, while trying something new in the classroom. This balance might not be achievable during the implementation of a new curriculum, when teachers have high levels of pressure, as there is usually no extra time to prepare for the different lessons they need to teach, and as the changes are compulsory. For this reason, I wanted to investigate teacher voluntary change outside implementation of mandatory curriculum reform.

The Reconnaissance Period (RP) showed that Purple Valley was adequate for my purpose of developing a PDI, with balance between risk and confidence. The Headteacher was agreeable to a project that brought innovations that her mathematics teachers were willing to try. Also, towards the end of the RP, David and Julia agreed to continue with similar arrangements for the next academic year. For these reasons I decided to design a PDI to be carried out at Purple Valley for my data collection, this was the opportunity I mentioned before.

I could have found a PDI that was already in place, but Purple Valley School constituted a context where I had control of many features of the PDI. It meant fewer participants, but increased my capacity to describe it and to alter its features according to the needs of the study.

In Section 3.3 I discuss some results in the literature related to PDI focused on teacher change. Here I describe features of the PDI I developed for this study. The features on which I comment, are the initial plans of how I intended the PDI to progress during the main study. A description of how the PDI activities developed over the year is the topic of Section 5.2.

4.2.1. General features of the PDI

The PDI for my study is a parallel intervention designed to generate perturbations (Shaw et al., 1991). These perturbations would expose conflicts and dilemmas (Wood et al., 1991) in teacher' practice, in order to resolve these conflicts, teacher might decide to implement change.

Inspired by the literature discussed in the previous chapter, by my tentative results after the RP, and the aim of exposing conflicts in a non-threatening way, I decided to adopt the following features for the PDI:

- Long-term duration: The duration of one academic year was feasible for the PhD and natural for the teachers. Also, many research results indicated that time is fundamental for effective PDI in general and for teacher change specifically (Borko, 2004; De Geest et al., 2009; e.g. Garet et al., 2001). Therefore, I planned to maintain the PDI in my study for the whole academic year, having extended time *with* teachers (lesson observation, meetings and interviews) and more time *for* teachers (to experiment, discuss and develop familiarity).
- Focus on practice: The aim of my study was to look at teacher change in practice, and to do that I wanted teachers to try something new in their classrooms (Clarke, 1994; Vangrieken et al., 2017). Fortunately, this was easily accepted by the teachers in Purple Valley School, so in order to promote that, the teachers agreed to use lesson plans designed to incorporate new elements

for their practice with their low-set groups. The characteristics of the lesson plans will be discussed in detail in Section 4.2.2.

- Collaboration**:** In this study, collaboration is seen as collective participation. Also, considering the flexibility of the PDI, the level of teachers' interaction was not pre-determined. Meetings would be scheduled according to teachers' availability, but collaboration would also take place when researchers observed lessons and talked informally with the teachers. In this context, collaboration meant that we would discuss ideas and try to make decisions together regarding lessons (Peter-Koop et al., 2003).
- Respecting teachers' autonomy: I made deliberate choices aimed at respecting teachers' decisions about their teaching, in other words, to respect teachers' professional agency (Ketelaar et al., 2012; Vähäsantanen, 2015). This feature was key to understanding the relationship I wanted to build with teachers. Since the beginning of the RP, the researchers did their best to listen to teachers' views and opinions, to value their experience and knowledge, and to reach decisions through discussions, taking into account all the challenges and limitations of being a teacher. This was also the stance I followed during the main study.
- Balance: The features mentioned above, especially collaboration and autonomy, acted together to create balance between risk and confidence when teachers were trying new practices in the classroom. As well as that, the design of the lesson plans should also contribute to balance, as will be discussed in Section 4.2.2. My aim was to create a safe environment for teachers to change their practices (Vangrieken et al., 2017), as suggested by the notion of Innovation Zone (Section 2.4.2).

In summary, the main features of my PDI are long term duration; focus on practice; collaboration; respecting teachers' autonomy; and balance. They derived from the literature and grew out of the RP. These

guidelines for the intervention do not fixate the topic that is going to be discussed or the pedagogical approach to be adopted. These choices should be made during the initial meetings with the teachers. For this study, the teachers in Purple Valley chose fractions as the subject topic and we agreed on visual representation as the classroom strategy we were going to look at. I describe the particular intervention after I comment on the activities planned for the teachers during the PDI.

It is still necessary to clarify how these features would be translated into actions of a PDI. From the perspective of the teachers, the PDI would be composed of meetings with the researcher (around one meeting per month) and lessons in which the teacher would use the lesson plans collaboratively developed. I will discuss these actions in the next sections.

a) Meetings with the teachers

The meetings with the teachers had two main goals. The first refers to planning the lessons. In the RP, although all the teachers discussed the ideas for the lesson plans collaboratively, Julia worked by herself on the alterations agreed during the meetings. Through following this process, it took us six months to develop three lesson plans, and only Julia taught the lessons. During the RP, we asked for ideas of tasks from all the participants, but only Julia brought something to the following meeting. During the interview with Julia, also in the RP, she mentioned how she and the other teachers rarely have time to discuss their planning of lessons.

For this reason, it seemed unrealistic to expect that teachers would have extra time (outside the meetings) to engage in all the planning of the lessons throughout the whole academic year. It would also be potentially risky, considering that this was the data collection period of the PhD and it would be very complicated to extend the period in case I was not able to collect enough data during that year. In order to avoid

that, I presented ideas for the tasks of a lesson and we discussed them, agreeing how they would become lesson plans.

Additionally, I wanted all the teachers to use the lessons. If only one of them was responsible for the adjustments in the lesson plans, I would have to use the meetings to present these lesson plans to the other teachers and extra time to familiarize ourselves. By concentrating the initial design of the lessons and the incorporation of changes agreed during the meetings on the researcher, all the teachers would start the meetings with similar information about the lesson plan. Also, knowing the main ideas for the tasks before the meetings with the teachers allowed me to plan for the discussions.

Research on teachers does not agree about whether teachers should prepare their own lessons, or if ready-to-use scripts are better. Little (1982) found that a characteristic of successful schools was that "teachers plan, design, research, evaluate, and prepare teaching materials together" (Little, 1982, p.331). On the other hand, Cobb, Wood and Yackel (1990) argued that having a lesson plan ready for implementation allowed the teacher "to concentrate on the development of her classroom practice and was not distracted by the need to search for or develop from scratch instructional activities" (p.130). The approach adopted in this study was that teachers and researchers would discuss the lesson plans.

To ensure teachers' participation, all ideas were presented to them, and they would be asked to read them and solve some tasks. The researcher planned a discussion about the ideas, during which the teachers were encouraged to suggest changes and adaptations for their own specific groups. This process would also allow teachers some ownership of the lesson plans, which is potentially beneficial for teacher change (Ketelaar et al., 2012)

The second goal of the meetings was to promote discussions and reflection on teachers' experiences with the lessons planned

collaboratively. These are factors often reported in studies about effective PDI of mathematics teachers (e.g. Borko, 2004; De Geest et al., 2009). For these occasions, I select students' responses that might have some interesting aspect to be discussed, such as unusual solutions and common mistakes. These discussions, aimed at:

- motivating and inspiring teachers with episodes that had happened in a colleague's classroom, and were usually positive experiences one of the teachers had had during the lessons planned collaboratively;
- providing feedback about the lessons that were taught and overall feedback after a sequence of lessons;
- encouraging teachers to provide their impressions about the lessons planned collaboratively.

In summary, the two main goals during the meetings with the teachers were discussing and developing lesson plans, and discussing elements of the teachers' experiences in practice with these lessons planned collaboratively.

More than an activity of the PDI, these meetings would also be moments of data collection. All the meetings were audio recorded and were used as a source of data when considering teachers' impressions about, and engagement with, these lessons.

b) Teaching the lesson plans

Another major activity of the PDI is teachers using the lessons planned collaboratively in their own groups. For my study, teaching the lessons planned collaboratively will be the moment when teachers experiment with an innovation. An experimentation in the classroom is one form of "practical approach" (De Geest, 2009), or "active learning" (Desimone, 2009), which is highlighted in the literature about effective professional development, as a core feature to be considered when evaluating a PDI. Planning the PDI activities to explicitly include a phase

that translates these features will enable me to better investigate the impact of it in teachers' change process.

The reasons why I chose "classroom experimentation" as the activity that implements the practical aspect of the PDI for my study comes, initially, from my own background. As a teacher, the main indication of the effectiveness of an approach came from experience with that approach in my lessons.

Clarke and Peter (1993) argue that

> Teacher professional growth must be viewed in the same way as any other form of learning. As learners construct cognitive models of past experiences and test these against new experiences. So teachers experiment with new classroom practices and refine these according to their perceived association with valued classroom outcomes. Central to this process of experimentation and refinement is teacher reflection on valued outcomes and their relationship to the classroom experimentation. (Clarke and Peter, 1993, p. 172)

Clarke and Peter's argument about the role of teacher experimentation in the classroom (also discussed in Section 3.1) resonated with the impressions I had as a teacher. The interconnected model of professional growth, developed by Clarke and Hollingsworth (2002) brought more empirical evidence to the process of 'teachers experimenting in their classroom and reflecting about the experience' as being fundamental to the process of teacher change in practice. Other models of teacher change, such as Guskey's (2002) and Smith, Smith and Willians' (2005), also highlight that this process is one way that teachers can change (see Section 3.3 for more examples).

In summary, I plan to use teacher experimentation in the classroom as a catalyst to teacher change. Acknowledging that there will be steps to move from 'experimenting' to 'change'. One of these steps is reflection on the experience, which is part of the agenda of the meetings (Section 4.2.1.a above). The experimentations with the lesson plans, will provide paradigmatic cases to be discussed latter.

Considering that I will also be observing the lessons (Section 4.3 below), teachers and I will be able to have a shared knowledge of what happened in the experimentation. Including aspects that would be difficult to consider if I am not in the classroom during the experimentation, such as: how much alterations the teacher did in the original lesson plan, how was students' behaviour and unforeseen situations.

These general aspects of the PDI were planned to investigate how teachers change when they participate in a non-imposing PDI, I planned to look at the ripples that this intervention would cause. The specific features of the intervention I was going to implement are described below, and they are already in accordance with the conditions of the context.

4.2.2. Specific features of the PDI: lessons about fractions

Now I describe the specificity of the intervention that was put in place in Purple Valley, and how the general features (Section 4.2.1) were implemented considering the focus on how low achieving students learn fractions through visual representations, which was the specific goal of Barichello's PhD study (Barichello, 2019).

The teachers agreed to spend the whole academic year having regular meetings with me and Barichello, to discuss tasks to teach addition and subtraction of fractions (topic chosen by the teachers). One academic year was the longest period possible considering the regular length of PhD studies, but it was also a natural cycle for the teachers. Barichello designed three sets of lesson plans, one per term, each set composed of three to five lessons conceived to be enacted consecutively and in a row.

In order to allow time for discussion of the tasks, teachers were asked to teach the lessons on the last half of each term. In other words,

the experimentation phase should be after we had meetings to talk about the tasks on each lesson plan. This experimentation also contributed to focus the PDI on teachers' practices. The regular meetings would be scheduled considering teachers' availability, and action that helped to ensure collaboration. Teachers chose the topic of fractions early on during the RP, and the meetings were aimed at building the lesson plans based on the tasks brought by Barichello, and the suggestions and ideas the teachers had during our discussions.

A major aspect of this PDI is to seek balance for teachers when they are teaching the lessons planned collaboratively. This balance was developed through a number of actions such as: time to discuss the tasks and lesson plans; the incorporation of individual teacher's suggestions into the lesson plans; flexibility in terms of when the teacher choose to teach the new lessons; support during the experimentation.

Additionally, teachers also agreed that they would not teach other lessons about fractions to the chosen groups other than the ones we were planning together.

As mentioned before, the tasks for the lesson plans discussed collaboratively during the meetings were developed by Barichello for his PhD study. One of the finalized lesson plan is given in Appendix 2. Barichello was responsible for developing the initial lesson plans ideas and I was able to read these ideas before showing them to the teachers to ensure that they were compatible with the features I wanted for the PDI. From now on I will refer to these lessons as 'project lessons'.

I begin presenting the three design principles behind the lesson plans we were developing for this PDI. They were: (1) lessons should be focused on encouraging students to build their knowledge about fractions on visual representations; (2) students should have the opportunity to solve tasks without being told how to do it beforehand; (3) lesson plans should maintain coherence with participant teachers' current practices (Barichello, 2019).

The two first design principles clearly suggest changes in practice for the teachers participating in this study if they follow the project lesson plans as expected. Teachers adapting lesson plans and making changes in tasks to accommodate their own teaching preferences are reported in many studies in mathematics education (e.g. Cohen, 1990; Stein et al., 2000; Stein and Smith, 1998). That was one of the reasons, in my study, that lesson observation when teachers were teaching the project lesson plans was fundamental.

The third design principle was aligned with the suggestion in Section 2.4.2, where I proposed that teachers might be able to implement novelty (a different approach to teaching fractions) in their classrooms if they reach a middle ground (or a balance) between the Risk Zone and the Confidence Zone. The project lesson plans should keep some congruence with the regular practices of the teachers, and be aiming at improving teachers' confidence, while incorporating the novel practices suggested.

In summary, while the first and second principles tried to move teachers towards their Risk Zone, the third ensured a certain level of familiarity, confidence and control for the teachers, keeping them in the Innovation Zone.

I move on to describe the general structure of the project lessons. The third design principle, "keep the lesson plans coherent with participant teachers' current practices", implies that it is necessary to understand teachers regular practices for low set groups in order to be able to plan the project lessons. I describe in details the regular lessons of the participants in Section 5.1, and I had already observed many lessons during the RP (Section 2.2.1). In general, their lessons follow a sequence of starter-introduction-main tasks, and this is the structure adopted for the project lessons (Barichello, 2019, p.102).

Related to the second design principle, Barichello explains the innovation related to teaching strategies that was being introduced by the project lessons:

> The most relevant difference of [the project] lesson plans compared to their [participants] regular lessons refers to the nature of the introduction. […] one of my three design principles is to give opportunities for the students to engage with the visual representations and build what is necessary to solve the task by themselves. Therefore, instead of showing examples during the introduction and then posing tasks that could be solved following exactly what was shown before, I wanted the teachers to use the introduction to present as minimally as possible. This stage should focus on arbitrary knowledge, and avoid presenting necessary knowledge. (Barichello, 2019, p.102)

The first design principle emerge in the structure of the project lessons as eventual manipulative materials (paper cut-outs), videos showing these cut-outs being manipulated and diagrams, sometimes already drawn in worksheets, and sometimes for students to draw.

In terms of materials, there were worksheets (see Appendix 2), paper cut-outs, short videos for the teachers to use as examples in some lessons and a document called "Comments for the teachers". This extra document was

> usually only one-page long and were composed of: a description of the learning objectives, a list with the material, a commented sequence of expected stages for the whole lesson and some extra questions to be used, if necessary, at the end of the lesson. In the comments I tried to anticipate critical moments and make general recommendations about how the teacher could discuss them with the students and what questions could be used to deepen their understanding (Barichello, 2019, p.105)

The first set of lessons were dedicated to the introduction of the rectangular area model, the connection between the model and fractions, and equivalence and comparison of fractions. After that, the second set of lessons started with addition and subtraction of pairs of fractions in which

one denominator is a multiple of the other. The third, and final set, focused on progressing to addition and subtraction of any two fractions[8].

Barichello (2019) also highlighted that

> a special emphasis on comparison of fractions was given based on the proposal of Siegler et al. (2011) regarding the unifying role that the idea of magnitude can play when it comes to whole numbers and fractions. This was done by including questions asking students to compare two given fractions throughout the three packs (Barichello, 2019, p.108)

Table 4.1 below presents the main topics and material used on all the project lesson plans.

8 All the initial versions of each lesson can be accessed at http://dx.doi.org/10.17639/nott.353.

Lessons from the first set				
Lesson 1.1	**Lesson 1.2**	**Lesson 1.3**	**Lesson 1.4**	**Lesson 1.5**
Introduce the rectangular area model;	Introduce fractions from the same family as 1/2 through the model; Equivalent fractions;	Introduce fractions from the same family as 1/3 through the model; Equivalent fractions;	Fractions from other families; Equivalent fractions; Comparison of fractions;	Equivalent fractions; Create a booklet with diagrams;
- Cut-outs	- Cut-outs	- Cut-outs	- Cut-outs	- Diagrams
Lessons from the second set				
Lesson 2.1	**Lesson 2.2**	**Lesson 2.3**	**Lesson 2.4**	**Lesson 2.1**
Decompose the unit as a sum of fractions; Comparison of fractions;	Add and subtract fractions from the same family as 1/2;	Add and subtract fractions from the same family as 1/3 and 1/5;	Word problems	Decompose the unit as a sum of fractions; Comparison of fractions;
- Diagrams	- Diagrams	- Diagrams	- Diagrams	- Diagrams
Lessons from the third set				
Lesson 3.1	**Lesson 3.2**	**Lesson 3.3**	**Lesson 3.1**	**Lesson 3.2**
Introduce addition and subtraction of fractions from different families	Add and subtract fractions from different families;	Word problems	Introduce addition and subtraction of fractions from different families	Add and subtract fractions from different families;
- Cut-outs	- Diagrams	- Diagrams	- Cut-outs	- Diagrams

Table 4.1: Topics and material for each project lesson

This PDI can be seen as a parallel intervention to my study, the PDI was affecting teachers and I was investigating how they were responding to that perturbation, particularly focused on the influences of the intervention in their classroom practices. In the next section I discuss the methods I planned to collect data, and I consider advantages and disadvantages for each of them.

4.3. Methods for data collection

My research goal was to explore the process of teacher change in practice and investigate the features influencing it. Purple Valley was an appropriate location for the PDI I wanted to implement for two main reasons: (a) the school's profile, being a socially and economically disadvantaged neighbourhood with overall achievement below the national average; (b) the Headteacher, the head of the mathematics department, and some teachers agreed with my proposal.

Considering the in-depth investigation I was seeking, relevant information about the work routine of the participants would be important in setting up the context of the findings. One way to acquire this relevant information was to "follow" the teachers in their lessons at school. I considered that four or five teachers would constitute a manageable number of participants in terms of the time I would spend with each teacher and of the group size for meetings. With this number of participants, my research would not be compromised in case of anyone dropping out. Having five participants would possibly provide some level of variation among their personal and professional characteristics, and I would still be able to embark on in-depth investigations of their involvement with the project.

Having been a teacher myself, I doubt that teachers can explain their reasons for every action taken in the whirlwind of the classroom. This resonates with Polanyi's (1966) remark about tacit knowledge: "we can know more than we can tell" (p.4). The concept of tacit knowledge is frequently related to teaching practices and classroom management (Eraut, 2004). Results show that experienced and successful teachers frequently have knowledge of the classroom environment beyond what they can articulate verbally (Grigorenko et al., 2006). Not surprisingly, tacit knowledge is recognized as hard to acquire and to access (Eraut, 2000). Therefore, as the topic of my study is immersed in practices teachers might perform in the classroom, but might not be able to

describe, it is important to consider possible ways to overcome this issue. One option would be to employ more than one method for data collection, aiming at a more holistic view of the phenomena.

Since I am interested in teachers' views, interviews would certainly be one of main data collection methods. Additionally, considering that I am also interested in change in practice, lesson observations would be central to my data collection. Together they would provide complementary lenses through which to investigate my research questions. These methods are discussed below.

It is important to highlight that my experience as a teacher allowed me to be in a strong position to explore what was happening during lessons, as it was a familiar situation for me, and I could embed myself as a participant, an insider of the natural setting. On the other hand, I bring my own values and views of teaching, learning and mathematics with me. The first strategy to minimise unjustified judgements of the context would be to practise describing and offering accounts of the participants' lessons. Dealing with the teachers daily might also contribute to my awareness of my own prejudices and prompt me to seek deeper understanding of other people's views.

4.3.1. Lesson observations

Having been a teacher myself, I can remember situations when I was trying to share with a colleague something that had happened in my classroom. On the one hand, with colleagues that were familiar with the group of students I was talking about, the situations could be easily described and they had a strong impact on the listener. On the other hand, I perceived that I still had to provide a lot of information to describe what had happened and to avoid unwanted biases. This was my initial and personal argument to implement lesson observations as one of my main data collection methods: by observing teachers' lessons I could give my version as well as theirs, for the same episodes.

Since my focus was on teacher change in practice, I wanted to observe teachers teaching, and have the "direct experience" (Guba and Lincoln, 1981) of (possible) changes in practice. Moreover, in order to perceive change, I needed to know what was common in teachers' practices before the PDI, which would be possible because the lesson observations could start before teachers began the implementation of the project lessons.

Regarding my stance, I was aware that the external observer may cause many different reactions in the classroom from both students and teachers. Based on the experience during the RP, and the nature of the data I wanted to collect, I planned to adopt the stance of a participant observer (Wragg, 1999), in this case participating as a teacher. I believed that I would be less disruptive for students and for the teacher if I acted as a teacher assistant. I wanted to interact with students at appropriate moments, generally when the teacher was also doing so. Most of the time I would check answers, provide simple directions regarding the tasks posed by the teachers, and occasionally engage in conversations about the content of the tasks.

Acting as a teacher assistant enabled me to blend in the classroom, and at the same time, served as some recompense for the teacher who was allowing my presence at her classroom. Additionally, it allowed me to consider how the students were interpreting teachers' questions and requests. Since English is not my first language, these interactions with students also helped me to develop specific vocabulary about classroom situations.

I also planned to take notes about some students' individual work, and about the groups in general, since I hoped that this data could be used to illustrate students' engagement in the lessons.

I kept an audio recorder at the back of the classroom or at the teacher's table and used the camera in a mobile phone to take pictures of worksheets and of the board. During the lessons, my initial focus was on the tasks teachers posed and how they enacted them. Sometimes the

task 'on paper' can be quite different from the task actually implemented in the classroom (Mason and Johnston-Wilder, 2006). Bearing this in mind, my lesson observation schedule (see Appendix 1) was composed of an initial page, with general information to identify the teacher, the group of students and the lesson, followed by an area for recording the s*tarter*. After that, I included one extra page for each task the teacher used. This page had four main fields:

1) Introduction: to write about how the teacher presented the task and any explanations given before the students were asked to start working;
2) The task: a picture of the board or a scan of the worksheet the teacher had handed out to students;
3) Development: what the teacher was doing while students were solving the tasks;
4) Closure: how the teacher concluded the task, for instance, by showing answers or asking for input from students.

I am calling this 'task structure', and a lesson was usually composed by more than one task. A comparison between task structures over the year could give me insights into changes regarding teachers' practices. This observation schedule has been developing since the RP (see Section 2.2.1), and examples of a completed one can be seen in Appendices 6, 7 and 8.

Besides its role as a data collection method, the lesson observations would give opportunities to build rapport and familiarity with the teachers and their practices. Also, during the project lessons, I would be able to support the teacher during the implementation, since I would know the lesson plans and the goals of each task very well.

4.3.2. Conversations with teachers

Due to the design of my data collection, a considerable amount of time would be spent in the school, and, consequently, I would interact

with teachers in many different situations. I wanted to plan moments of formal conversations with the teachers, during which I could investigate their personal views on the project. For this reason, I planned individual interviews, three with each teacher, taking place shortly before the end of each term, so I could gather data at different stages throughout the whole academic year, following the development of the PDI. Following Kvale's (2008) suggestions regarding planning and conducting interviews, I planned to conduct semi-structured interviews in the format of a "conversation with a purpose" (p.14) with the teachers.

The interviews would work as opportunities to gain insight into teachers' thinking, regarding issues that emerged from the lesson observations, meetings or other interactions with them at school, as well as to elicit their accounts of events that happened during my data collection (Wellington, 2000). Considering that the meetings were already a collective activity, where I could obtain their views as a group, during the interviews I could focus on their personal views and experiences in a more relaxed environment, with no pressure from other people.

As many researchers suggest (Walford, 2005), it is important not to see the data from interviews in isolation, or somehow more important than other data. Instead, I will interpret it as part of the complex interactions between me, the teachers and the whole environment where my research took place.

The other conversations between us were the many informal talks during breaks. I am aware of the potential of less structured data that could emerge from these interactions, so I would try to take notes about these conversations as soon as possible. In any case, they would help to inform the planning of the interviews, and could also be taken into account during data analysis, increasing the reliability of my conclusions.

4.3.3. Considerations about the data

The design described previously would require constant visits to the school. I planned to have around 10 meetings and, at least, 15 lesson

observations (considering the project lessons) for each teacher. Moreover, since I was investigating teacher change in practice, I planned to have more lesson observations than just the ones with the project lessons plans. These observations would initially allow me to be in a better position when assessing which practices were usual, and which were isolated occurrences. Practices that were stable in teachers' lessons can be placed in their Confidence Zone, and I might be able to single out the novel practices in their Risk or Innovation Zones. Additionally, these observations would strengthen the trustworthiness of my data by increasing my immersion in the context of my research and my contact with the participants (Newby, 2010).

Another benefit of this prolonged contact was that I would have the chance to talk to teachers about their practices more often than only during the formal interviews. These conversations could happen before or after lesson observations, providing data about teachers' views on a lesson that could then be contrasted with my observations or even with data from the interviews and meetings, working as triangulation (Wellington, 2000).

Triangulation is possible by combining data from different methods of data collection – lesson observations, interviews, informal conversations, and meetings with the teachers – since they are overlapping in many situations. For instance, by talking to the teacher after a lesson observation, I can bring situations I observed to be discussed during meetings and during interviews. These actions will help confirm that evidence of an influence on teacher change that was perceived in one situation is also observed in a different moment or from a different perspective. This confirmation improves the likelihood that I am observing an influence that was actually affecting the teacher (Beuving and De Vries, 2015; Shenton, 2004).

Following the suggestions of Beuving and Vries (2015) and Guba and Lincoln (1981), I plan to use: simultaneous and overlapping methods of data collection; note taking about my data including theoretical

reflections; corroboration of my interpretations with participants; and constant comparison of my findings as tools to foster the validity and the reliability of the study.

A possible drawback of this plan is the large amount of data it might generate. I would have to be organized with my field notes and the audio files in order to be able to trace back issues, especially during the analysis. My idea was that the notes during the lesson observations and the talks with teachers would be digitalised, a process that would also serve as opportunity to include initial impressions, and consider possible implications for the upcoming visits to the school. This, together with hearing the audio from the lessons, would comprise the initial analysis of my data.

The data analysis should also be strengthened by thick descriptions of the participants and actions in which they were involved, enhancing the credibility of the findings by providing a better understanding of the context in which the research is embedded.

4.4. Ethical considerations

The RP (Chapter 2) happened under a research project already in progress, led by my supervisor, Dr. Gates. The head of mathematics, David, and Dr. Gates had worked together before and they were involved in a project with low-sets and visual and spatial imagery. Dr. Gates had agreed the terms of his project (see consent form in Appendix 3) with David, and during meetings with the Headteacher. On those occasions the project was explained in detail, including the involvement of the researchers in the school routines and in classrooms. After that, the head of the mathematics department also discussed the project with other mathematics teachers in the school, inviting them to take part.

Dr. Gates suggested that I could start visiting Purple Valley, and we began to discuss the differences in the daily activities in schools in England and in my home country, Brazil. Focusing on universal ethical

principles of respect, autonomy, privacy, offering reciprocity and treating people equitably we talked about the expected and acceptable demeanour of a visitor. Meanwhile, I received the Disclosure and Barring Service clearance through the University of Nottingham and the School of Education Research Office.

During the RP, all my visits to Purple Valley were accompanied by Dr. Gates. He introduced me to the teachers in his project and the Headteacher of the school. In the following academic year, I began this study and Dr. Gates ended his project after a couple of months into the new academic year.

Next I discuss ethical issues from my study. I comment on the actions I took before the study began and the procedures I followed during the data collection period.

Since my project originated within Dr. Gates' project, his participants were the first teachers to know about what I was planning to do the following academic year. David invited all the teachers in the mathematics department to join the project and I explained it to the three teachers who had demonstrated interest in the first meeting of the 2015/16 academic year. The teachers were informed about confidentiality, anonymity, non-traceability of their identities and that they may freely withdraw from the project at any time without risk or prejudice. Additionally, detailed information about the research design was presented to them. The three teachers were given a copy of the information sheet and later signed the consent form (see Appendix 4).

These documents were also presented to the Headteacher, and she agreed to the project. We engaged in conversations in the corridors or the staff-room, during which she asked about my project, so was able to maintain some level of supervision through our encounters. Because of this, I decided that I did not want to impose any further conditions, such as a signed contract, which might risk damaging our relationship.

A similar situation happened when I discussed the possibility of parental consent. David explained that the position in Purple Valley was that the Headteacher acted as "*in loco parentis*", which means "*in the place of a parent*", so in other words the Headteacher assumes the responsibilities of the parent. This was one of his reasons for saying I need not ask for signed formal consent from parents, guardians or responsible others. Additionally, the Headteacher guaranteed that parents had already had to consent to some specific situations, one being the presence of other people in the classroom. This was a common situation, because of trainee teachers from different programmes being observed by their tutors from university, external staff from trusts or local authorities, Ofsted officers, etc. Avoiding the risk of damaging our relationship, I agreed with David about not asking parents for signed consent.

All the three teachers explained to their students that I was a mathematics teacher and I was there to observe the teachers in Purple Valley. They emphasised that my focus was on the teacher, not the students, but I would sometimes act as a teacher assistant, i.e. helping and talking to students around the room at appropriate times.

My actions in the daily situations of the classroom were always towards being discreet and focusing on behaviours to minimize the disruptions my presence could cause. For instance, I expected that the teachers had developed some trust in my mathematical knowledge during our meetings in the RP. Additionally, I constantly had conversations with the teachers about the interactions with students I had and making sure teachers were aware of any possible problems that might need to be addressed later. I only engaged in conversations with students when they were solving tasks, and the teacher was also walking around checking answers and helping students to progress. In general, I did not engage in conversations with students if I was not aware of the teacher's goal for that specific task. I would move away if a student showed any signs of not wanting to interact with me, such as a student with a raised hand

who did not ask me his question when I went over to his table. I also asked students to check with the teacher in case I thought I could not give appropriate guidance, such as students asking to go to the toilet, or asking if it was okay to do something different from what the teacher asked them to do. I was careful at all times not to undermine the teacher in any way.

Another issue that was considered was the fact that I was using audio recordings and taking pictures of the classroom. It was agreed between the teachers and me, that any data from students would not be traceable, and the images where students could be seen should be used only for my analysis of the data, with the necessary alterations, so that no identification would be possible. The data would be stored in the appropriate spaces provided by the University of Nottingham, which were password protected.

I gradually increased my use of a mobile phone to take pictures of the board and of worksheets in the classroom over time, expecting that it would help students and teachers to get used to it. However, I always kept the number of pictures to a minimum, and considered whether the photography could wait until after the end of the lesson, which was generally the case with worksheets. The audio recording device was initially placed on the teacher's table, and the teachers knew how to turn it off. After some months, I asked to place the device at the back of the room, so I could also record some interactions between students and teachers, to which all the teachers agreed instantly.

So far, general issues of my presence at Purple Valley and in relation to students have been considered. However, the focus of my study is on teachers' practices, so as mentioned previously, I wanted to have teachers' views on their practices, making my good relationships with teachers essential to the study. Therefore, I now discuss the ethical issues particularly related to my interaction with the participant teachers.

I begin by commenting on the two teachers that stopped participating in Dr. Gates project during the RP, Omar and Otto. I consider their participation in more detail later in Section 8.1.2.d. In relation to the ethical issues around their withdrawal, I consider that it was the open communication between David and the researcher that allowed us to deal smoothly with the situation. For internal reasons we agreed with David that Omar would not continue to participate. The other teacher, Otto, stayed in the project for a longer period. He attended the initial meetings, and I had observed his lessons frequently during the two first months of the RP. For our fourth meeting in the RP, Otto did not attend, and David told us he had taken other responsibilities in the school and did not have time for the project any more. It was the end of the RP, and Julia was teaching the lessons about fractions, so we were only observing Julia's lessons. In the next academic year, Otto did not volunteer to participate in my study.

Since our first encounter when still in the company of Dr Gates, I continued to be referred to as a mathematics teacher studying for a PhD in education. These elements brought some initial credibility to my professional profile, both as a teacher and as a researcher. This might have been a good start, but another possible ethical issue that might have happened was of teachers feeling evaluated and under pressure by my presence in their classrooms. Considering teachers' feedback during the interviews, this was not the case, and they even reported the opposite, being comfortable with the project and talking about lessons in a non-threatening way. My actions, especially in the first weeks of the project, were deliberately planned to start with a positive comment about each lesson, and also to be careful about my posture when observing the teacher by paying attention and showing interest.

My questions to teachers after a lesson were deliberately avoiding denigrating teachers' practices, so in order to achieve that I focused on initially asking their opinion about the lesson or commenting on something that was clearly an unusual event, such as the behaviour of a

particular student (good or bad), or a new element that I had never seen the teacher use before (e.g. an electronic whiteboard). Only after that would I move to questions about why they had chosen a task, or a specific strategy, or that way of solving an item.

The interviews were scheduled in advance, and while we were talking, I always kept track of the time in case the teacher needed to leave. The questions (see Appendix 5) generally allowed teachers to talk about a topic rather than press for a direct answer, which allowed the teacher to only talk about something they wanted to. I normally asked for clarifications, but was conscious of clues that suggested they did not feel comfortable any more, such as long pauses, and repetitively saying "I don't know".

After the interviews, I was conscious not to disclose any information the teacher had mentioned. During the meetings, I tried to ask everyone's opinions, but not pressing teachers if they were not willing to share. Even though they had quite different hierarchical positions (David was the head of department, Julia was second in maths and Alice was a new teacher mentored by Julia), they always seemed to treat each other as equals and to consider each other's views during our interactions as a group.

In my study, the ethical procedures followed the British Educational Research Association's Revised Ethical Guidelines for Educational Research (Gardner, 2011), which is adopted by the School of Education in the University of Nottingham.

Based on my own evaluation, my period in Purple Valley was respectful to the people involved and I believe that no major discomfort occurred due to my presence in the school. I visited the school three times after the end of the data collection and was warmly welcomed by the three participant teachers. Finally, after the end of my data collection, I can state that no incident that would require reporting happened during my visits to Purple Valley.

Chapter 5 Participants, data collection and the process of analysis

In this chapter I present the three teachers who participated in my main project. Knowing my participants well was important because of the exploratory nature of this study (Chapter 4). I needed to know their usual and preferred styles of teaching, since I wanted to investigate whether there was change in their practices. I also needed to know the characteristics of the participants that might have influenced their engagement, as I wanted to consider possible factors influencing change in practice. The sections below about each teacher are an introduction and description of them and their practices, together with information about the time I spent with them during the data collection. Chapter 6, Chapter 7 and Section 8.2.3 are entirely focused on analysing data from Julia, Alice and David respectively.

The second section of this chapter is about the data collection period. I visited Purple Valley for the whole academic year, observing lessons, and holding interviews and meetings with the three teachers. This was the most intense period of work of my PhD, as besides the activities in the school, I had to engage intellectually with the data in order to plan the next visits. This process was important to:

- decide the focus I would have during the next lesson observation;
- inform the planning of the meetings with the teachers;
- consider questions that I could ask teachers in the interviews.

Finally, I present the process of how I analysed the data. The analysis process was the most time-consuming phase of this study. I think that one of the reasons was that it was hard to be confident enough (or to know when) to stop analysing and start developing the conclusions. Journal articles rarely have enough space to give details about the whole process of analysis, and readers (especially new

researchers) are left with books and theses to find a more complete account of how an open-ended approach to coding is carried out. And still there is no access to the whole data set with the details of what was done during the analysis.

I had good examples from Strauss and Corbin (1998) and Corbin and Strauss (2008), but they present the process with many different sets of data that were simplified to fit the book. Also, as Strauss and Corbin are such experienced researchers, I sometimes felt intimidated when reading the connections the authors suggested, as I thought I would never be able to come up with such insightful and clear ideas.

My intention with this section about the data analysis is to attempt to record, as closely as I can, the process that I went through when trying to analyse the data. Hopefully, this will allow the reader a better understanding of the following chapters of the thesis, especially the discussion chapter. In fact, I tried to write a section about data analysis that I would have liked to have read before analysing my data. Part of the section on the analysis process was presented at a New Research Day Conference of the British Society for Research into Learning Mathematics in June 2017.

5.1. The teachers

Julia, Alice and David were the three mathematics teachers in Purple Valley who participated in my study. Julia and David had been in the project since the Reconnaissance Period (PP), Chapter 2, and Alice was beginning her school-based teacher training that year. Table 5.1 below provides background information information about the teachers.

		Teacher		
		Julia	**Alice**	**David** (head of department)
Info	**Years teaching**	1 year training plus 12 teaching mathematics	1 year as assistant teacher in another subject and this is her first year training to teach mathematics	1 year training plus 8 teaching mathematics
	Years at Purple Valley School	12	This is her first year in the school	3
	First degree	maths-related degree	maths-related degree	maths-related degree
	Group year taught during 2015/16	Year 8 set 4 out of 5, Year 9 set 5 out of 6, Year 10 set 1 out of 6, Year 11 set 2 out of 6, Year 11 set 6 out of 6	Year 7 set 1/2 out of 6, Year 7 set 5/6 out of 6, Year 8 set 5 out of 5, Year 9 set 1 out of 6, Year 10 set 6 out of 6	Year 9 set 6 out of 6, Year 10 set 4 out of 6, Year 11 set 1 out of 6, Year 11 set 4 out of 6
	Group year they taught the project lessons	Year 8 set 4 out of 5	Year 8 set 5 out of 5	Year 9 set 6 out of 6
	Group year they taught extra lessons about fractions	Year 8 set 4 out of 5	Year 7 set 5/6 out of 6	Year 9 set 3 out of 6 (this was a new group that David took over because another teacher left the school)

Table 5.1: Information about the three participant teachers in 2015/16.

For now, these descriptions are aimed at setting the scene for the periods of data collection and data analysis that follow in this chapter. Additionally, highlighting differences and similarities of aspects of the teaching jobs of my participants will help me illustrate how I reach my conclusions.

As can be seen in the Table 5.1 above, the length of experience in teaching mathematics varied, from 12 years in Julia's case to zero for Alice. Julia had had practically all her experience of teaching at the same school, Alice was an assistant teacher of physical education (PE) before coming to Purple Valley, while Purple Valley was David's fourth school. They all had to follow a scheme of work, which in Purple Valley determined the topics that each group should be studying each week. But this scheme of work did not suggest how the lessons should be structured, and teachers were free to plan any activities they wanted.

The three teachers were very welcoming to people coming to observe lessons. After the initial weeks, it became normal to have the teachers initiating conversations about episodes that had happened during their lessons. My analysis suggested that our rapport had an impact on their engagement with the project, and some factors influencing teacher change in practice. Rapport, meaning "trust", "support" and "familiarity", is discussed in Chapter 8.

Julia, Alice and David taught different year groups and different sets (see Table 5.1). For this academic year Purple Valley used a banded scheme to group Years 7 and 11, this was due to issues in schedule. The banded scheme meant, for Years 7 students, that the whole cohort was split in three groups according to prior ability. Each group was then split in two to form the sets. This is represented in Table 5.1 above by "Y7 s1/2" and "Y7 s5/6". For example, "Y7 s5/6" was composed of students that would be in set 5 and set 6 if the school did not use the banded scheme. Next I describe, for each teacher, general aspects of their lessons, their motivation to become mathematics teachers and the reasons they gave for participating in this project. I then suggest some

accounts for the differences between their lessons according to the set, and I finish this section with a table summarizing the main features mentioned in the descriptions.

5.1.1. Julia

The first time I observed a lesson from Julia was the beginning of the academic year 2014/15. My notes after the first few weeks show that I particularly noted Julia's classroom management and how she was able to keep the children's behaviour under control.

A feature that caught my attention was Julia's control over the whole environment of her classroom. She always had the initial task already showing on the projector (or as a worksheet on each table) before the students entered the classroom. This activity was called the *starter*. The learning outcomes would also be written on the board before anyone entered the room. In order to achieve that pre-lesson setup, even in lessons with no break between them, Julia began to prepare for the next lesson during the last few minutes of the previous one. Usually, during the last few minutes when students were packing up and waiting behind their chairs to be dismissed, Julia would be setting up for the next group.

In addition, I noticed how she was organized with the materials. Students' notebooks were placed alphabetically on a table by the door and students could take them on their way into the classroom before proceeding to their seat. After the group of students was settled and working on the *starter* activity, Julia took the register, calling every name and waiting for an answer, rather than just checking if the student was actually in the classroom. Apparently, she even changed her tone of voice to a softer level, which I asked her about, and she told me that this was intentional, as she wanted students to calm down. Additionally, she told me she was aware that this might be the only time of the day that she would say their names, and she considered it important for them to listen to her.

Most of the examples, explanations and exercises were presented on slides. When showing an example, it was common to have one slide for each new line of the solution being presented. In general, after presenting a couple of examples, Julia would hand out a worksheet and walk around the classroom, while individually students were solving the items. While walking around the classroom, Julia frequently helped students, but with these conversations being usually short and in whispers, there were rarely any students talking out of turn.

During the lessons it was possible to notice that she was quite alert to the environment, and students were promptly reprimanded or attended to, so every student action was rapidly dealt with by Julia. This also included her planning fitting perfectly the duration of the lesson. Her classroom was normally very quiet.

Figure 5.1 below shows the position of the tables (rectangles) in her classroom. The numbers represent where the students sat at each table for her Year 8 set 4 (the group she taught the project lessons to). I asked her why the tables were grouped, as Julia said she had not liked groups earlier in her career, but the school asked every teacher to use them at some point. After trying it, she said she recognized some benefits, which are:

- being good for Year elevens to talk to each other, because she can trust them;
- not a problem in terms of being easy to control behaviour, and she does not think she has any problems with students behaviour any more;
- easier to get around the room, “to talk to every single child” (Interview 2, 36min 12s), something that Julia did every lesson while students were working on a task;
- better to bring students and teacher closer in terms of status, “if everything was in rows then it is like "You're behind that line and

we're behind this line". It is a bit more of a relaxed atmosphere [in groups]" (Interview 2, 36min 30s).

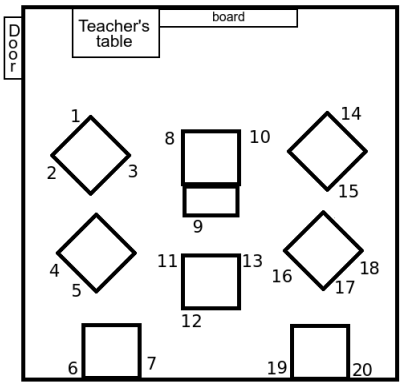


Figure 5.1: Position of the tables in Julia's classroom – The numbers represent students in her Year 8 set 4, but the tables were kept in the same way for all her other groups.

In addition, students participated in the lesson by raising hands and giving answers to Julia. Even though Julia usually asked for further explanations from the students when she was giving feedback on a task, she never invited them to go to the board or to present their solutions for the whole class; Julia was in charge of the classroom activities the whole time. The lessons might be labelled "teacher-centred", as Watson (2014) defined, "[…] traditional teacher-centred approaches which involve the teaching of methods and students learning through practising with routine problems" (Watson, 2014, p.2). But during whole class teaching situations Julia also took students' answers and opinions, often leading a discussion around them. Julia developed her explanations based on her questions and requests to students (from students' answers and suggestions), which was more aligned with "student-centred" activities. Therefore, I argue that there is no clear benefit to my study, for such labelling to describe the teacher practice, since there were both teacher-centred and student-centred aspects to her practice.

Julia told me that her interest in the teaching profession began when she was still young, when she played school with her sister, but also from an "inspirational teacher" (Interview 1, 55s) from when she was in secondary school herself. The decision about the subject came later, as she said she also considered teaching physical education, but chose mathematics because there were more job opportunities for that subject.

David, the head of department, invited Julia to participate in the project. Julia told me she said yes even before she was completely aware of all the details of the project. She told me that she was just curious to see what Dr. Gates was suggesting, she knew him from her teacher training course 10 years before.

I observed more than 70 lessons from Julia. The table below provides more details specific to the time I spent with Julia during the main project. Timetable for data collection – Julia – 2015/16.

Regular lesson observations in Julia's classes: year groups			9			8					
			9, 8, 10		8	9		8			
		7, 8, 9, 10	8, 9, 10		11	8		8	10	8	
		7	8		8	8		8	8	8	
		9, 8, 10	10, 9	9	11, 8	8		9	9, 8	8	6 (STEM day)
		7, 8	9	9	9, 8	8	11	8	8	8	
Academic year 15/16	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
	2015				2016						
Special events: MGT; PL; MJ; Int	MGT 1		MGT 2	Int 1	PL 1.4	MGT 5	PL 2.1		MGT 6	MJ	PL Multi 1
			MGT 3	PL 1.1	PL 1.5		PL 2.2		MGT 7	MGT 8	PL Multi 2
				PL 1.2	PL 1.6		PL 2.3		PL 3.1	MJ	PL Review
				PL 1.3	MGT 4		PL 2.4		PL 3.2		Int 3
							PL Review		PL 3.3		
							Int 2		PL Review		

Table 5.2: Timetable for data collection - Julia – 2015/16.

The abbreviations are as follows:

MGT – Meeting with the group of teachers;

PL – Project lessons;

MJ – Meetings only with Julia;

Int – Individual interviews.

Table 5.2 has to be read from the middle up or the middle down, always beginning from the months in the grey cells. The top half of the table displays all the lesson observations I carried out in Julia's classrooms over the year. The numbers indicate the year group. For instance, in September/2015 I did not observe any regular lesson from Julia, but we had a meeting with the group of teachers (MGT 1). In October/2015, we did not have any special event, but I observed one lesson in her Year 7 and another in her Year 8 on the same day; on another day I observed a lesson with her Year 9, Year 8 and Year 10. A similar table is presented in the next Sections for Alice and David.

From December/2015 all the lesson observations I did (with the three teachers) were audio recorded, in addition to the notes and pictures that I was already taking. Apart from the lesson itself, I also recorded conversations I had with the teachers before or after each lesson, and my notes on these conversations were recorded on the observation schedule of the lessons, but the conversations are not represented in their individual timetables.

An example of an observation schedule of one of Julia's lessons can be seen in Appendix 6. In total, I gathered more than 60 hours of audio recording and more than 200 pages of notes from the lesson observations.

Julia attended all eight meetings with the group of teachers (MGT) and we had two more meetings (MJ, on the table above), without the other teachers, to talk about extra lessons (PL Multi 1, 2 and 3) she wanted to plan and teach to her students. Julia's engagement with the project went well beyond what was initially envisaged: the meetings, the

lessons about fractions and the interviews, and no unforeseen circumstances compromised her participation.

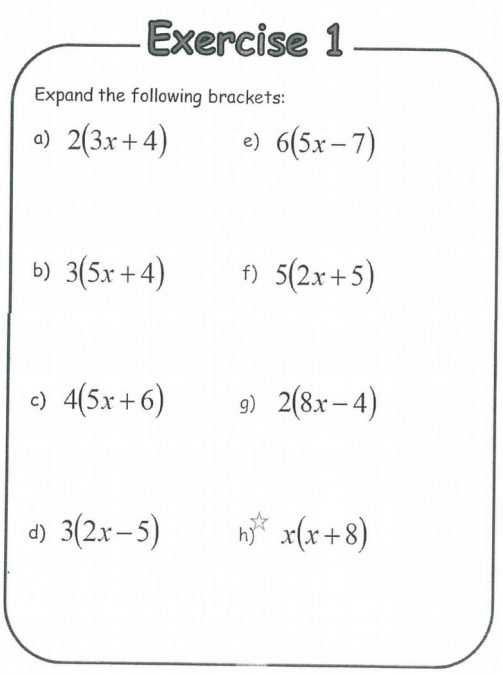
Besides the 13 planned project lessons (PL) spread out through the year, Julia taught three review lessons (PL Review), that repeated the previously covered topics. They are all represented by the same colour in the timetable (Table 5.2) because they were following the project lesson plan principles. It was common for Julia to plan a revision lesson at the end of every topic.

In an attempt to enrich this description, I have chosen two lessons that followed formats Julia commonly used, they are paradigmatic examples of her regular lessons. As Julia herself described, her lessons always began with a *starter* activity. This task was composed of three or four simple items revising topics that the students had been working on in previous lessons. After that, the two typical formats of lessons, based on the introduction of the tasks, the structure of the tasks and the feedback for the tasks, were:

Triple X lessons (an example is shown below on Table 5.3):

Julia commonly used this type of lesson when starting a new topic, and would follow this format for the first few lessons of that topic. Evans and Swan (2014) called "triple X" a lesson following the sequence "exposition, examples, exercises". According to the authors, during such lessons teachers are less likely to mention alternative approaches, all students are likely to solve the tasks with the items of a task with the same method which decrease the chances of students difficulties being a challenge for the teacher. The predominant discourse loop in this format of lesson is similar to what Sinclair and Coulthard (1975) called initiation-response-feedback (IRF) routine, as mentioned earlier (Section 2.2.1).

Title: Expanding a single bracket	
Year 8 set 4 – Julia – 22/Jan/2016	
Learning outcomes	(1) set up a grid correctly (2) demonstrate/explain how to expand a single bracket

Starter	09:47 to 10:06
	Julia had a slide with the items for students to work on their notebooks.
Task 1	10:06 to 10:26
Introduction:	Julia showed the following slide: EXPANDING BRACKETS "Every term on the inside gets multiplied by the term on the outside" Then, asking students to give suggestions, Julia solved the following items on the slide: 8 (5x– 9) → x | 5x -9 / 8 | 40x -72 4 (7x + 3) → x | 7x +3 / 4 | 28x +12
Worksheet:	Julia handed out the worksheet below and let students work on it while she walked around helping and checking their work. 
Closure:	Julia asked for feedback.
Task 2	10:26 to 10:40

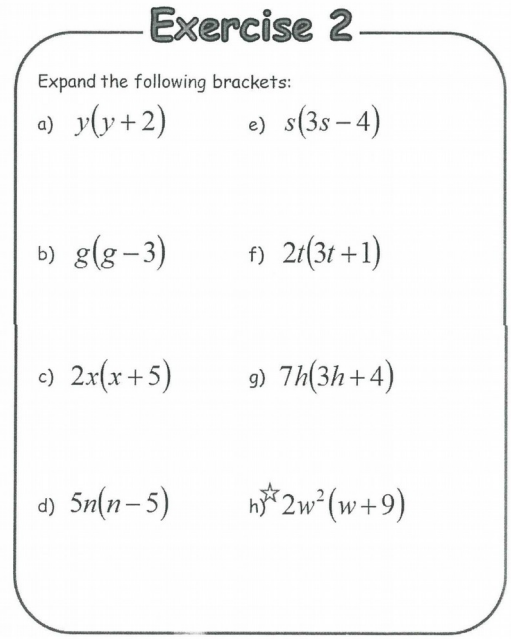
Introduction:	Julia showed a slide with the following: 'What about this one?' 1) x (x + 10) 2) 3x (x + 8) She expanded the two items asking students for suggestions. She also solved another item on the board: 4x (3x + 8)
Worksheet:	Julia handed out the worksheet below and let students work on it while she walked around helping and checking their work. 
Closure:	Julia asked for students to feedback their answers.
	*For the last five minutes Julia was setting homework and checking their planners[9].

Table 5.3: Some of my notes during a lesson observation in Julia's class, example of 'triple X' lesson.

In summary, a triple X lesson consists of:

1 – Julia solves an example of the type of items she will give the students in the first task. This initial explanation usually includes student participation and is presented on the slides or on the board.

9 "Planners" are diaries in which students should make notes about their school activities such as, homework, examinations, detentions, etc.

2 – Julia hands out worksheets (or sets up a slide) with many items very similar to the one that has just been solved as an example. Students are asked to solve the list of items by themselves.

3 – Julia walks around the classroom checking students' answers and giving diverse instructions to help them get to the end of the list.

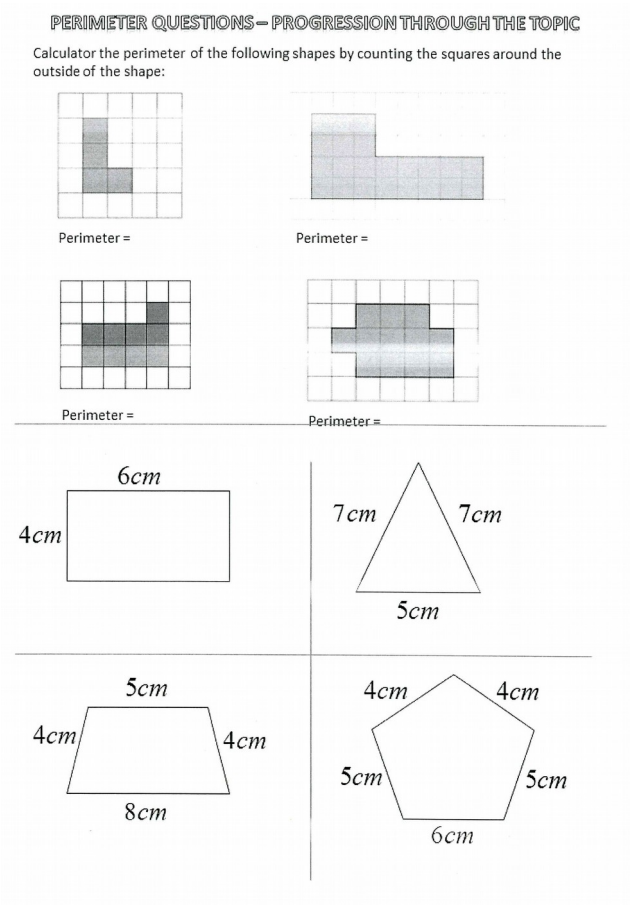
4 – Julia brings the classroom together and asks for feedback of the items students have been solving, and shows the answers on the board, the visualiser or on a slide.

5 – The cycle restarts with Julia presenting an example of a new item, which is similar to that in the previous task they had just checked, but with some novelty – Table 5.3 above is an example.

Practice lesson: (an example is shown below on Table 5.4)

This second format was common as a final lesson of a topic, or as a practising moment, when students were supposed to practise what they had been learning in the last three or four lessons. A typical example of a 'practice lesson' is the lesson below:

Title: Perimeter: progression to the topic	
Year 9 set 5 – Julia – 28/Jan/2016	
Learning outcomes	(1) recall the meaning of the word perimeter (2) apply understanding to a range of problems (3) show progression of understanding
Starter	08:42 to 9:13
	Julia had a slide with four items on it.
Task 1	9:13 to 9:22
Introduction:	Julia showed a new slide with 4 different types of perimeter questions: - shape draw on a squared paper; - shape with two sides given (rectangle); - shape with expressions as sides and perimeter given (similar to the item in the *starter*); - functional question. Julia talked about them, mentioning the method they

	should use in each one of them, keeping the solved items on the board. Julia handed out the double sided worksheet, talked about it and asked students to "have a go" with the items. She then began to walk around the classroom helping students.
Worksheet: Side A	

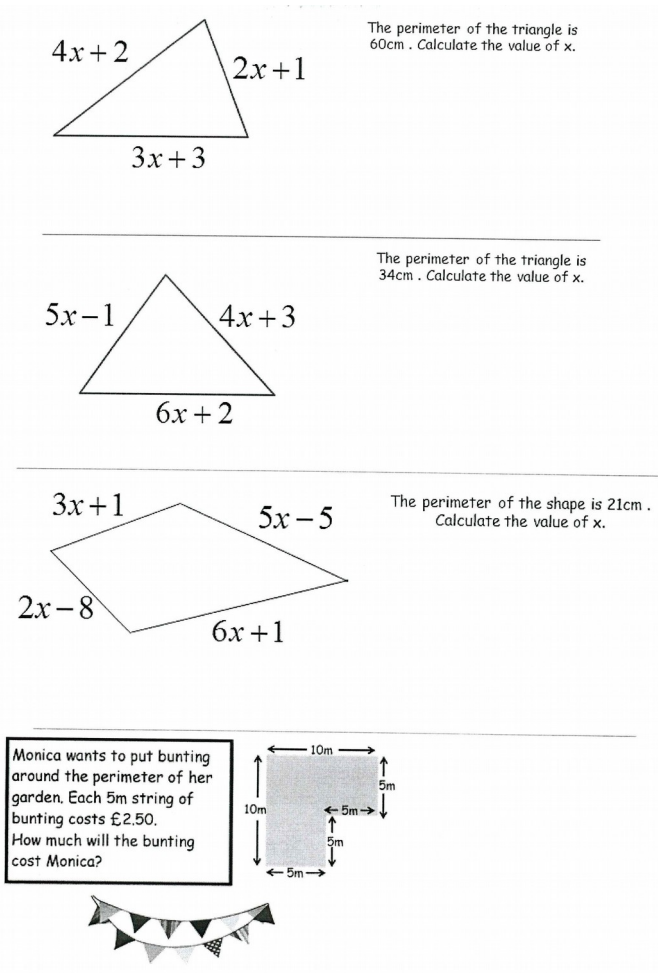
Worksheet: Side B	
Closure:	9:22 to 9:45
	Julia stopped students to give a strategy they could use for the first item (physically mark the edges that you are counting). For the rest of the lesson Julia was walking around, helping students individually at their desks.

Table 5.4: Some of my notes during a lesson observation in Julia's class, example of a 'practice lesson'.

It was common for Julia to allow students to talk to each other at their tables during a practice lesson. After her explanations at the front of the classroom, she walked around the tables, helping and checking students' progress for the remaining time of the lesson.

The practice lessons can be described with only two distinguishing phases, as follows:

1 – Julia gives detailed explanation of some items, solving it in front of the class, as a teacher-led moment;

2 – After that, students solve the other items in the same task until the end of the lesson.

Triple X lessons and practice lessons were similar in terms of Julia solving an item to serve as example for the following items students had to solve, but for practice lessons there were fewer explanations from Julia between the tasks and students had more moments to interact with each other. Triple X lessons had more than one task, with each new task incorporating an extra step in the topic Julia was teaching. In general, practice lessons had only one task, with less text in it than the tasks in the triple X lessons. Also, while in triple X lessons, students rarely interacted with each other, and for the majority of the time Julia was leading a whole class discussion, asking for suggestions or for answers. In practice lessons, Julia had fewer moments of whole class discussion and more moments of individual interaction with students at their tables.

As mentioned before, I was focusing on low-set groups, but I also observed Julia teaching some high-set groups. I did not observe any clear differences between Julia's lessons in a low- or a high-set group, considering the structure of the lessons, or the general dynamics, or the pace of the lessons. The main difference I noticed was the amount of student talk in each group.

For the high-set groups, the classrooms in Purple Valley had more students, and most tables in Julia's classroom would have four students at each for the higher-set groups. During the moments when Julia asked them to work on a task, students in high-set groups almost immediately began to talk to each other, and Julia did not try to stop this talk if she considered it was about the tasks. This was different from the low-set

groups, with fewer students at each table, as they rarely engaged in conversation with each other.

Another situation in which high-set groups talked more than the lower-set groups was when Julia asked for feedback on the items of a task. The students in the high-set groups normally gave more than just the final number of an answer; it was common for them to provide some kind of justification, or to mention the method they had used to solve the items, whereas the students in the lower-sets normally provided only the final answer when being asked, and only sometimes were pressed for more than that by Julia. This tentative explanation has similarities with what Lubienski (2002a, 2002b) found when she tried to increase discussion in her mixed ability group; students from low social economic status did not participate as effectively as their more privileged peers.

These comments were based on data from the lessons I observed, but differences between her lessons with different groups was not the focus of my study.

5.1.2. Alice

The first time I talked to Alice was during the RP. She had not started teaching yet, but she was coming to Purple Valley to observe some lessons. Since Julia was her mentor for the upcoming year, she had invited Alice to observe one of the project lessons during the RP. After that lesson, we all sat down to talk about it, and by the end of the meeting, Alice had already said she would be interested in participating in the project the next year.

The next time we met was at the beginning of the main project in 2015/16, when I began to observe Alice's lessons. As part of her training course, Alice had to make written records of her lessons. For most of the time, her learning objectives, *starters* and the tasks would be on slides. Alice regularly used the visualiser and the board to solve examples and to show answers. It was not common for her to need extra items, as in

many lessons students did not reach the end of the tasks she had proposed.

Figure 5.2 below shows Alice's classroom for most of the year, but in May 2016 she changed the table arrangement. Figure 5.3 shows the new position of the tables in her classroom.

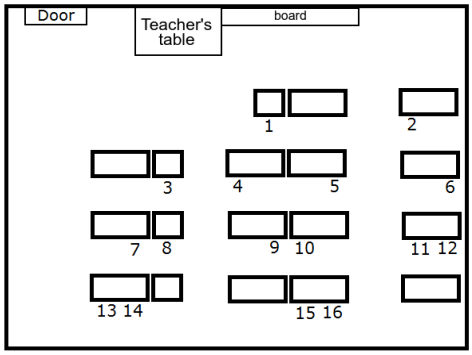


Figure 5.2: Position of the tables in Alice's classroom until May 2016 – The numbers represent students in her Year 8 set 5, but the tables are kept this way for all her other groups as well.

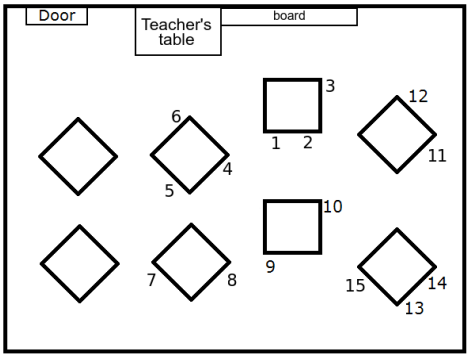


Figure 5.3: Position of the tables in Alice's classroom after May 2016 – The numbers represent students in her Year 8 set 5, but the tables are kept this way for all her other groups as well.

The numbers in the figures above illustrate the position of her students in Year 8 set 5 for most lessons I observed. Alice chose where each student would sit, but eventually changed that for a lesson in which she wanted group work.

As presented in Table 5.1, Alice had three lower-set groups with a small number of students; Year 7 set 5/6[10] and Year 8 set 5 had 16 students each and Year 10 set 6 had 8 students for most of the year, going up to 18 when the school had to redistribute students from Year 10 set 5, because a teacher left the school in the middle of the academic year.

The timetable below shows all of the lesson observations, meetings and interviews I had with Alice during the academic year 2015/16. Each rectangle of the table represents one day, so if "9" and "10" are in the

10 The sets in Year 7 were banded for timetable purposes, meaning that every two sets were mixed together before being separated into two groups. That is, set 5 and set 6 were the same "level", composed by a mixture of students.

same cell it means that I observed one lesson in her Year 9 group and one lesson in her Year 10 group on the same day. The abbreviations are as follows:

MGT – Meeting with the group of teachers;

PLA – Project lessons planned by Alice;

PL – Project lessons;

PL – Y7 – Project lessons that Alice taught in her Year 7 set 5/6;

Int – Individual interviews.

Regular lesson observations in Alice's classes: year groups						7					
			8			8					
			8, 7		7, 10	10					
		9, 10	10, 7, 8		7	10, 7		7			
	6 (STEM day)	7, 8, 9, 7	10, 7, 8, 9, 7		7	8	7	10	7, 8		
		8, 10	10, 7, 8, 7	10	7	10, 7	8	9	8		9
Academic year 2015/16	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
	2015				2016						
Special events: MGT; PLA; PL; PL-Y7; Int	MGT 1		MGT 2	PLA 1.1	MGT 4	MGT 5	PL 2.1		MGT 6	PL 3.1	PL 1.1 – Y7
			MGT 3	PLA 1.2			PL 2.2		MGT 7	PL 3.2	PL 1.2 – Y7
			Int 1	PLA 1.3			PL 2.3			PL 3.3	PL 1.3 – Y7
				PLA 1.4			PL 2.4			MGT 8	Int 3
							PL 2.5				
							PL 2.6				
							PL 2.7				
							Int 2				

Table 5.5: Timetable for data collection - Alice – 2015/16.

An example of an observation schedule of one of Alice's lessons can be seen in Appendix 7. In terms of data, I gathered more than 50 hours of audio recording and more than 150 pages of notes from the lesson observations and informal conversations.

Alice was teaching five groups, see Table 5.1, and although in the table above I do not differentiate her Year 7 set 5/6 and her Year 7 set

1/2, the majority of the lesson observations I did in her Year 7 were of her Year 7 set 5/6.

She attended all eight meetings with the group of teachers (MGT). After the third meeting, Alice asked if she could plan the initial lessons herself, although she wanted to use the ideas we discussed. One of the reasons she gave was that she wanted these lessons to be the ones she would present as her assignment for the teacher training programme, for which she needed to prepare the lessons herself. These lessons are labelled PLA in Table 5.5. For the second and third set of lessons in the following terms, Alice asked to use the complete lesson plans we had developed during the meetings and she followed them very closely.

Another extra activity that Alice engaged in was to teach the lessons again for a different group. Alice decided she wanted her Year 7 set 5/6 to revise addition and subtraction of fractions using the shapes. These lessons are labelled PL – Y7 in the table above. I discuss this event as one of the changes in Alice's practices in Section 7.2.2. The project lessons that Alice taught as they were planned are labelled PL. They are all indicated by the same colour in the timetable (Table 5.5), because they were all following, some more than others, the project lesson plans. Alice's engagement with the project went beyond what was initially expected.

As with Julia's lessons, it is also difficult to describe the style of Alice's lessons. Teachers have different styles or approaches to lessons for all sorts of reasons: depending on where they are in a topic – introducing, developing or revising it; trying to vary the dynamic to engage students; testing something they have just heard about from their colleagues, the internet or a book. In addition to that, Alice was a trainee teacher and had to attend courses at the University, where she might be given suggestions for different teaching approaches. She was also being observed regularly by staff from Purple Valley and the University, and these tutors were giving feedback about her teaching.

Therefore, Alice had many influences (other than this project) acting on her at the same time.

Alice had always been involved with sports since her own school days in a girls' school. She had experience in coaching, and being a sportswoman herself, when she was hired in a private school to work as a physical education (PE) teaching assistant. She told me that the job as a PE assistant came about through social connections, and she also said that it was an experience she enjoyed a lot. It is one of the reasons she decided to become a teacher.

Even with numerous influences, Alice was apparently developing some consistencies in her teaching style across lessons. My descriptions below were based on the lesson observations I did of her groups over the project year.

In general, Alice's lessons usually began with a *starter*: a task that students should be able to try without any further instructions from the teacher. One of the goals was to keep students working while everybody was walking into the room, opening their books and preparing for the lesson. Alice would normally get feedback from the *starter*, asking students or just solving the items on the board.

Following this warm-up task, Alice normally began the topic of the day by showing the learning outcomes on a slide. She did not necessarily read the slide, but she would talk about the items. A common feature for Alice was to ask students the meaning of the keywords or concepts she was going to talk about during the lesson. Alice did not always have volunteers to answer these questions and, when this was the case, she would choose a student to participate. Students in her top-set usually had an answer she would be satisfied with, and that served as a reminder for the other students. In her lower-sets the answers she normally got from students were not completely accurate and Alice usually restated them, as the following example illustrates:

Alice: What does perimeter mean?

Student: The outside.
Alice: Yeah, the path that goes around the outside of a shape. The distance around a shape. (Lesson in Year 10 set 6, 02/02/2016, 8min 37s)

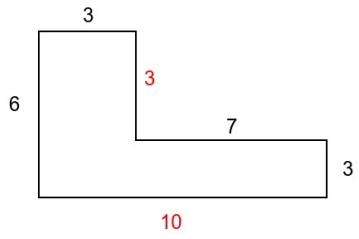
After sorting the meaning of one or two terms, Alice presented some items on the board, or on a slide, about that topic and solved them as examples, asking students for some suggestions about how to reach the final answer. Then students had a task to solve using the same method Alice had just presented. It was common to have two to five cycles of that 'example-task' sequence (Table 5.6), with no feedback on the answers to the tasks.

Alice was normally highly active in the classroom. After asking students to try a task, she would walk around, helping them and checking answers. For her lower-sets, there was always a teacher assistant designated for the group. This person usually took a small group of students to work outside the room on something else or stayed in the classroom next to the same student for the entire period (usually the same every lesson), depending on the class.

The questions at the beginning of the lesson, followed by giving examples on the board, were moments when Alice was addressing the whole classroom. It was clear in my observations that students in her top-sets were paying more attention and were more willing to engage in those interactions than her students in lower-sets. Apart from her Year 7 set 5/6, which was quite active and willing to participate, Alice had to direct the question to a selected student in order to have an answer when she was teaching her Year 8 and her Year 10. Therefore, although her lessons for all the groups seemed very similar, the lack of student participation and interaction with each other in the lower-sets resulted in lessons with fewer student discussions and a slower pace than her top-sets.

The examples below show some of my notes for two lessons I observed from Alice in her Year 10 set 6. The first one, Perimeter, is an

illustration of the 'example-task' format which represents the strategy of solving an example first.

Title: Perimeter	
Year 10 set 6 – Alice – 02/Feb/2016	
Learning outcomes	(1) Recognize 2D shapes (2) Define perimeter (3) Work out the perimeter of compound shape
Starter	8:46 to 8:55
	Alice showed one of the exercises students had in their assessment the previous week.
Task 1	8:55 to 9:05
Introduction:	Alice asked: "What does perimeter mean?" She talked about the topic, showing pictures on the board and calculating the perimeter for two quadrilaterals and three triangles.
Worksheet:	Seven items – 2 squares and 5 rectangles for students to find the perimeter.
Task 2	9:05 to 9:15
Introduction:	Alice solved the item on the board, asking students for help to find the numbers in red. 
Worksheet:	Hand out a worksheet with 4 compound shapes (similar to the example) – the first two had all the sides' lengths and the last two had some lengths missing.
Task 3	9:15 to 9:19
Introduction:	Alice talked again about the perimeter of triangles, showing the same slide as she did in Task 1.
Worksheet:	Six triangles for students to find the perimeter.
Task 4	9:19 to 9:35
Introduction:	Alice talked about circles. Mention that pi is an irrational number. Presented the formulae and explained that they

	need pi to calculate the perimeter (or circumference) of a circle. Showed two circles, mentioning the ratio and the diameter and the difference between them. Alice showed how to press pi on their calculator.
Worksheet:	Six circles – 4 with the diameter and 2 with the ratio given for students to calculate the perimeter.
Task 5	9:35 to 9:43
Introduction:	Alice talked about another type of exercise in which students were asked to find the perimeter of shapes in a grid.
Worksheet:	Alice handed out a sheet with six shapes in a grid – 3 are rectangles and 3 are compound shapes.
	During this lesson, Alice was always walking around the room helping students and checking answers. She did not solve any item on the board other than the examples.

Table 5.6: Some of my notes during a lesson observation in Alice's class, 'example-task'.

Alice's lessons in the example-task format were similar to Julia's triple X lessons, but Alice did not ask for much feedback from students at the end of each task.

Although the format described above fitted most of Alice's lessons, it was common for her to teach different lessons once a week for each group, or at least insert a different activity in a regular lesson. The second example (Table 5.7) was a lesson in which Alice asked students to walk around the room as part of a game. Alice had a background in sports, and had experience of organizing activities for the students to compete. Some of my notes during a lesson observation in Alice's class show examples of students being 'physically active' in the classroom:

Title: Substitution	
Year 10 set 6 – Alice – 03/Dec/2015	
Learning outcomes	(1) Collect together like terms in an expression (2) Factorise by pulling out a common factor (3) Substitute values into an expression
Starter	11:23 to 11:39
	Alice solved one example on the board: 4x + 2y + 3x + y She then handed out worksheets with 10 items similar to the example above, and asked students to solve. Alice was walking around, helping students.
Task 1	11:39 to 12:06
Introduction:	Alice solved two examples on the board of substitution explaining what she was doing. Alice solved another 4 examples on the board this time asking students to participate. Alice asked them to copy the last example in their books.
Activity:	Alice explained the game they were doing – a treasure hunt. There are sheets on the wall around the room, each one with a substitution question written on it, the answer indicates the sheet they should go next. The final answer is the sequence of numbers that describes the order they followed to go through all the sheets. Individually, students stood up with their books and began to solve the items. Alice was also standing up, among the students, helping them to solve the items.
Task 2	12:06 to 12:20
Introduction:	Alice talked about what expanding the brackets means and solved one example on the board.
Worksheet:	Alice handed out a sheet with some items for which they had to expand the brackets.

Table 5.7: Some of my notes during a lesson observation in Alice's class, example of students being 'physically active' in the classroom.

Alice's lessons had some student disruptions (students talking out of turn or laughing loudly), which Alice would normally address quickly. Her lessons were not completely silent, as Julia's were, and students talked to each other while Alice was walking around helping or checking their work. Students also got up to borrow materials from colleagues, or

for no obvious reason, but Alice would quickly regain students' attention when she wanted to address the whole group.

During the interviews, Alice commented on her reasons for pursuing a career in teaching. She said she had a good experience as a PE assistant, but being paid a salary while training to be a mathematics teacher, made the option very convenient.

Alice was invited by David and Julia to participate in the project after her lesson observation of one of the project lessons during RP. During our third interview she told me that she wanted to seize any opportunity to do something different, since this was her training year and she thought it was a good idea to try everything she could.

5.1.3. David

I observed lessons in all the groups David was teaching during the project, but most of the time I was with his Year 9 set 6 class. See table below with all the lesson observations, meetings and interviews we had during 2015/16.

Regular lesson observations in David's classes: year group						9					
						9					
						10					
			9, 10		10	9				9	
			9, 10		9	10				10	
	9	9, 10, 11, 11	9, 10		10	9		9	9	9	
Academic year 2015/16	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
	2015				2016						
Special events: MGT; PL; Int	MGT 1		MGT 2	Int 1	PL 1.6	MGT 5	PL 2.2		MGT 6	MGT 8	PL 1.1
			MGT 3	PL 1.1	MGT 4	PL 2.1	PL 2.3		PL 3.1		PL 1.2
				PL 1.2			PL 2.4		PL 3.2		PL 1.3
				PL 1.3			PL 2.5		PL 3.3		PL 1.4
				PL 1.4			PL 2.6				PL 1.5
				PL 1.5			Int 2				PL 1.6
											PL Ext
											Int 3

Table 5.8: Timetable for data collection - David – 2015/16.

The abbreviations are as follows:

MGT – Meeting with the group of teachers;

PL – Project lessons;

Int – Individual interviews.

An example of an observation schedule of one of David's lessons can be seen in Appendix 8. In terms of data, I gathered more than 40 hours of audio recording and more than 100 pages of notes from the lesson observations and informal conversations.

David rarely had a lesson plan with all the details of the lesson. Normally, he had a *starter* and a couple of tasks (printed or on a slide), and he would explain the topic and give examples using the visualiser. David formulated and wrote the learning outcomes of a lesson before students entered the room or while students were solving the *starter*. It was common to see David also devising with further examples during a lesson that would serve as explanations of something he perceived

students needed, or provide extra items to be solved if students finished all the tasks he had planned.

Students in David's top-sets would have to sit in pairs because of the number of students in the room and the limit number of seats. For the lower-sets, David designated places, so that students were spread out in the classroom. Figure 5.4 below shows the usual position of students in his Year 9 set 6.

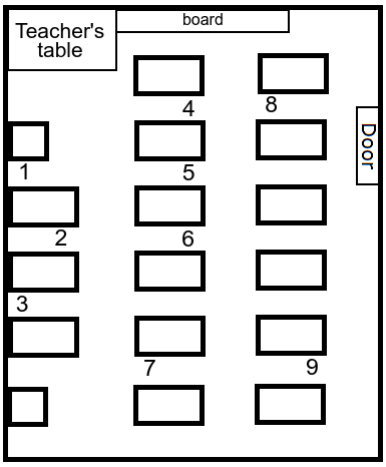


Figure 5.4: Position of the tables in David's classroom – The numbers represent students in his Year 9 set 6, but the tables remained the same for all his other groups.

In his higher-set groups (with more students), it was common to observe David asking students to discuss a task. Those were the only situations in David's lessons in which I observed the noise level to rise, but the teacher regained attention quickly once he wanted to address the whole group again. His lessons rarely had any disruption from the students.

In many lessons I saw David asking students to stand up and bring him notebooks and worksheets to be checked. It was not unusual for David to ask students to change places, so that she or he could help a peer or check their answers. As the head of department, David had to deal with behaviour issues from students in the other mathematics

teachers' classes, giving detentions or receiving the student into his own lesson.

David and the students normally greeted each other when they were still outside the classroom. At the last few minutes of the lesson, it was common to observe the students and David engaging in informal conversations while they were waiting for the bell. In some lessons, in which David had a task related in some way to daily life (e.g. prices of products at the supermarket, speed of runners, or money), he would take a few questions related to that topic, and start a conversation that was not only focused on the mathematics of the topic, but this was not frequent.

The table below is an example of a common type of lesson in David's group considering the type of tasks, the strategy for presenting the tasks and how he normally obtained feedback from the items in the task.

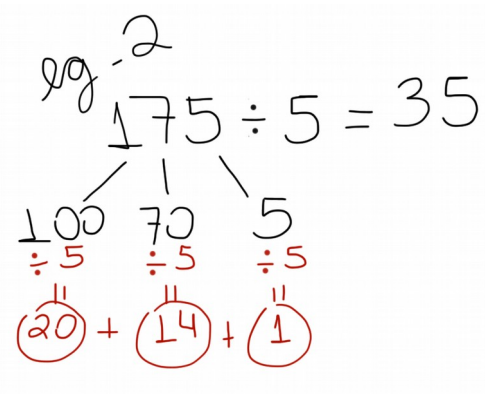
<table>
<tr><th colspan="2">Title: Fractions of amount</th></tr>
<tr><td colspan="2">Year 9 set 6 – David – 19/Nov/2015</td></tr>
<tr><td>Learning outcomes</td><td>(1) use methods to break down numbers when dividing
(2) apply this when finding fractions of amounts</td></tr>
<tr><td>Starter</td><td>8:43 to 8:56</td></tr>
<tr><td></td><td>David had a slide with the following items on:

Round the following
a) 21.1263 (to 1 dp)
b) 54.119 (to 2dp)
c) 371.6 (to 1 sf)

Simplify…
c) 6x + 2y – 4x + 9y
d) 6a + b – 4a – 2b

If the temperature during the day is 3°C and falls by 7°C at night, find the temperature at night.

8:51 – David began the feedback, asking students to give the answers for the items. He did not write any of them on the board.</td></tr>
<tr><td>Task 1</td><td>8:56 to 9:10</td></tr>
<tr><td>Introduction:</td><td>David showed the following example under the visualiser:</td></tr>
</table>

	eg. 1) 170÷2 He solved it, asking students to give ideas. He asked students to copy and showed a second example: eg. 2) 175÷5 David solved the second example with some students helping. The following picture is a reproduction of David's solution under the visualiser: 
Slice:	David showed a slide with the following items: $\frac{1}{2}$ of 150 | $\frac{1}{10}$ of 180 $\frac{1}{9}$ of 99 | $\frac{1}{4}$ of 140 $\frac{1}{8}$ of 24 | $\frac{1}{7}$ of 42 $\frac{1}{2}$ of 160 | $\frac{1}{7}$ of 49 $\frac{1}{5}$ of 125 | $\frac{1}{6}$ of 120 The teacher solved the first item talking about what it meant to have half of something. After talking about how to get ¼ of something he asked students to solve the other items.
Closure:	David asked for the answers and wrote them under the visualiser.
Task 2	9:28 to 9:44

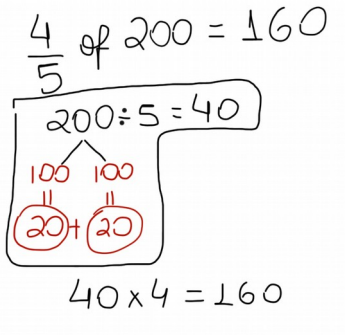
Introduction and task:	David showed a slide with the following: $\frac{4}{5}$ *of* 200 $\frac{2}{8}$ *of* 72 $\frac{2}{3}$ *of* 69 $\frac{4}{5}$ *of* 160 $\frac{4}{9}$ *of* 90 He solved the first item asking students for suggestions. 
	David solved the second item as well and asked students to solve the others without using the timetable they had in their planners. 9:41 – David solved the third item on the board and asked students to choose one of the other two and focus on it.
Closure:	David solved the two last items of the task. This time he did not write on the board, instead he only talked about the steps and the answers.

Table 5.9: Some of my notes during a lesson observation in David's class, example of a common lesson.

After his first degree, David started a PGCE[11] to become a mathematics teacher, mainly because he did not have any other plans, and because he wanted to live in London. Since he got a scholarship to do that, he took the opportunity and moved to London.

Teaching was not a childhood dream, but a project during his undergraduate degree took him to schools and he enjoyed the experience a lot. Also, he told me, that his confidence in mathematics and his good

11 PGCE stands for Post-graduate Certificate in Education, which is one of the routes to get qualification to become a teacher in England.

memories from his school time, encouraged him to take the PGCE route to become a mathematics teacher.

David was Dr. Gates' contact, and he was the one who had agreed to commit to the project, first in his previous school, and continuing after he had moved to Purple Valley. He invited Julia and Alice (and also Omar and Otto). David told me that his motivation to begin the project was related to his perception that he should be constantly learning. He said he seized the opportunity to work with Dr. Gates, because he did not want to stagnate and as Dr. Gates was suggesting things David was not doing in his lessons, David saw an opportunity to do something different from what he had been doing so far.

Because of his role as head of department, David had administrative commitments and he taught fewer lessons per week. Nevertheless, he engaged with all the activities throughout the project, and only missed one meeting.

5.1.4. Summary

The three subsections above describe general teaching characteristics of the participants in my study. Although the teachers were in the same school, they were very different in some respects. I summarise these teaching characteristics in the table below.

		Teacher		
		Julia	**Alice**	**David**
Info	Students' behaviour	Her lessons were very quiet	Not as quiet as Julia's lessons, but it seemed easy for the teacher to regain attention	Quieter than Alice, not as quiet as Julia
	Lesson plans and materials	Rarely had to improvise, every detail seemed to be planned in advance	Improvised more than Julia	Improvised more than Alice
	While students were solving a task, the teacher would….	Walk around, helping and checking answers most of the time		Walk around a little, but not as much as Julia and Alice
	Students' position in low-set groups	Spread around the room		
	Motivation to teach	Childhood ambition and good teacher example	Good experience during university	Good experience during university
	Motivation to teach maths	Pragmatic choice: this career would start paying since the training (had more job opportunities)		
	Prominent difference between high-set and low-set lessons	Students in high-set groups talked more about mathematics in general (with each other and with the teacher)		
	Motivation to participate in the project	Invitation from David and curiosity about Dr. Gates' suggestions	Invitation from David and wanted to learn about different things	Seeking different teaching approaches

Table 5.10: Differences and similarities in teaching aspects of the participants in 2015/16.

One reason I decided not to contact other mathematics teachers in Purple Valley to participate in the project, nor to look for another school in which to collect data, was that Julia, David and Alice provided a large variety in terms of experience and classroom control. These three participants in Purple Valley provided as much variance as I could expect to handle in a qualitative case-study with one year of data collection.

Julia, Alice and David participated together in this project, working collaboratively during the meetings. In the following section I describe how the data collection developed over the year and I also describe how Julia, Alice and David engaged in very similar ways. The discussion in Chapter 8 is focused on the features that might explain the teachers' engagement and change processes.

5.2. Data collection

The timeline below (Figure 5.5) is an overview of the data collection period from September 2015 until July 2016:

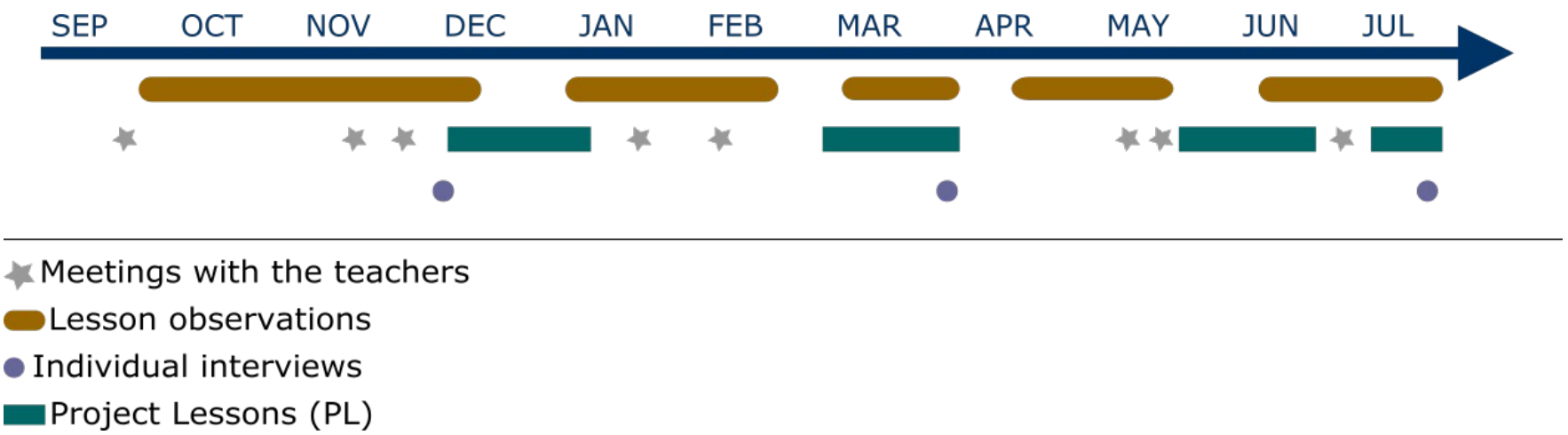


Figure 5.5: Timeline for the data collection.

I observed more than 170 lessons given by the three teachers. Beginning at the end of September, I undertook lesson observations until the day before the last day of term in July. In around 50 of those lessons (dark green rectangles, Figure 5.5), the teachers were following the project lesson plans. I had eight meetings with the teachers to talk about the project lessons (grey stars, Figure 5.5). I interviewed each teacher three times around the same period, just before they began to use the project lessons; after they finished the second pack of lessons, and after they finished the extra lessons (see Section 5.2.3).

The subsections below follow the terms in Purple Valley: Autumn term (September – December), Spring term (January – March), and Summer term (April – July). Every change of term gave a two-week break in school, and every half-term gave one-week break. Those breaks were useful times when I could catch up with the planning of meetings and interviews and engage with more systematic analysis of the data.

5.2.1. Autumn term (Sep – Dec)

A meeting with the teachers marked the beginning of the project in the academic year 2015/2016. The three teachers attended this meeting and we discussed three main topics for around one hour: the initial plan for the current academic year, the year groups each teacher wanted to work with, and I explained the outline of my research project.

Regarding the lesson observations, I was going to the school three times a week and I would spend each day with one teacher. This allowed me to talk to the teacher during breaks and while students were settling in or leaving the classroom. This intense contact improved my rapport with the teachers. It also made it possible to talk to teachers about episodes that had just happened, bolstering internal validity of the data through lesson observations, since they were not having to recall situations. Sometimes teachers would comment on something about the lessons even before I asked anything at all, and those moments could open up issues the teachers were more concerned with, or what they

thought I would be interested in knowing more about. This showed how much our rapport was developing.

The last reason to stay with one teacher for the whole day was that it allowed me to observe the teachers with different groups, varying across age and ability sets. I wanted to investigate whether there were any differences in the teachers' practices across the groups. I discussed some differences I perceived above in Section 5.1.

Our second meeting happened in November 2015. This was the first meeting that Dr. Gates did not attend. The three teachers attended, and we discussed a summary of last year's lessons (RP, Section 2.2.2); a test about fractions to be administered to the focus year groups; and the plans for the next meeting. The next meeting was scheduled for the 25th of that same month.

During this period I was still following the one day with each teacher scheme: Tuesdays with Alice, Thursdays with David and Fridays with Julia (see Table 5.11). I had reached 54 lesson observations and I can say that my rapport with the three teachers was very good. We were having many professional conversations and they seemed to trust and value my views and opinions.

	Alice	**David**	**Julia**
	Tuesday	**Thursday**	**Friday**
Period 1	Y10 s6	Y9 s6	Y7 s1/2[12]
Period 2	Y7 s5/6		Y8 s4
Period 3	Y8 s5	Y10 s4	Y9 s5
Period 4	Y9 s1	Y11 s1	Y10 s1
Period 5	Y7 s1/2	Y11 s4	

Table 5.11: Year groups and sets each teacher taught on the day I was observing them.

The main aim of the meeting at the end of November was to discuss the first set of project lessons. This first set was composed of four

12 After a few months into the academic year, Julia was asked to swap this group for a Year 11.

lessons. The teachers could read the initial ideas for most of the tasks in the lessons and we discussed them. I also scheduled one-to-one interviews to be conducted before they began to teach the project lessons.

In this first set of interviews I had a common set of questions: about the teachers' qualifications, reasons they became mathematics teachers, their teaching in general and about the lower sets in particular. Beside these questions, I also asked about one or two features I had selected from each teacher that had caught my attention during the lesson observations, see Appendix 5. The aim was to have more information about possible reasons teachers taught the way they did.

Alice decided she would start the lessons about fractions as soon as possible, and also that she was going to plan the lessons herself based on the initial ideas we discussed in the meetings, meaning that she was not going to follow the lesson plans as they were designed. That was **not** my initial plan, but it was not a problem considering that I wanted teachers to feel comfortable. This was apparently an important phase for Alice to get used to the approach and the style of tasks, which I discuss further in Chapter 7. Unlike Julia and David, Alice was not in the school during the RP, so she was probably not as familiar with me and the aims of the project as the other two teachers. I argue that this phase was important to foster:

- Alice's trust in me;
- her curiosity about the project lessons plans;
- congruence between her regular lessons and the project lessons.

These issues are discussed in more detail in Chapter 8.

The initial lessons about fractions, in Alice's group, enabled me to establish more realistic necessities in terms of data collection during the observation of the project lessons. In order to have a better understanding of the lessons, I needed more than the notes I was taking. For Alice's second lesson, she agreed that I use an audio-recorder and

took pictures in her classroom. Apparently, since Alice was trying something different from what she normally did in the classroom, I had more information to capture than I had in previous lesson observations. I was not sure what data would be relevant, but with the audio record I had Alice's complete verbal explanations and even some of her interactions with students.

During December, all three teachers began to use the project lessons (or the ideas of the project lessons for Alice). While teachers were using the project lessons, I stopped the one-teacher-per-day scheme in order to be able to observe the lessons when they were teaching the project lessons plans. By the end of the term, only Alice had finished the first set of project lessons. David had one lesson left and Julia had three, so both of them decided to finish the first set of project lessons lessons in January.

During the break in December, I finished the article for British Society for Research into Learning Mathematics (BSRLM) proceedings about the RP (Guimaraes, 2015). Writing this article allowed me to develop my focus on the influences on teachers' engagement and change in practice.

5.2.2. Spring term (Jan – Mar)

Julia and David finished the project lessons by the middle of January. I was already observing other lessons during that period, but I had decided to change the one-teacher-per-day scheme. The main reason for this was because I wanted to choose lessons that I knew I could discuss with the teacher before or after the lesson, as these talks were rich situations from which I was getting different information than from just observing more lessons. The lesson observations in which I had the chance to talk to the teachers were enhanced, because in addition to my notes and the audio recording, I had some comments from the teachers as well. Besides, the marathon of four or five lesson observations in sequence were physically very demanding for me, and it

was hard to work on the digitalisation of the notes after spending the whole day in the school. With the new scheme of selecting the lesson, I was able to focus on issues related to my study and not be so immersed in the day-to-day school routine. Moreover, I had already achieved some benefit from the large number of lesson observations I did during the Spring term. I developed a good rapport with teachers and students, and the fact that they were now used to me being in the classroom allowed me to take more pictures from the board and the worksheets without disturbing the lesson. I became an accepted part of the context, and teachers' and students' actions seemed to be less and less disturbed by my presence, allowing my data to be more representative of a natural environment.

On January 2016, we had a meeting involving the three teachers and the two PhD researchers to talk about the teachers' experiences with the first set of project lessons. The teachers shared their impressions about the lessons and I invited them to talk about positive and negative aspects of the experience. David and Julia commented on possible ways to improve the lesson plans, and some things that did not work well, but also offered many positive aspects to share. On the other hand, Alice commented exclusively on negative aspects (the lessons did not prepare students for the examination paper; students' behaviour got a lot worse; students could not work independently; the initial activities were too demanding), although she did agree with some positive aspects mentioned by the other two teachers. These aspects were explored in further discussions with the analysis of each teachers' data, Julia in Chapter 6, Alice in Chapter 7 and David in Section 8.2.3.

I continued the lesson observations on the same weekdays and still in the new scheme: I was trying to observe lessons in which I would have time to talk to the teacher before or after that lesson. With this scheme, it was common for me to observe two teachers per day. Just before our next meeting, the fifth, I reached 100 lesson observations in total.

The meeting in February was focused on solving and discussing the next set of project lessons, about addition of fractions. By that time, Dr. Gates' project had finished and he stopped visiting Purple Valley. His visits during the RP had laid the ground for the other two projects, and his absence did not seem to interfere with the teachers' engagement with the meetings and teaching of the project lessons.

By the end of February and beginning of March all three teachers had begun the second set of project lessons. Alice and Julia were teaching the lesson with the same year group, Year 8 set 5 and Year 8 set 4, respectively. This caused two of the project lessons to happen at the same time (all groups of the same year had lessons at the same time), so while I was observing Alice's lesson, Barichello was observing Julia's. I could still have a fair representation of Julia's lesson since Barichello obtained audio recordings of it, and I discussed the lesson with him and I had access to all students' worksheets.

During the second set of project lessons, we ended up developing a routine with David. Even though all the files with the lesson plans were sent through email for him before the day of the lesson, David would usually say that he had not had time to look at it and he would ask to have a "quick chat" just before the lesson. It became common for me to arrive a few minutes before David's lessons, when he would be in his classroom looking at the project lessons plans and we would have time to discuss the sheet with the instructions for the teacher and the tasks for students. This same sequence of events happened in most of David's lessons, until the end of the academic year. Since David was the head of department, he had many administrative commitments, which other teachers did not. Apparently, these commitments interfered with his planning of lessons in general and it was the same for the project lessons.

My availability and flexibility allowed David to engage with the project lessons, which he probably would not have been able to have

done had we not arranged the pre-lesson discussions. Support, time and flexibility are features of the project discussed further in Chapter 8.

I arranged the second individual interview to be just after the teachers had finished the whole second set of project lessons. My intention was to talk to Julia, Alice and David as soon as possible after they had taught the second set of project lessons, in order to have their impressions on the recent experience (see interview schedule in Appendix 5). This time, the three teachers had taught the lessons following the project lessons plans closely, and they were in general very pleased with how the lessons had worked.

5.2.3. Summer term (Apr – Jul)

After the Easter break, I resumed the lesson observations, and in May we had a meeting focused on sharing comments about the second set of project lessons. I used teachers' comments from the individual interviews to prompt the discussion. We also had some time to discuss the first lesson of the third and last set of project lessons.

We scheduled another meeting a week after that to discuss the other two lessons from the third set. This was the first (and only) time David did not attend the meeting, and the only time any one of the teachers missed a project meeting.

All three teachers finished the third set of project lessons by the beginning of June, and I reached 160 lesson observations in total. We had our last meeting at the end of June. We focused on talking about their impressions of the final set of lessons and an overview of the whole process. The atmosphere during this last meeting was of a "job well done" and also an anticipation of nostalgia, as David said, "You are certainly part of the team now: everyone knows you. You are here for the maths faculty" (meeting on the 22nd June, David, 50min 09s).

I was interested to see that all the teachers had plans to use the lessons again before the end of the academic year. Julia wanted to plan

lessons to teach fraction multiplication following a similar approach. We met her twice to discuss her lesson plans, and she taught three lessons moving forward with the same year group. Alice taught the lessons from the first set to a different group: her Year 7 set 5/6. Since she had planned her own lessons in the first set, this was an opportunity for Alice to teach the lessons using the project lesson plans.

David decided he wanted to teach the project lessons for a different group as well: his Year 9 set 3. He taught seven lessons, six of which were the original project lessons plans he had used before, only with fewer tasks in each, so students would progress more quickly. The seventh lesson he planned himself as a final revision lesson.

The initiative of teaching extra lessons came individually from each teacher, as nobody had asked the teachers to try the lessons again. Julia was talking about the continuation of the topic and I encouraged her, but it was her idea. Alice and David commented that they were going to use the project lessons plans again in different groups. Apparently, they felt some sense of ownership over the project lessons plans, and also suggested that they enjoyed the experience of teaching the project lessons. Agency and positive experience are constructs that influenced the teachers' engagement in the project, as discussed in Chapter 8.

In the last week of term, I interviewed all three teachers again. This last interview schedule was more closed than the two previous ones. For this last interview I asked about teachers' perceptions of the benefits of using visual representation, and their beliefs about teaching and learning in top-sets, low-sets and for our lessons (see Appendix 5). During the analysis, when I was coding these last interviews, I did not perceive that I had gathered new information. This phenomenon was probably a sign that I had reached saturation in my data, a point when no new information is being gathered.

5.2.4. Reflection

The period of data collection was exciting and intense for me, as a new researcher in a different country. There were so many aspects of the daily routine of the school that were intriguing and might be worth investigating that I found it very hard to focus on my study. After the data analyses and during the writing up period it became clearer that I had more data than I was going to use for the thesis. Aspects of the lesson observations, such as the details of the tasks, and the audio-recordings, such as the teacher-student interactions, were only marginally influencing my findings in this study. Hopefully, I will be able to carry on analysing different aspects of this data into the future.

During the whole period any disruption was minimal. David did not attend one of the meetings and Alice had to reschedule one of the fraction lessons, because she was called to cover another lesson for a teacher who was absent. However, all the other scheduled activities ran as planned, suggesting that the demands on teachers were possible to meet, given teachers' commitment to the project.

The lesson observations became more than a moment for data collection, being also valuable to strengthen my relationship with the teachers. All of them trusted me to help students during the lessons when I was not taking notes, and after some months all the teachers began to thank me for the help after each lesson I had observed. The audio-recorder and the pictures became natural accessories and did not cause any kind of disruption during the lessons. The teachers would even save me an extra copy of the worksheet they were using, up to the point when Julia began to save the sheets she used during the lesson under the visualizer, with her notes and answers she had written to show students (see example in Figure 6.1). The teachers apparently trusted me, and did not seem worried that I might judge their work, and were usually happy to hear any comment I had about their lessons.

The interviews were not much different from a long conversation after a lesson, or as suggested by Kvale (2008), "a conversation with a structure and a purpose" (p.149). Although the first interview with Alice was not as smooth as the others, I consider that it was because of my inexperience as an interviewer, having done only one interview with Julia and a couple of courses at the university. I was not used to applying techniques to encourage participants to deepen their answers. This first interview with Alice was 18 minutes long, with a very similar interview schedule that generated 25 minutes conversation with David and 47 minutes with Julia.

I perceived that the rapport we developed over the year transformed the interviews into moments of reflection and, apparently, Julia and David agreed with me, as David said at the end of our final interview:

> Rita: Thank you very much for your time.
> David: No that's absolutely fine. Quite enjoyable [both laugh]. Well it's an opportunity to reflect a little bit, isn't it? (David, Interview 3, 50min 23s)

Additionally, Alice and Julia had moments when they stopped answering my question and began to reflect about something related to the topic we were talking about. Alice, without being asked, mentioned a different topic that could be taught in a similar way to the project lessons:

> Yes or you could do it with percentages, you could just do one example where you just find 1% and then using that, they should be able to find any percentage and they should be able to do any percentage increase or any percentage decrease. (Alice, Interview 2, 18min 54s)

These were the main reasons why I considered the interviews to be safe and open spaces, where the teachers were able to talk freely about their practices. The meetings developed along a similar path to the interviews, with participants contributing more, offering their views on

the topics being discussed and asking each other's opinions. These are similar to how communities of practice are developed (Wenger, 1998), which I discuss to in Section 9.2.

These reflections about some aspects of the project are already an example of the analysis of the data. These considerations contributed to the investigation of features that influenced the teachers to teach the project lessons. The next section is a more detailed account of how I analysed the data for this study.

5.3. The processes of analysis

The experience with the data in the RP (Section 2.3) influenced my approach to the data analysis during the main study. During the main study I digitalised all my notes after each day of lesson observation, including comments from talks I had had with the teachers, and I also took notes about classroom incidents that I thought were worth paying attention to for the next few visits to the school. This process, of organizing the record of the lesson observations, including my initial impressions in the form of notes, can be characterised as an ongoing analysis of my data. The insights and ideas I had during these moments informed the planning of the interviews and meetings by indicating topics that might be worth getting more information about from the teachers. These ideas also guided the focus of the lesson observations.

Another important experience during the RP was transcribing Julia's interview myself and coding for emerging themes with pen and paper. The process was very time-consuming, as I tried to prepare myself for the interviews of the main study. The first action was to become familiar with a software for the coding process. I chose NVivo[13] because it was provided by the university. I did not begin transcribing the interviews immediately after, and looking back, I think I should have done that, but, at the time, I felt it was not worth reducing the lesson observations to

13 NVivo Pro 11 - http://www.qsrinternational.com/nvivo-product

focus on the interviews. After each round of interviews, I listened to the audio-recordings and took notes about issues that I thought were important and wanted to follow up on.

Towards the end of the academic year, after the end of the lessons at Purple Valley, I decided to prepare the interviews for coding. I needed some level of transcription of the interviews to do the coding. This was the most intense period of data analysis. I began the transcription process with the three interviews with Julia. I was not sure about how much of the interviews would need to be transcribed, and in order to decide that, I approached each interview differently. For the first interview, I wrote sentences to summarize what Julia was saying.

For the second interview I rewrote some parts of the interview as verbatim transcriptions and some other parts as summarizing notes of the main ideas Julia had mentioned. Finally, I fully transcribed the third interview. All these text files were produced with the software oTranscribe[14]. This software was helpful, because it offers keyboard short cuts that allow the user to play and pause, rewind and fast-forward, slow down and speed up and to insert timestamps along the transcriptions.

With Julia's interviews transcribed in three different ways, I could compare the three levels of detail, and make a more informed decision about which one would provide a better base for the coding process. I decided that I needed the full transcription in order to do the analysis. The full transcription was the only format that allowed me to have easy access to quotations of what the teachers were saying, and also the closest one to the original data (verbatim). In retrospect, my choice was probably due to lack of experience in coding data. I was not confident that I was able to capture the most important ideas in my summary notes of the interviews. Having the verbatim transcripts allowed me to code based on the teachers' words, not on my own notes of what teachers had said. With the verbatim transcripts, I could reconsider teachers' comments without having to go back to the audio-record.

14 Available at http://otranscribe.com/

Once I established that I needed the whole verbatim transcripts of the interviews, I began to fully transcribe the other two interviews with Julia. At the same time, I had the other six interviews (with Alice and David) professionally transcribed. This decision was taken because the task of transcribing was very time consuming, especially considering the idioms and expressions I was not familiar with, since I am a non-native speaker. Also, the spoken English (as any other spoken language) creates challenges for non-native speakers with issues such as pace, articulation and accent. The effort of transcribing the interviews by myself was not worthwhile in terms of benefits of providing an initial contact with the data, which I already had because of the process of hearing the audio-recordings of all the interviews soon after they had taken place. Additionally, I had spent a long time transcribing Julia's interviews and I noticed that I was not able to pay attention to the meaning of what Julia was saying while I was typing the words.

The company responsible for the professional transcriptions had recommendations from three different members of staff at the University of Nottingham. I could choose the type of service, that is, how much of what is said in the interview being written down, so I decided on the "intelligent verbatim", in which the transcriber would type everything that is said, but omits fillers and stumbling over words. The examples available at the website showed that this option was similar to what I had done with Julia's interviews. Also, this choice was coherent with my intentions regarding the analytical process of the interviews, of using open coding in relation to meaning, not just in relation to language (Kvale, 2008).

I imported the six text files of the transcribed interviews to oTranscribe (the software mentioned above), in order to include timestamps in the files. Timestamps provide an easy way to track any part of the data. Most importantly, the process of adding the timestamps provided a simple way to perform a quality assessment of the files. Before coding, I would hear the whole interview, check the file and edit

any possible misunderstandings of terms, which turned out to be only a small number of specific terms from mathematics and schooling. Finally, this meticulous assessment proved to be less time consuming than having transcribed the interviews myself and it allowed me to immerse myself in the data, while not worrying about idioms that I could not understand and typing words correctly.

5.3.1. The coding process

The initial attempt to code an interview showed that the codes I was suggesting were, most of the time, too broad and did not explain what the teacher was saying (e.g. Students' attitude; Teachers' engagement; Teaching strategies). As I was using software, it was easy to change the codes. It was also easy, using the software NVivo, to create many codes for the same section of text, making it possible to classify a piece of data in more than one way. An example of the coding processes is given later in this section.

From now on, I will use the word 'node' when I refer to the sentences (or the tag) used to code my interview data, since this is the name that is used in NVivo. The verb 'code' will be used, in this thesis, to refer to the process of allocating pieces of the data to nodes.

Considering all the nodes I created for one of my interviews, it was possible to see that they constituted a summary of what the teacher covered during that interview. The list of nodes became quite long. By the time I finished coding Julia's interviews I had 298 different nodes. When I finished coding all the interviews, my list had 645 nodes in total. I coded almost all the text in the transcriptions, with NVivo showing that I had at least 90% of all the interview text coded. My aim with this initial coding was to be comprehensive. I wanted to have all the topics discussed, so I could see what was coming from my data, rather than forcing pre-established categories into the data. On the other hand, with 645 nodes I was not able to categorise them all together, as they were

too many. I will explain how I dealt with the list of nodes in Section 5.3.1.b.

Although 645 nodes might seem too many after coding only nine interviews, suggesting that I did something wrong, I was conscious and cautious that there were no major issue with my process. I had been using a systematic procedure of reading the previous nodes before starting coding new data, I always had the nodes in a spreadsheet in case I wanted to check if I was creating duplicates.

Nvivo, electronic spreadsheets and search tools allowed me to handle the numerous nodes and all the data in each of them with the confidence that I was not losing information. Moreover, starting from the data, in a bottom-up coding process, was my choice since I was following a grounded-theory approach for this phase of data analysis (Strauss and Corbin, 1998).

The term microanalysis, as described by Strauss and Corbin (1998), gives a good idea of the process I was going through: a line-by-line examination, understanding what and how the interviewees were saying and considering, both in a *descriptive sense*, as a description of a specific situation, and also in an *analytic sense*, as to why the respondents were saying what they were saying (Strauss and Corbin, 1998, p.65). The coding for *analytical sense* took me to nodes that contained non-action words: nodes that did not describe situations or actions, but that suggested opinions and beliefs, for instance "Proud of her job", "Enjoy challenges", "Taking responsibility", "Being reflective about her teaching to understand", etc.

The coding process was a lonely endeavour for me and I found very helpful the few opportunities I had to discuss some of the nodes with my supervisors, but this was not the norm, and I remember feeling unsure about my choices of words and my interpretations of the data. I felt that the coding process was somehow influenced by my own background. My views, perspectives and experience from the years

teaching and working with teachers could be seen as a strength, since I was an experienced person in the field, but at the same time, I was concerned about how impartial my analysis of the data was, and if another researcher would have similar nodes.

The process of writing about the nodes in a way that convinced my supervisors of my findings was the moment I noticed that another researcher might come to different conclusions when analysing the same data, but they should not be contradictory ones. My findings were coming from the focus I had and the whole process was influenced by my own background. Another researcher with similar goals might notice different aspects that I could not, but I should be able to justify my arguments well enough so that someone else would understand and agree with my interpretation.

Additionally, my findings should come from the data, coherently with grounded theory, and are not pre-established beforehand, allowing the reader to be convinced by it in the knowledge of how I chose to approach it. Nevertheless, the fact that I was just learning about the rules and the ways of working of the educational system in the UK actually helped me to approach any event as an outsider, fostering a more curious approach to any unusual action from the teachers. An example of this situation can be noticed in some seemingly naive questions I asked during the interviews, such as "What is TLC?" (Interview 1, 36min). Julia explained that it was an acronym for 'tender loving care', but she went on to explain why she thought students needed that and how she perceived she could provide it during mathematics lessons.

As mentioned before, the daily process of organizing and recording the lesson observations and field notes constituted initial analyses of my data. These were initial conceptualizations and classifications of events during my data collection phase, and many of these topics came up when I was coding the interviews. These two sources of data, interviews and lesson observations, were complementing each other, and now, towards

the end of the analysis, I can see how my lesson observations raised my awareness of issues that could be identified later in the interviews. This was the most common way to employ a comparative approach to my data analysis, or a way of triangulating my findings (Wellington, 2000).

The actual sentences for my nodes were sometimes the participants' own words (e.g. Don't want to just give them the answers), called *in-vivo coding* (Corbin and Strauss, 2008) or live coding. On other occasions, they were my initial interpretation of what they meant (e.g. Enjoy challenges). I say 'initial' because I was not making deep connections at this stage, but wanted to have simple interpretations that I could easily explain for someone who had not been present during the interviews or during the lesson observations.

a) Example of the coding processes

As an illustration of the coding process, I present below a section of Julia's third interview.

> Rita: […] considering a regular week of work, how do you go about preparing for the lessons of that week?
> Julia: I am in a position now where I've got quite a lot of resources already done, so what I tend to do is... I would never just pull up an old PowerPoint and use it. Sometimes I look back on a slide or something and oh my god, they are like, "Why did I do that?". What I tend to do is I pull something up and try and adapt it. But I still don't think I have enough time to really think about what I am doing. (Julia, interview 3, 1h 05min 25s)

This whole segment of text (including my question) was coded with the three different nodes below:

Node 1 – Commitment – to her job: because it seemed that Julia was worried with the materials she used in her lessons, and was not only re-using slides from previous lessons. Also, she suggested that her old lessons might not be acceptable now;

Node 2 – No time to prepare lessons the way she wanted: Julia mentioned she did not have enough time to think about her planning as she would like. I coded the whole paragraph under this node because it would be out of context to select only the last sentence;

Node 3 – Creating moments for her to reflect on her practice: Julia mentioned that some of her old slides were poor, that she normally adapted things for a new lesson, and also that she did not have time to "really think". All of this together suggested that she was trying to create moments to think about her lesson plans.

Additionally, I had three other nodes attributed to parts of the segment above:

Node 4 – How she plans lessons – already have a lot of resources: For the initial sentence, "I am in a position now where I've got quite a lot of resources already done, so what I tend to do is...".

Node 5 – How she plans lessons – never using exactly the same old PowerPoint: For the middle part, "I would never just pull up an old PowerPoint and use it. Sometimes I look back on a slide or something and "Oh my god, they are like...why did I do that?"".

Node 6 – 'How she plans lessons – re-adapting old resources': For the final comment, "What I tend to do is I pull something up and try and adapt it. But I still don't think...maybe I have enough time to really think about what I am doing.".

This overlapping and multiple coding allowed me to allocate all the topics discussed during the interviews in as many different interpretations as I could develop during the coding process.

b) Developing categories

It was possible to group the 298 nodes from the interviews with Julia into categories that might be important for addressing my research questions. By reading and comparing the nodes, I was able to try different groupings, refining the categories and the nodes in each one of

them. Following Strauss and Corbin (1998), my aim was to develop categories that reflected influences on the phenomenon I was interested: teacher change.

It was clear that the nodes could be grouped in many different ways, depending on the focus I had on phenomena I wanted to investigate. The categories I created were developed considering my research questions as guides. For instance, I could have had a category called "learning outcomes" or "the use of PowerPoint" but I considered that these topics were not related to my research questions.

In order to present these categories to my supervisors and to justify why they were important, I started writing about Julia: this writing later became Chapter 6 in this thesis. The writing process was fundamental in developing the categories that were associated with the nodes, but it was not easy to justify the groups of nodes I had placed under the same category.

For instance, one attempt at creating categories for Julia's data came after I sorted out the nodes according to the topics of the research questions: teacher's change; features that influenced the changes; and how the teacher perceived the new lessons. Initially, I decided for each node, if it belonged to one of the three topics, it was possible that a node did not fit any of them, e.g. Reason to become a maths teacher, which would be helpful in the description of the teacher. This was a slow process because reading the name of the node was not always enough to decide to which topic it belonged, so sometimes I also had to read the coded text under that node in order to make a decision about where it should be placed.

In NVivo I created a folder (NVivo calls it a set) for each teacher and a sub-folder for each topic. With the nodes organized in these folders, I just needed to export a spreadsheet, with a list of the nodes related to each topic, for each teacher. To most of the nodes I added

some emblematic quotation. Initially, I did that for the three interviews with Julia.

Selecting one of the topics, I printed the lists of nodes and tried to group them looking for categories that were apparently related; for instance, in the topic of "features that influenced the changes" one attempt to develop categories led me to the following:

A) Against what the project lessons are suggesting
B) Belief about students – worried about students' emotions – not fixed ability
C) Changed before
D) Reflection
E) Results in the classroom
F) The teacher feels responsible for the lessons
G) Organization – knowing the curriculum
H) Take risks – Confident – Experienced
I) Personal characteristics
J) In accordance to what the project lessons are – the teacher sees it as an advantage
K) Support – Collaboration
L) Belief about maths
M) Motivation from external factors
N) Time pressure

I tried to understand the connections between these selected categories, building diagrams and writing text explaining possible relationships. This process was repeated for the three topics, and at least twice for each topic. After I had reached a coherent explanation, I would move on to re-reading the nodes and the quotes in order to be able to write more extensively about the connections. At this stage, I also considered other parts of my data, such as the meetings and the lesson observations, which were not coded in NVivo.

The reason the meetings were not coded in NVivo was that I did not have time or resources to have them transcribed and to code them. Instead, I went back to the audio recordings and took notes from what the teachers were saying. I made a text file for each teacher, containing notes from each of the meetings. Since these files were created after I had already coded the interviews, it was possible to pay attention to situations related to issues already raised by the interviews.

The lesson observations, as mentioned before, provided initial topics that influenced the planning of the meetings, the interviews and of following lesson observations. Again, I did not have time or resources to have them transcribed and to code them. Additionally, I used the data from the lesson observations and the audio from these lessons to investigate the changes in practice from each teacher (see Sections 6.2 and 7.2.). Each lesson observation was also recorded on an electronic spreadsheet. I also took notes about the topic and about emblematic moments that I might want to use later in the analysis.

This process of looking at other parts of the data enabled me to find inconsistencies in my analysis at that point. The explanations I had developed with the nodes from the interviews were not always in accordance with the data I had from the meetings and from lesson observations. This was the triangulation process of my analysis, where comparison of data from different sources enabled me to corroborate or discredit the categories I had developed with the interviews.

For instance, the categories ‘beliefs about maths’ and ‘changed before’, which were constantly appearing in Julia’s interviews, did not have the same relevance in the other sources of data. On the other hand, ‘reflection’ and ‘results in the classroom’ were also appearing in the data from the meetings as important categories about what influenced Julia to change.

Therefore, the final categories that build up the conclusion of this thesis emerged after I had tried many different groupings of the nodes

from Julia, and after I went to a similar process of categorising the nodes from Alice's interviews.

c) Moving beyond categories

It was not simple for me to move from the categories to the findings of this thesis. The suggestions from Bazeley (2009), about ways to move beyond finding themes, helped me to focus on the process of "describe – compare – relate" (Bazeley, 2009, p.10). Following this sequence, I began to write Julia's chapter (see Chapter 6). The first few versions of the chapter were attempts to develop and describe influences on change from the nodes of the coded interviews. After considering some possibilities of how to divide the influences, I chose to have a section describing the changes, and another considering possible influences on the changes.

I was still not moving beyond the comparison of some of the characteristics influencing change and I reached a point when I did not know how I could move the topic any further. After some more consideration, and re-reading my own text, I was able to add explanations for the changes I observed.

I was able to explore the change process, considering many of the characteristics of the teacher (e.g. organized, curious, motivated, etc.), mixed with characteristics of the project (e.g. time for discussion and reflection, support during the implementation of the project lessons, etc.). For instance, Julia followed the project lesson plans, and told me she was curious to see how much students were going to "pick it up". During the meetings to discuss the lessons, Julia agreed that she would not show a procedure of how to solve the items of a task before letting students try. After her experience during the RP, she trusted that students would be able to progress without a lot of guidance from her. As I was always in those lessons, afterwards we would discuss them and

consider what to do next, encouraging Julia to keep following the lesson plans.

Additionally, I also considered the influences of specific events that happened due to the features of the lesson plans (e.g. use of cut-outs). For instance: considering Julia's reaction after the project lessons and her answers in the interviews, it seemed that Julia had a good experience teaching the project lessons. Julia told me that students were engaging more than they normally did, and she considered that the cut-outs helped foster that engagement. Julia appreciated the use of visual aids during the project lessons, and she decided to plan and teach lessons about multiplication of fractions following a similar strategy. She did not want to revert back to her "other way to teach fractions", which did not use any visual aids.

My analysis of the change process, together with Julia's characteristics were about 50 pages long and with an intricate argumentation that did not really point to any clear conclusion or pattern. At this point, in discussions with my supervisors I decided to move to the next teacher – Alice. I had started with only one teacher because it seemed simpler, due to the quantity of nodes I had after coding all the interviews with all three teachers. Since my goal was to investigate change in practice, I wanted to move temporally with one teacher over the whole period of the project.

Also, since I had the experience with Julia from the RP, my initial hypothesis about changes in practice and the influences were related to her, and it was convenient to follow those initial tentative findings. Additionally, I knew more about Julia than I knew about Alice and David, and I thought this knowledge would help in the investigation for reasons behind her changes. Another reason to begin analysing Julia's data, was because I perceived that she was the teacher that changed the most and with the least resistance; this was an initial impression, probably because Julia was the most talkative teacher, giving the impression she had engaged more with the project. Also, because Alice was a trainee teacher,

she did not have such a regular practice to begin with, making it harder to identify changes in practice.

The second teacher that I decided to analyse was Alice. My hope was that Alice, being so different from Julia, would simplify the comparison phase (Bazeley, 2009) of the influences on change. I followed a similar process with the nodes on Alice's interviews. I created folders for each topic, which now were only 'teacher's change' and 'features that influenced the changes'. I did not have a third topic any more ('how the teacher perceived the new lessons'), due to the new structure developing after writing about Julia. The topics inside 'features that influenced the changes' were divided into four groups depending on what I perceived as the source of influence: teacher's practice, personal context, reflection and actions of the teacher, and other influences. These four groups were used to organize how I present the influences for Julia (Section 6.3) and for Alice (Section 7.3).

Again, I printed the spreadsheets with the nodes in "teacher's change" topic and in "features that influenced the changes". Reading and re-reading the nodes, I developed categories and try to build diagrams to explain the relationships between them. Finally, I wrote a similar chapter for Alice, that was even longer, around 80 pages. This may be because Alice was a new teacher and less consistent than Julia, or because I was now, after writing about Julia, able to consider more aspects when analysing Alice's data in depth, or maybe both. For Alice, I observed fewer changes in practice and more resistance, but I found more influences that could have an impact on her teaching, and consequently, these influences could be possibly affecting her changes.

The idea was to compare the two teachers, but that was not an easy task, as I was not able to filter the influences on change by any criteria. I finally decided to pinpoint the many influences on each one and classify their origins, but I had two major problems with that. One was that there were too many important influences for each of the teachers: maybe they were not that important after all. Secondly, the classifications

I had tried (following previous suggestions from the literature or combining more than one suggestion and developing new classifications) sometimes had too many overlaps and sometimes did not cover all the influences.

Only when I decided to read the chapters thinking about possible explanations for the change and the characteristics influencing it at the same time, was I able to find *common features* acting for both Julia and Alice. Considering they had a similar experience with the project and that they both ended using the project lessons plans, I was able to elicit the features that were fundamental to the process of change in practice for both of them. Apparently, I needed to understand what the change was before trying to capture what fostered or hindered the process. Looking back it seemed a simple step, but it was not, and to reach the components presented in Chapter 8, I had to revisit this process many times – going back to Julia's and Alice's chapters, re-writing the explanations for the changes and refining the meaning of each element influencing the process.

I had many rounds of refinement of the components influencing change. This was the "relate" phase (Bazeley, 2009). At the same time, the components elicited, which included both teachers' characteristics and features of the project, as part of the explanations for why Julia and Alice managed to change their practice while teaching the project lessons plans (turn to Sections 6.4 and 7.4 for examples).

In Chapter 8, these components were organised into three groups according to which phase of the change process they were related to. The groups are related to teachers' professional characteristics; to a positive experimentation; and to features of the professional development initiative. Since the RP, when I suggested the Zone Model (2.4.2), I was considering that the process of change can be represented in a model, and as Bazeley (2009) suggested,

> the process of creating a flow chart or model will stimulate your thinking at any stage in the research process, as you determine how the various elements (or themes) that you are investigating fit together (Bazeley, 2009, p.18)

Although the attempt to represent the components influencing change in a diagram helped me to consider possible relationships between them, as Bazeley (2009) suggested, I could not develop a diagram to illustrate all the mechanisms involving the components I had identified. Instead, in Chapter 8, I link the components of the change process to previous results in the relevant literature, and explore the change process for each teacher.

Finally, I tested the components using David's data. The interviews with David were already coded, but I had not isolated the changes and influences on him at that point. I went back to the nodes in his interviews and to other parts of the data from David, and reconsidered the components elicited from Julia and Alice, ending up adding new components, "consistency" and "agency", which also came from discussing initial versions of Chapter 8 with my supervisors. In general, adding David's data was a way to strengthen the change process and a revised the components in Section 8.2.4.

As mentioned before, the data collection lasted for the whole academic year, with diverse sources of data being gathered (Chapter 4). With this approach I developed a substantial dataset, and I had to chose how to begin the data analysis. I decided for the interviews, since I had had more interactions with the lesson observations during the process of digitalising and organizing them after every day I went to school. The interviews were also interesting due to the diversity of topics covered. Teachers and I would talk about lessons, about the PDI, about the school, etc. Additionally, having the three interviews spread throughout the academic year provided a more longitudinal portrait of the participants.

Coding the data from such a rich and diverse source of information enabled the analysis to start without pre-established nodes and would

allow the emergence of new influences that might not be noticed otherwise. The influences would latter be checked using the data from lesson observations, meetings and informal talks. In any case, still following a bottom-up coding approach.

The fact that I developed 645 nodes is not surprising since I was considering all the data and any possible influence on teacher change. Starting with the data is exactly what grounded means, and the refining phases I described in the previous sections led to a new conceptual model (Chapter 8). I was able to identify new influences and to uncover others that are confirmatory of previous results in studies about influences on teachers change (Chapters 8 and 9).

5.3.2. Final remarks about the analysis process

The analysis of my data started the first day I visited Purple Valley, i.e. the first day of data collection, and it could go on for much longer. I have the impression that I did not use all my data, but the writing of my analysis and conclusion suggested I had reached saturation point, since the last episodes were fitting the change process I had developed and were not adding new information to it. For my study, the long period I spent visiting Purple Valley, with an almost ethnographic style of data collection, was an important step to develop rapport with participants and familiarity with their context.

After I had coded all of the interviews, I felt that I was close to the end of the analysis, but I could not have been more wrong. The writing process was actually the phase when the findings were emerging. Being able to discuss my ideas with my supervisors and with some colleagues in the University, and at conferences was extremely important in developing my findings. These discussions showed me that my initial attempts at writing the findings could be built on, and that I could develop a deeper layer delving into how the influences were acting on my participant teachers.

Lastly, I also want to comment on the emotions during the periods of intense analysis. The acceptance of the fact that finishing the coding of the interviews was not the end of the analysis was not an easy process. This coding took a long time and by the end of it I felt I was somehow near a conclusion, but I could not actually state it. Once I understood that I still had work to do after the coding, I began to search for ways to explain the change process of my participants (as I explained in Section 5.3.1.c) based on my analysis. The next barrier was the questions that arose (sometimes from myself, sometimes from my supervisors) that could not be answered by these initial explanations I developed. At first, these challenging questions worked as fuel to move forward and to revisit the analysis of my data. After a few of them came the fear that this process might never end. Fortunately, I had enough support to keep my resilience. Finally, a clear version of a possible conclusion came while I was preparing slides for a session in a conference (BCME 9 – British Conference of Mathematics Education). It had been some time since I had summarised the initial phases of my PhD, the exercise of putting it all together in a reasonable number of slides allowed me a panoramic view of my study. When I got to the slides with my conclusions, the categories I had elicited from the coding finally fitted together in three areas, and I was ecstatic. It was the first time I felt I had reached a conclusion. Naturally, I refined the categories and the three areas many times after that, even before the conference where I presented those slides. The conclusion I present in this thesis is also a refinement of what I presented at the conference, a result of discussions with my supervisors and with myself. But since that day when I prepared the slides for BCME 9, I knew I had a conclusion. Thus, the process of analysis leading to a conclusion was far from linear, and even though there was a feeling of wholeness in the process regarding data collection, analysis and conclusion, there was also a feeling of discovery and breakthrough in the end.

I believe this account of the analysis strengthened my conclusions, because it suggested that the categories came from careful consideration of the completeness of the data and not from selected quotes of scattered parts of one interview.

Chapter 6 Julia

In this chapter I focus on Julia. She had been in the project since the Reconnaissance Period (RP), and was the teacher who taught the lessons about fractions. The data collected during the RP was from Julia and her experience teaching these lessons (Section 2.3). Aspects of her teaching career are described in the previous chapter, in Section 5.1.1, when describing all three participants of the main project.

For the following sections I take an analytical stand regarding the data I collected over the 18 month period I spent with Julia. Initially, I comment about how we developed a close rapport over the project period. I present episodes of her lessons to illustrate changes in her teaching, both during her regular lessons and when she was teaching the project lessons.

Additionally, I investigate the features that enable Julia to engage with the project and constrained and encouraged her to change her practice. Using the influences identified, I provide short accounts of Julia's changes, developed to explain the processes Julia went through during the project.

6.1. My rapport with Julia

I began observing Julia's lessons in December 2014. My impression, formed in those initial lesson observations, and which Julia confirmed during our conversations, was that having someone else in the room was a familiar occurrence for her. Julia, being accustomed to this approach, helped me to quickly feel comfortable in her classroom.

The students, after just a couple of weeks, were (apparently) equally unaffected by my presence in the classroom. Julia told me that she had explained to them that I was observing her teaching, not them.

> I am quite open to... if people need to sort of come in, you know? In the past, because I've been a PGCE and a NQT[15] mentor, I'm kind of used to people coming in and watching me. And I don't particularly do anything different when people come in my room, so you know. What you saw of a lesson is what the lesson [is]. What the pupils would ordinarily have got, you know. Very often I didn't potentially even know that you were going to be in. And it was literally like people would just turn up. So it was nothing fake about it. It was very sort of real kind of experience you saw. (Interview RP, 6min 22s)

The assertion from Julia about the lesson observations, mentioning that students were not being disturbed by my presence and that her lessons were the regular lessons she would normally teach, are important for the validity of my data. This is another benefit achieved through the extended period of time I have spent in Purple Valley School.

During the RP I observed 10 lessons from Julia, and we had six meetings and one interview. Additionally, we had dozens of conversations about her lessons. My aim was to establish a relationship with Julia that allowed us to engage in conversations about any topic related to her lessons and to teaching mathematics. Towards the end of the RP I felt that we had already achieved that.

Considering the main project, I have more than three hours of formal recorded interviews with Julia, compared to only two hours each with the other teachers using similar interview schedules. I felt very comfortable talking to Julia during our three semi-structured individual interviews. Julia also appeared relaxed and happy to talk to me, and she always scheduled the interviews for periods when she would have more time than I had asked for. At the end of our last interview she said:

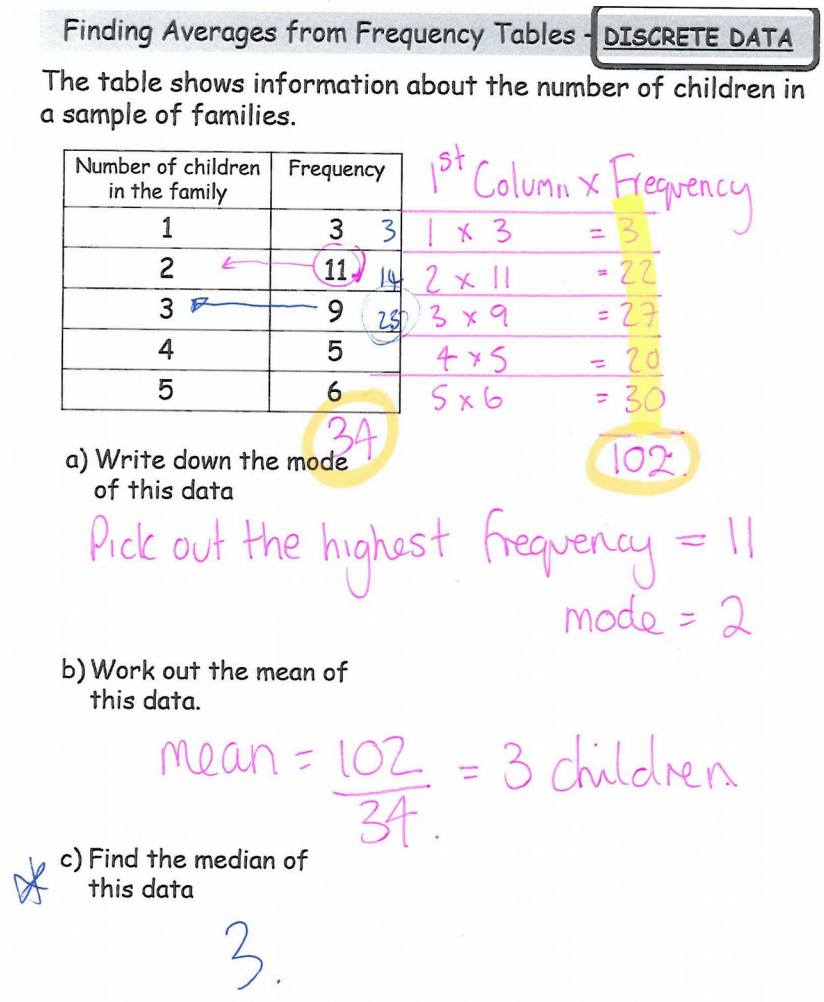
> Julia: Sorry for taking so long...
> Rita: No, no! It was great for me! Thank you.
> Julia: I really got a lot to say. Thank you very much. (Interview 3, 1h 52min 16s)

15 NQT stands for Newly-Qualified Teacher – It is a probationary year and every NQT is assigned an experienced teacher in the school they are working in to be their mentor. The experienced teacher is responsible for advising the trainee teacher over this period, after which the training will be complete and they will become a fully qualified teacher.

These last two comments suggest that she enjoyed our conversation and that she did not rush her answers, which was also my impression. Julia talked extensively after I had posed my questions, sometimes asking for extra clarifications and taking time to think about what she was going to say.

Coming from a different culture, I had concerns about what level of rapport it would be possible for me to establish with my participants. Having a common interest in teaching mathematics was certainly a facilitator, and books such as Hammersley and Atkinson (2007), Hammersley (1992) and Newby (2010) helped by providing many examples and suggestions of how to gain rapport and sustain relationships with participants.

In any case, rapport is something hard to measure, but considering how frequently Julia started conversations about her lessons after an observation, how she thanked me after each lesson I was in, and the fact that she never denied me access to her classroom, all suggest to me that we had a good relationship. By the middle of the academic year, Julia was so accustomed to my routine in her lessons that she would have spare copies of the worksheets for me and would keep the sheets she had used, so I could have them at the end of each lesson. Figure 6.1 is an example of a worksheet she used to show answers to students under the visualiser and that she kept to give to me after the lesson finished.



Finding Averages from Frequency Tables - DISCRETE DATA

The table shows information about the number of children in a sample of families.

Number of children in the family	Frequency
1	3
2	11
3	9
4	5
5	6

1st Column x Frequency

1 x 3 = 3
2 x 11 = 22
3 x 9 = 27
4 x 5 = 20
5 x 6 = 30
102

34

a) Write down the mode of this data

Pick out the highest frequency = 11
mode = 2

b) Work out the mean of this data.

mean = 102/34 = 3 children

c) Find the median of this data

3.

Figure 6.1: Worksheet that Julia wrote on under the visualiser and kept so I could have it after the lesson.

I am certain that the rapport Julia and I built was a relevant factor to my research. The approach I have chosen to data collection, to be immersed in their daily lessons, could have been strained, possibly causing dropping out, if our relationship had not been enjoyable. My study was obviously influenced by it, and I am confident to say that I have made the most of it, using our proximity as a way to enhance the validity of the data Julia generated.

Having said that, my relationship with Julia was close, but strictly professional. Reflecting on it, I do not consider that at any point I lost

focus on the research purpose, and our talks were mainly about the lessons. I never forgot to record our interactions, and new sources of data were still emerging during the last few weeks of the data collection period, such as when Julia planned and taught the lessons about fraction multiplication. For the last two years of my PhD study I stopped attending the school and dedicated myself exclusively to analysis and writing this thesis. This distance helped me to focus on Julia as a participant, avoiding any friendship feelings from clouding my analysis.

6.2. Julia's changes

I begin by claiming that Julia changed the way in which she taught fractions, particularly during the 18 project lessons in her Year 8 set 4 (see Table 5.2). In total, 13 of those lessons were designed by Barichello and the other five by Julia herself. Whether she will change the way she teaches fractions in all her future lessons of this topic is impossible to predict, but I argue in this chapter that Julia changed her practice, and she tried new approaches to teach fractions that were not in her repertoire.

This section is divided into three main areas depending on how the change was observed: 1) Changes when Julia was teaching the project lessons; 2) Julia's claims about her own changes and 3) Changes in her regular lessons – that might have been influenced by the project.

6.2.1. Changes when Julia was teaching the project lessons

The project lessons were really different from the way Julia normally taught, as she herself mentioned in many situations. This section focuses on aspects that I observed when Julia was teaching these lessons. All these aspects represent changes in her teaching practice, because she followed the lesson plan, which was important as an authentic exploration of a new way of teaching for her, as I discuss in

further in Section 8.1.1. The last two changes also showed that Julia was aware of the new approach we had been discussing in the meetings, in terms of engaging and trying the features the project lessons were suggesting.

a) Getting a solution without a procedure

By following the lesson plans, Julia did not give a list of steps that students needed to follow in order to get to the answer of the items in the tasks. In many of her regular lessons, Julia had a list of steps (or fixed procedures) that students could follow to solve all the items. For instance, the lessons used as examples in Section 5.1.1: triple X lessons suggested that students could follow a procedure to get to the answer, using the grid (Table 5.3). For practice lessons, Julia was even clearer about the procedure to be followed, and said, "You physically just count the number of squares on the edge of the shape," to explain how they should solve the first four items. Then she said, "Walking around the outside of the shape, you've got to add every side of the shape," to explain the next set of questions in that lesson (Table 5.4).

Other than it being common to have fixed procedures to follow for any task, for the topic of fraction sums Julia would have the procedure associated with the mnemonics of the arithmetic operations students needed to follow to get to the answer. For the addition of two fractions, Julia said to students, "cross and smile", which was a mnemonic to remember to multiply the numbers across, and add them as the numerator of the answer and multiply the two bottom numbers obtaining the denominator of the answer. See representation in Figure 6.2 below:

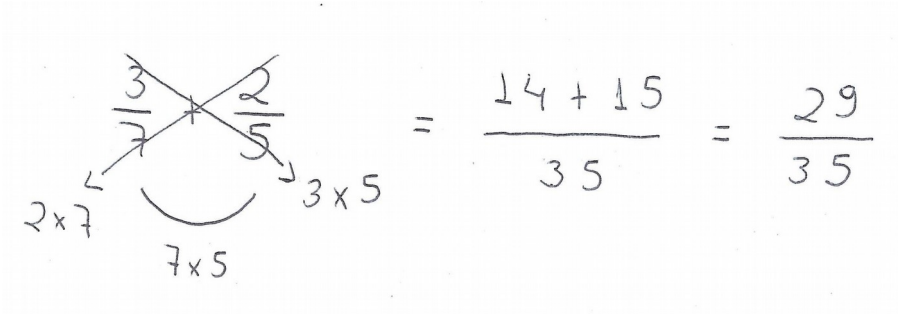


Figure 6.2: Reproduction of Julia's example of the method "cross and smile" to add two fractions.

Not having fixed procedures to solve any item in the project lessons was a change in Julia's practices. During the project lessons it was evident that not having a list of procedures to follow caused other changes during Julia's lessons. There was now the possibility that items in the project lessons could be solved in more than one way. Julia was apparently comfortable with this novelty, and when asking for feedback during the project lessons, she would ask for other possible answers and/ or different ways to solve the same item. For instance, the first task of the second set of lessons asked students to create sums that added up to one with at least two fractions of the list $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$ and $\frac{1}{16}$, Julia showed many different solutions from students on the board when she asked for feedback on this item.

b) Progression of a topic

It was common to observe Julia bringing the class together to introduce the next variation in the topic they were working on. As triple X lessons example illustrates (Table 5.3), Julia got feedback from the first task and then solved three examples on the board. These examples had the new feature students needed to solve the items in Task 2. Only after solving the examples did she hand out the worksheet with the next task.

Julia abandoned this approach when teaching the project lessons. She was letting students solve the tasks without stopping them whenever

a new feature was introduced. For instance, in one of the project lessons the students had seven items with fraction addition and the eighth item was a subtraction. Julia did not offer any further explanation before students got to that item, and afterwards she was impressed with how they were able to "seamlessly transition to subtraction".

Julia knew that the task had an item with subtraction and she still followed the plan, not interrupting students to give any further explanation, changing what she would usually do in a similar situation. She trusted me when I suggested that it would be interesting to see whether students could solve that item. This was a successful experience for Julia, and she was impressed with students' progress and engagement during other project lessons as well.

c) Julia was doing less talking

The teacher-led moments were reduced during the project lessons. Julia was giving instructions only at the beginning of the lesson and the information was mostly related to organisational issues, such as where students should write their answers, and what materials they were using for that lesson. Julia would still comment on the topic, briefly saying how it related to previous lessons and also go through the silent animations that were suggested on the lesson plan. However, there was no explanation of the topic in a whole classroom discussion format and feedback of items in a task was rarely done as a teacher-led moment, and then only if it was suggested in the "comments for the teacher" sheet.

Although the number of teacher-led moments was reduced, Julia kept her habit of walking around the classroom helping students. During these moments Julia was talking, but the conversation was usually started by a student's question. The teacher's role was apparently shifting during those lessons and Julia seemed to be coping well with the new situation.

d) Asking questions to interact with students

As mentioned above, Julia was still interacting a lot with students during the project lessons, but the nature of her interactions was different from those in her regular lessons. Julia needed to understand what each student was doing before providing him/her with useful feedback for progressing in the task. Julia told me that she was not simply giving them the answer, which I could confirm during some lesson observations, but was asking questions that could help students identify a mistake, or that could hint what the next step should be. For instance, it was common to hear Julia repeating the question that was written in the worksheet, or making comments, such as, "Get to know the pieces first"; "What does this piece represent?"; "How many pieces do you need?".

Considering that Julia did not plan those lessons, and that they did not require a lot of teacher-led situations, the moments when Julia was interacting with students were an important opportunity for her to understand students' thinking and to enhance her familiarity with the lesson style and structure. Overall, she seemed comfortable with her different role in these lessons, providing only enough information for students to progress on their own, rather than providing a fixed list of procedures to be followed.

These two changes reported in 6.2.1.c and 6.2.1.d are related to the interactions (or conversations) between Julia and her students. Considering my notes and audio recordings from Julia's regular lessons and from the project lessons in her Year 8 set 4, students were talking more and Julia was listening more during the project lessons. Also, the project lessons had less moments of whole class teaching than her regular lessons. This aspect of students talking was described as a difference between Julia's lessons in high and low-set groups in Section 5.1.1. During the project lessons in Year 8 set 4, Julia's high-set and low-set lessons were not very different any more.

6.2.2. Julia's claims about her own changes

During the interviews, Julia mentioned changes that happened to her practice due to her participation in the project. Some were described with examples from her daily practice, and in this section I comment on them and try to identify underlying issues.

a) Students have to "think for themselves"

Since our first interview in 2014/15 Julia identified influences that the project had on her own teaching. She commented on changes associated with the project and the new curriculum[16] (which was not the focus of the project), and she perceived her way of teaching as not appropriate any more:

> I think what it [the project] has made me do in my other lessons, and this is also with the changes in the curriculum, […] there's been less teacher talk and a bit more 'just have a go, just play around, see if you can find a connection'; 'what do you know?'; 'what can you write down?'; 'where could you start?' I've tried to go away from just standing at the front, so I suppose I've tried to make them a little bit more, not open-ended tasks, but they're a bit more, they're [the students] really having to think for themselves as opposed to just going 'Right, this is how you do it, just have a go'. Mainly because the curriculum is changing as well. And that is the big thing for me, the fact that the curriculum, how I currently teach my Year 11s is not really going to be suitable for say, my top set Year 10 that I've currently got, going into Year 11 next year. (Interview 2, 14min 34s)

Julia suggested that the lessons should now change so students were not only mimicking what the teacher had shown on the board. Julia perceived that students have to "think for themselves" (see quote above).

This quotation suggests that Julia changed her practice in regular lessons in terms of the way she presented and developed new topics during the lessons: asking students to have a go with a task, and letting

16 The new curriculum Julia is talking about is the national curriculum introduced in September 2014.

students look for connections and "think for themselves". From her last sentence in the quote above, it seems that Julia thought the way she was teaching her high-set groups should change to more independent work from students.

b) Thinking about the reasons to use a task

During the whole project, Julia and I would engage in conversations about her lessons in many different situations. Julia was always willing to talk about what she had planned for future lessons, or to comment on what had just happened in the previous one. In order to better understand her way of thinking, I often asked for clarification about her planning and her teaching. I noticed some of the impact of that questioning during our interviews. The extract below is Julia's answer when I asked her, "Can you think about anything you have learned with this experience [teaching the project lessons] that will help you to teach fractions in any other kind of way?"

> […] it also made me think when I've been planning some other things, **it makes me question a lot more why am I doing certain things**. And sometimes, sometimes you've just got to do it a certain way, but it definitely **made me think "why" am I doing things**. Why am I doing it this way? If I teach fractions, particularly starting in Year 7 and moving up, I don't think I will revert back too tight (*sic*) necessarily, I think that would have to be something that would be very much like in-joke, Year 11, you've got two months, just learn this method. (Interview 3, 38min 14s, emphasis added)

This excerpt suggests that Julia was reflecting on her planning and her choices for her lessons and rethinking. Which I conjecture was because of her involvement with the project. Apparently, she also compared the new way of teaching fractions (the project lessons) and her old way (focused on procedures). After that talk in our interview, I asked Julia:

> Rita: And can you see any reason why teaching these lessons would lead you to think more about why you are doing different things?
> Julia: Mainly because, both yourself and Leo [the other PhD researcher] are quite reflective, because you've read a lot of research in that and it always kind of like "why?". But why? But why? And it is kind of like, you pick up on that..."why", "but what would happen", "but why". (Interview 3, 38min 24s)

I was imagining that teaching the project lessons would have encouraged her to think more, but her answer was only marginally related to the lessons themselves. Julia associated this change mainly with our relationship and the position I adopted: asking questions to better understand what she was doing. The influence of an external person on teachers' reflections about their practice has been consistently reported as a beneficial aid for teacher development (Clarke, 1997; Nisbet et al., 2003; Watson, 2014).

Julia told me that she spent a lot of time planning her lessons. Her planning was organized through the slides she wanted to show, and she said that she was constantly creating new tasks, because "what works with one class wouldn't necessarily work with another class." (Interview 3, 1h 06min 10s) and "a lot of the thinking into the resources is now different, because the curriculum is changing and so it's gone more functional" (Interview 3, 1h 06min 29s). Even working every night at home, Julia "still sometimes feel[s] that [she doesn't] have enough time to make it as good as [she] would like", when it comes to creating new tasks and resources for her lessons.

This change in planning her lessons came from Julia's account. Apparently, reflection and comparison were important when Julia pondered how different she was now. Even if that were something she would already be doing, reflection and comparison were influenced by her engagement with the project. The questioning about her lessons, coming from someone external to the school, but who was observing her lessons, might have provided a change of focus in Julia's thinking. The teacher trusted the researcher and she knew that I was familiar with her lessons.

These elements might have increased the reliance Julia had on my comments, as I knew more about that group and her lessons than anyone else in the school. These elements of reflection, comparison, trust and familiarity are discussed further in Chapter 8, and this episode suggests how they might be related.

c) Good experience with the use of diagrams

Julia also began to perceive that a diagrammatic representation can be powerful and beneficial for students learning fractions. During the final interview I asked her, "Can you think about anything you have learned with this experience that will help you to teach fractions in any other kind of way?" and she answered:

> I definitely like the fact that they've been able to visualize fractions a lot better. I remember having a starter question, "Which is bigger, a third or a quarter?" and I think the fact that they've been able to draw it, they can see that a third is bigger than a quarter, so I think that representation is something that I will carry on. I quite like it. I actually did a starter question with my Year 11 […] And one of the methods that we did was actually showing them [the diagrams] as an alternative method. (Interview 3, 37min 01s)

When teaching fractions operations before the project, Julia would not use diagrams as the project lessons suggested. She was aware that fractions is a topic that students in secondary school are revisiting, as they have previously experienced this topic in primary school. Nevertheless, Julia would investigate whether a group could add fractions and if only a few of the students remembered it, she taught fraction operations (addition, subtraction, multiplication and division), presenting numerical procedures and the mnemonics to remember them (as the example in Figure 6.2). Julia claimed that she had changed, and now she will incorporate diagrams in her lessons about fraction operations.

After trying the project lessons, Julia could compare her own experience of teaching them, with her perceptions about her own regular

lessons. The project provided enough support, motivation, challenge, and time to encourage Julia to go through with the experimentation. It seemed that influences from the project were also pushing Julia to her Innovation Zone, I discuss these influences in more detail in Section 6.3 and at Chapter 8.

6.2.3. Changes in her regular lessons

The lesson observations allowed me more insights into Julia's changes in practice, and this is the topic of this section. Julia claimed that she had become more reflective about her lesson plans. She told me that she now thought more about the reasons why she was doing this or that task, as discussed in the previous section. This statement is quite general and hard to observe. Nevertheless, the two moments I present below were situations when Julia planned lessons inspired by the project. The first example is a lesson with an animation to show how to find the equation of a line and the second example is a set of lessons to teach fraction multiplication with a focus on visual representations, similarly to the approach of the project lessons.

a) Slide animation to show gradient and slope

This use of a slide animation happened when Julia was teaching the equation of a line graph. I had already observed her sequence of three lessons about this topic for her Year 9 set 5 in November, 2015. In the first lesson Julia had tasks in which the lines were parallel to one of the axes, the second lesson was about how to write an equation of a line if you were given the gradient and the y-intercept (without associating it to a graph yet), and finally, how to identify the gradient and the y-intercept in a graph. During the third and final lesson on the topic, she handed out worksheets with a schematic picture about how to find the y-intercept, the rise, the run, and how to calculate the gradient and how to

write the equation (see figure below). The three lessons followed the triple X style, presented earlier in Section 5.1.1.

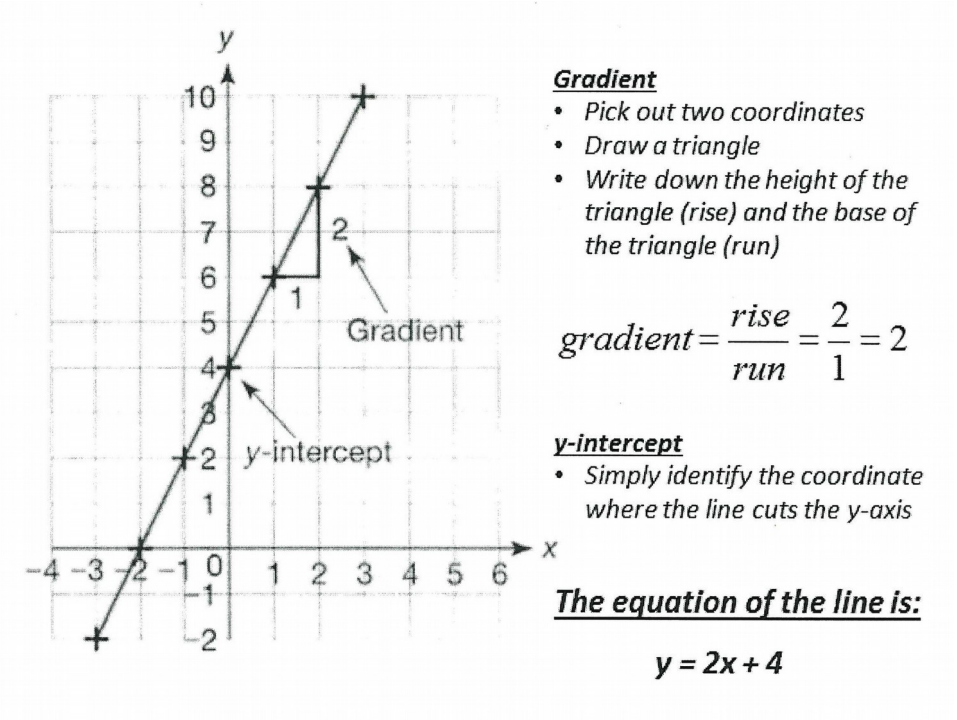


Figure 6.3: Julia's schematic representation of how to find the rise, the run and the y-intercept and how to calculate the gradient given a line graph – my notes Year 9 set 5, 26th Nov, 2015.

Some time after that, in April, 2016, with her Year 8 set 4, Julia taught similar first and second lessons as she had done previously with her Year 9. After the second lesson, about writing an equation knowing the gradient and the y-intercept, we talked about how students could find the run and the rise just by looking at a line in the graph. That same evening Julia sent me an email with an animated slide presentation. Figure 6.4 below shows a representation of some of the slides in the animation, the blue lines being the animated part of the slides.

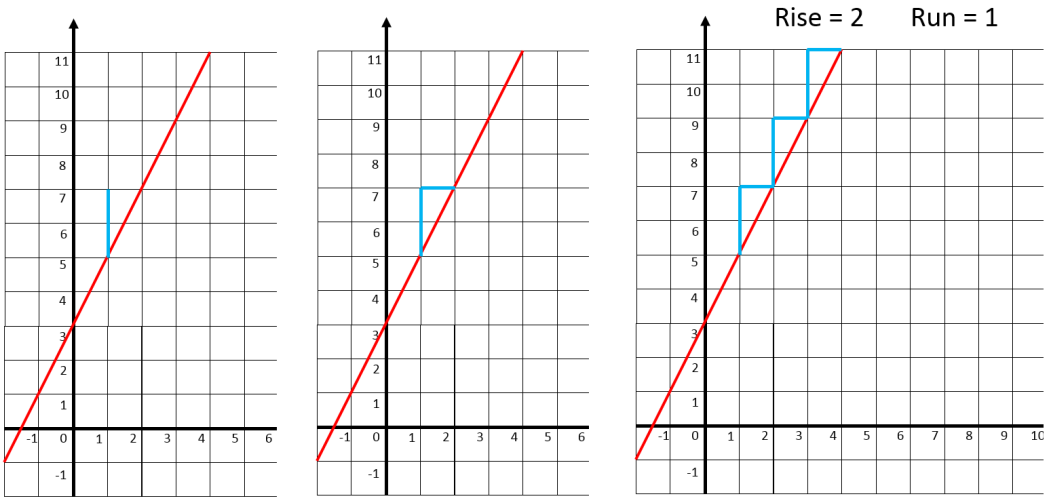


Figure 6.4: Slide animation that Julia did for her lesson about line graph – Year 8, set 4, 12th May, 2016.

I replied by suggesting that she could include an initial activity in which students would become familiar with the relationship between the rise and the run (without even knowing these names), by trying to find a connection between the coordinates of the points on the line. I sent Julia a file with questions about linear graphs purposefully selected to gradually increase in difficulty, followed by the question "Can you spot the relationship between x and y of the points on the red line above?". I also tried to explain the intention of the task in my email to her. My message was:

> I am just thinking that the equations are too disconnected from the coordinates of the points in the straight line. Thinking about it a little harder now, I would say that you can do something before your videos.
> [I attached a file with a graph line of y = x + 1]
> I think they will spot the pattern and you can translate it into the equation of the line (have faith in them!). You could do the same for y = 2x and for y = x – 2.
> Then after these examples, you could show your slide 3 as a case, which is not easy to spot the pattern, so we need a method to find out the equation. Your first example could come after that. That way the students can find out the equation, just by looking at the pattern in the coordinates, and then you show the video, with the rise and

> run to confirm that both methods give you the same equation. (Email conversation, May 2016)

I was suggesting that the equation could be found in two different ways, initially with the relationship between x and y, and then with the calculation of the gradient. My interpretation of her animation was that it was only "showing how" to find the run and the rise, in the same way as her sheet with instructions for Year 9 (Figure 6.3). I was not sure that the animation would add any extra information for students.

The next day Julia taught this lesson. She used my suggestions as the first task of the lesson and did not show an example first. As I expected, students were able to give more than one right answer. These two characteristics were not present in the tasks Julia usually had in her lessons (see tasks in Table 5.3). The following task had the animation illustrated above (Figure 6.4) to show the rise and the run. Julia asked for students' suggestions about how to obtain the rise and the run from a line in a graph, but again, this type of discussion was not common in Julia's lessons.

After the lesson, Julia told me that she perceived that students had problems with identifying coordinates on the line. The next lesson, Julia added slides to the animation showing the coordinates before drawing run and rise. This last lesson was perceived by Julia as more successful than the previous one and the lesson without the animation. She said she was happy that students were able to solve all the proposed tasks. Julia was, at the same time, both satisfied and puzzled about how students reacted after the lessons. How much they understood after watching the animation eluded her, but she thought that they were able to solve more tasks than she was expecting. She was, after all, satisfied that students could find the rise, find the run, calculate the gradient and write the equation.

As we talked about these lessons, I can say that Julia perceived the slide animation (rather than only drawings and her explanations) in the lessons about fractions to be helping students to solve fraction sums

without following a set of procedures, and she considered it better than her other way of teaching. Although Julia developed this slide animation to lead students to deduce the equations without following a set of procedures, from my point of view we did not achieve the same results with this topic.

Despite our talks and emails, the time the group of teachers spent on developing the project lessons was much greater. The meetings and the many lessons allowed us time to share our ideas, impressions and doubts. These activities allowed time for teachers to understand the path the project lessons were suggesting and what students were getting from each task, making it possible for Julia to follow the project lessons plans as they were, without any alteration, not even unintentionally.

Moreover, my suggestion for Julia did not consider her regular practices: the teacher-led moment I was suggesting in my email to her was not aligned with how she normally explained topics in her lessons. There was no congruence between the suggestion and the teacher's own way of explaining a topic. Maybe, with more time to discuss the strategy, Julia would be willing (and able to) to follow my idea, but one email message was not enough to make her aware of and/or comfortable with the differences in the approaches.

Nevertheless, Julia was moving forward with this experimentation. She had the initiative to plan the lessons with the slide animation and she decided to teach a second lesson with a new version of it. Julia might not have been as successful as I expected, but I believe there is sufficient evidence here to suggest changes in the way she was teaching this topic was motivated by her participation in the project.

Our discussions of the project lessons during the meetings were not enough for Julia to transfer all of the attributes of the representations (and videos) used during the project lessons to a different topic. But it was enough for Julia to notice that visual representations could substitute verbal explanations and lead students to make connections and

extrapolate relationships that have not being explicitly shown to them. Her experimentation with this different topic suggested that she was acting in her Innovation Zone. She was convinced enough to think it was worth trying.

b) Multiplying fractions

In most of the lessons I observed, Julia introduced every new feature of a topic as exemplified in triple X lessons (Table 5.3), calling students' attention to any variation that was being presented. Julia offered few opportunities for students to investigate by themselves any further aspect of a topic that she had not exemplified previously.

However, Julia appreciated opportunities when students could be more independent from her explanations. Since the beginning of the project, Julia seemed to have a personal concern with the issue of students working more independently. This quote from one of our first meetings (2014/15) represents many other situations when she expressed her desire to get away from the practice of "showing them how to do it":

> The idea was potentially get them to the point where they could add fractions and start to think about equivalent fractions without you directly telling them about that. And then eventually adding questions and realizing that if they turn into an equivalent fraction they would be able to add them. […] If you want to get away from the whole cross multiply method[17] than I think equivalent fractions are obviously quite important before you start adding, aren't they? Whereas if you just want to go back to the basic "oh yeah cross and multiply and smile" then you don't need to think about them. [equivalent fractions]. (Meeting 3, RP, 23min 52s)

Julia claimed that the project lessons had more mathematical connections within the tasks. More importantly, she noticed that these

17 "Cross multiply method" is a reference for the numerical steps that one should take if they want to add two given fractions. The exact mnemonic is "cross and smile". You have to multiply the numbers across and then multiply the two bottom numbers (see Figure 6.2).

connections were enough to encourage students 'to have a go' at the items. She perceived that the project lessons demanded fewer teacher-led moments allowing students to solve the items before 'being shown how to do it'.

Throughout the project Julia was pleased with students' progression with the project lessons. Her attempt to plan the lesson with a slide animation for the equation of a line, presented in the previous section, suggested that Julia was giving a lot of credit to the animation as a way to make students more independent. Another attempt that Julia had at planning lessons with a similar style, were the lessons about fraction multiplication.

Julia talked about her motivation to plan these lessons:

> It would be a shame if we were to do this again with the current Year 6, to do adding and subtracting in such a different way and then to go, "Right, now to multiply fractions go across the top, go across the bottom.[18]" It doesn't sit right now. It just seems like it would be going backwards, if you know what I mean? I wanted it as a complete unit. (Interview 3, 1h 02min 12s)

In order to plan these lessons about fraction multiplication, we had two meetings to talk about them (MJ in Table 5.2) without David and Alice. Together we managed to plan tasks that followed closely the format of the original project lessons. These extra lessons confirm the deep commitment that Julia had to the project, dedicating more of her time to discussing and planning extra lessons; and with the students, keeping the coherency in the way she taught the four fraction operations.

We began to talk about these lessons informally. Initially, I suggested some possible approaches to the topic and Julia sent her first lesson plan via email before our scheduled meeting. My impression after reading her email, was that students would have problems of progression in the lesson she had planned, as all the items were very similar, with a

18 This is a mnemonic to the arithmetic procedure to multiply two fractions. "Go across the top" refers to multiply the numerators and "go across the bottom" refers to multiply the denominators.

square and a fraction of a fraction underneath it (see Figure 6.5 below). Moreover, she was planning to show an example first, as she wrote in her email:

> I envisage that much of the explanation will be done under the visualizer. I have created a slide which explains how to complete a multiplication, but I think it can be done more effectively using the visualiser. (Email from Julia, 28th June, 2016)

The lesson was not about practising the procedure "multiply across the top, multiply across the bottom", but the steps that students had to follow could be described as a general procedure that would work for all the items on all the tasks of the lesson plan.

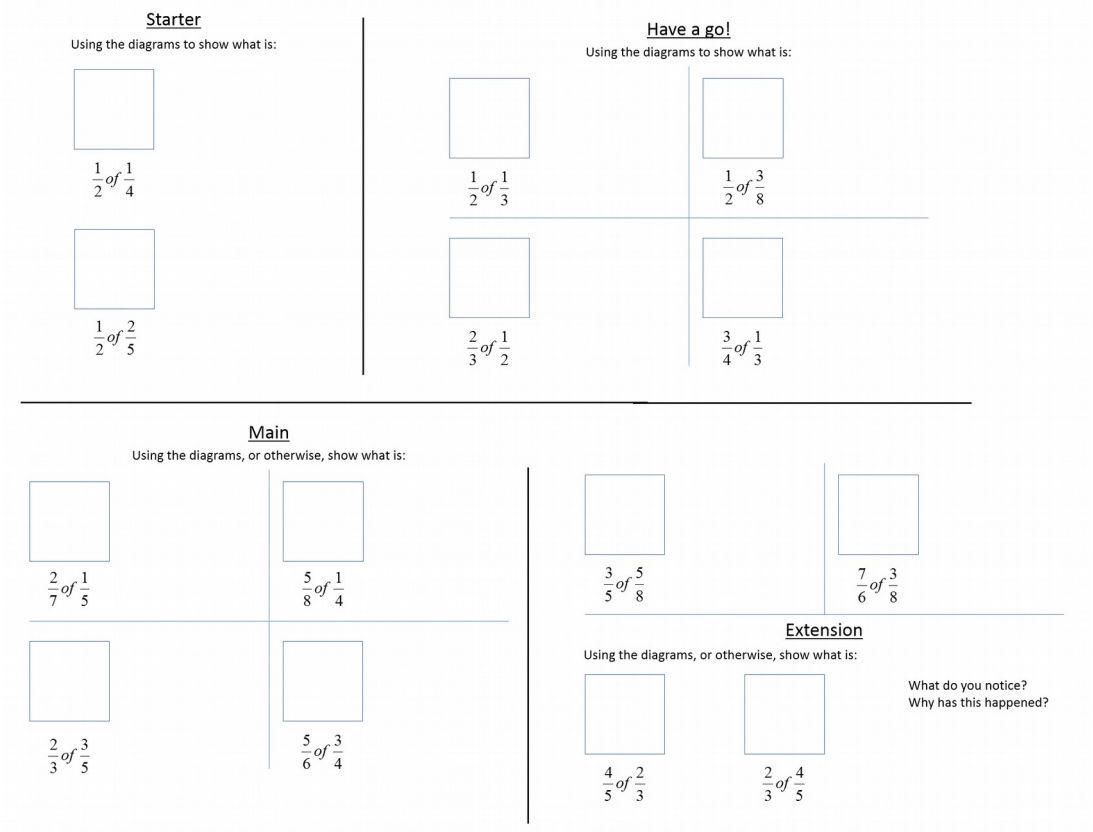


Figure 6.5: Initial draft of Julia's lesson plan to teach fractions multiplication.

After the meetings and some exchange of emails, the final lesson plan had items to encourage students to work with the meaning of the preposition "of" in mathematics in the *starter* (see Figure 6.6 below). The

following two items had one fraction shaded and asked for a fraction of the shaded part, suggesting the next sequence into the multiplication. The last two items were the same as the ones Julia had originally planned.

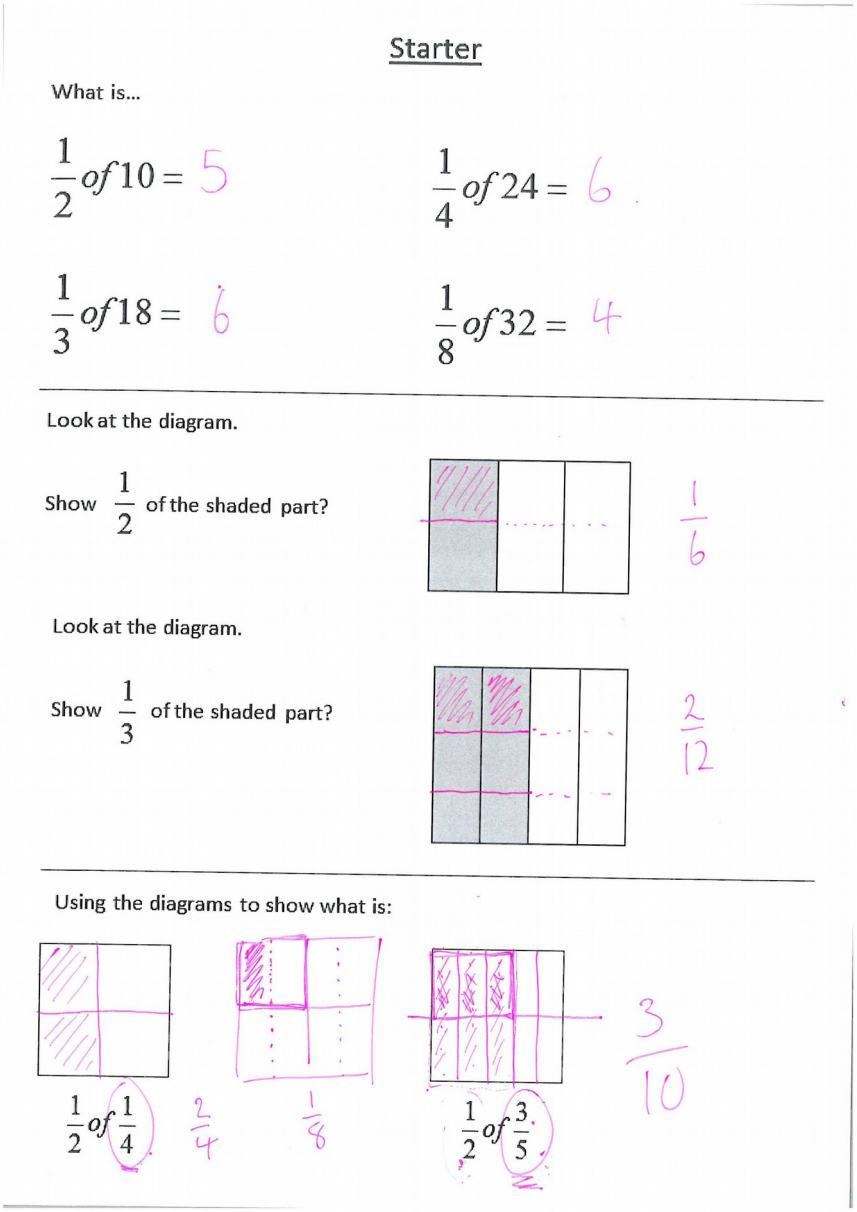


Figure 6.6: Starter from the first lesson about fraction multiplication - this is the worksheet Julia used to feedback under the visualiser. The pink ink is her writing.

In the main task, the sections "have a go" and "main" were also practically the same as Julia's original plans (see Figure 6.5) and the extension had an extra item which was a word problem.

During the feedback for the last item in the *starter*, Julia talked about a rule that students should follow to solve the task:

> What did each of them [the students who answered the 3 last items on the *starter*] do when they started drawing the diagram? They've all done something which is the same. What have they all done? [Julia asking the classroom] Right, so which fraction have they all, all three of those started with? The one on the right. The second fraction. […] **This is absolutely key, this is absolutely crucial in what we are going to do today. You start off by representing the second fraction first**. (Julia's feedback on the last item of the *starter*, 5th July, 2016)

Julia chose to give a rule for students about how to begin to solve the items. This was not suggested, or even mentioned during our conversations about planning the lessons. Julia behaved very differently from the project lessons with addition and subtraction of fractions, when she did not suggest a fixed procedure to begin to solve any item. For the project lessons, it would also be possible to present something that could serve as a first step to students, such as representing the fraction with the smaller denominator first, but Julia did not give any instruction of that kind when teaching them.

We talked about it after the lesson, and Julia told me that she thought students needed that tip because they were not able to see what they had to do. She said, "I just felt that if I gave the sheet [with the main task] now, it would be chaos." When I asked her why she felt that way, she said:

> I think it was because they weren't fully listening and concentrating. Hence, why I kind of made the point: "Which one do you do first? How are we going to do..." and then just making sure like... like even Charlie, I don't think was fully listening today, because he normally picks up things very quickly I think. (Conversation after the first lesson about multiplication of fractions, 05th July, 2016)

Julia talked about other students' behaviour in the classroom as not paying attention and engaging properly, not mentioning any problem that the tasks could have. Julia felt less confident with this lesson and her reasons were only focused on students' behaviour, and how she would probably lose control.

One way to consider this episode is that Julia had to balance the novelties of the lesson (e.g. the use of diagrams to talk about fraction multiplication) with some of her common practices (e.g. giving students the first step). On one hand, Julia kept control and managed to help students to progress in the lesson, but on the other, she had some experience in teaching using strategies that she had not used before. Julia was acting in her Innovation Zone. Apparently, to be able to move to the Innovation Zone, it was necessary to create a balance between the new ideas and Julia's consistent practices.

In my observation of this lesson I did not notice the classroom being louder or having more disruptions than usual, which, in Julia's lessons, would be very few.

A week later she taught the second lesson about fraction multiplication. This time students were not on their best behaviour, as they normally were in Julia's lessons, but were having off-topic conversations and not fully engaging with the tasks. During her teacher-led moment, getting feedback for the *starter*, she did not emphasize a list of steps to solve the items, she just mentioned once that the first thing to do was to draw the second fraction. After that, Julia established a sanction for the whole class; they had 30 minutes to finish the six questions and there would be consequences if they did not accomplish that.

Throughout the 30 minutes, Julia walked around helping students, and at the end of the lesson all the students had reached the end of the worksheet. Julia had to add an extension under the visualiser and pointed

out to them that they just had to have the right attitude to be able to complete the tasks.

Our conversation after the lesson suggested that Julia had to make strategic choices to ensure the progression of the lesson. Overall, she was disappointed by the students' attitudes toward learning:

> [...] it is just frustrating, because I know what they can do! That is why I don't get annoyed necessarily with them, I get annoyed because I know that they can do it. And they don't care that they can do it. I don't even know if that is the right word. They don't want to do it. But they can do it. (Conversation after the second lesson about multiplication of fractions, 12th July, 2016)

Julia normally did not have problems with student behaviour, but this is an example of how she handled the situation and engaged the whole class in working with the proposed tasks. Apparently, she chose to minimise the investigation aspect of the task (giving the first step), in order to facilitate the task to students, so they did not have any excuses for not being able to solve the questions. The teacher was facing a dilemma between her roles of facilitating the development of the lesson for all students, or keeping the initial intention of the task (not having a list of steps to follow).

Even with the disappointment for Julia and me due to the need of a first step to engage students in the tasks, the lessons about fraction multiplication were completely different from her initial approach to this topic, which was: present the procedure "go across the top, go across the bottom", give no opportunity for students to try for themselves, and no use of visual aids. Julia was determined to develop lessons about fraction multiplication that had the diagrams as a base and that followed the project lessons' ideas. I say that she was quite successful in developing such lessons and was acting in her Innovation Zone again.

6.2.4. Closing comment on Julia's changes

The previous sections are about Julia's changes in practice during the project. I divided the changes into three groups: changes while Julia was following the project lesson plans (6.2.1); Julia's claims about her own changes (6.2.2); and changes observed in her regular lessons (6.2.3).

The professional development initiative (PDI) in the project was already described in Section 4.2 and the general sequencing of events during the data collection in Section 5.2. The reasons why Julia was able to follow the path she did, which led her to opportunities to change her practice, were not determined merely by the circumstances of the PDI and the project. It is clear that personal aspects also play a big part in influencing teacher change and engagement. In the next section I investigate the influences that fostered or hindered Julia's participation in the project in general.

6.3. Julia: constraints and affordances to change

In order to enhance the investigation of how Julia changed her practice, I focused on the analysis of features and events that might have influenced Julia throughout the process of change. The features and events presented here come mostly from the analysis of the data from interviews, lesson observations, meetings and talks over the year 2015/16, but also from the RP (2014/15), which are described in more detail in Chapter 2. Considering the Zone Model (Section 2.4.2), the elements I investigate in the following sections are the factors helping or preventing the teacher to try the innovation proposed during the PDI.

From the previous sections in this thesis, when I describe Julia and her changes in practice during the project, some features are already evident, such as Julia's confidence about her job and her high levels of

organization and control in the classroom, which are probably the reasons why she seemed so comfortable teaching. In this section I develop further these constructs and elicit new ones. It will be evident that many of them are intricate and deeply related to each other. I explore these connections as they will be the bricks with which to build the path that explains how Julia engaged and changed during the project.

During the analysis, after coding all the interviews with Julia, I initially selected all the nodes that referred to changes in her practices. Considering this group of nodes, I went back to the data from lesson observations (observation schedules and the audios), and wrote Section 6.2 above. After that, I wanted to consider the influences on change. As described in Section 5.3, I had many nodes to consider at this stage. Trying to make it more manageable, I decided to group the nodes. After some attempts, I finally reached four fairly independent groups that allowed me to explore the change process.

The four subsections are:

- Julia's classroom practices;
- Personality and personal context;
- Reflections and actions influencing change;
- Other features influencing change.

In each of them I provide examples to discuss the categories I claim were important for Julia's process of change in practice. I illustrate how these categories emerged from my data, and I also show a table with them in each subsection. These tables represent one of my attempts to visualize my data in a way that would make it easier to compare and relate to the other teachers. It was difficult to separate the categories as they interacted with each other. I present some of these interactions below, but the final analysis and results are discussed, considering both Julia and Alice, in Chapter 8.

This process was time consuming, and as will probably be evident in the text, in the end I considered many aspects of the teacher that

were not relevant. I decided to keep as much of the text as possible, considering the word limit of this document, because it shows what I actually wrote before reaching the Discussion (Chapter 8) and Conclusions (Chapter 9) presented later. Therefore, this text is an authentic representation of my data analysis process.

6.3.1. Julia's classroom practices

I start by commenting on influential features from my observations of Julia's lessons. They were evident quite early on in the study, and after some months in the school, I did not see any further feature fitting this group. I see two reasons for that, one being that the influences in this group are highly evident for anyone observing Julia's lessons, (see examples of her lessons in Section 5.1.1). The second reason is that the more time I spent in the school observing Julia's lessons, more data I had. For instance, someone observing one lesson might not notice how much Julia identified herself with her students, how this seemed to have developed into a sense of responsibility, and how this influenced her commitment to her job, affecting how she taught her students.

Julia was very **organized** in planning and managing her lessons. Beside the examples mentioned in Section 5.1.1, Julia uses colours as codes for the list of materials she wants to use for each lesson: the number of the *starter* in green, the number of the slides she wants to show in red, and in blue, the tasks she has developed for students to solve.

Her **control** of the classroom environment, including students' behaviour, time keeping, and routines with homework were recognised around the school as exemplary.

The tasks in the two types of lessons presented in Tables 5.3 and 5.4 are representative of the typical tasks Julia usually presented in her lessons focused on **mathematical procedures**. Additionally, the students in Julia's lessons were **working individually** most of the time. In summary, Julia's lessons were highly structured.

Organized	Control
Lessons focused on individual work	Mathematical procedures

6.3.2. Personality and personal context

In this section, I investigate features related to Julia's individual personal(ity) characteristics. This encompasses features related to teacher identity, knowledge, beliefs and attitudes.

Julia is an **experienced teacher** and often gave examples that allowed me to confirm how **knowledgeable she was** about the mathematics curriculum, the examination board and the scheme of work she was supposed to follow. Our conversations also suggested that she had already tried many different resources and the number of lesson plans she had already done allowed her to polish the way she taught most of the topics, for instance:

> I've taught Pythagoras since I came here, but a lot of the resources that my current Year 9 class have used are new. Maybe some of the slides of my Power Point are the same, but a lot of the thinking into the resources is now different, because the curriculum is changing and so it's gone more functional. There is no longer that question where there is a lovely right angle triangle saying, find x y. You know, the length x and y. I think the back bones of a Power Point are still there but I think what is different is the tasks I give the children to do. 'Cause when I start to work at home my husband, sometimes would say to me "Why are you still planning? Why haven't you got something?" and it is like "It is not good enough now. I need to make it better." (Interview 3, 1h 6min 29s)

The years of experience have also contributed to her evaluations about how lessons are going to be, or about what in her opinion are good strategies for engaging students. This passage in the first interview is one example of Julia's comments on her strategies and how her ideas were valued in the department:

> One of the other things is the routine. Literally, every lesson like starter; do bit; have a go; instant feedback; using the visualiser all the time. Very, very religious with things like homework as well, set up on the same day, pick it in the same day. And the other thing which I do, and again is being more in the department, I am very much focused on the positives. So, I was very quick to capitalize, every time they have done something, lots of praise. Even if it is very, very small. (Interview 1, 8min 35s)

The quotations above were confirmed by my observations of Julia's lessons, and they illustrate features that contributed to the confident teacher that Julia had become.

Julia felt that she **shared a similar background with her students**, and also considered herself successful thanks to education and good teachers:

> I had the most inspirational teacher ever. He made me like maths even more, and because I was good at it, even from an early age, I knew I wanted to be a teacher. (Interview 1, 44s)

Added to those features is her enthusiasm for her job, which might be related to her feeling of commitment towards students' learning. Julia constantly mentions **students' attitudes toward maths**, other than aspects related to mathematical knowledge. When I asked her, "When you look back over your teaching career, what are some of the moments that stand out for you?" she said:

> The highlights are always when you can get a pupil, or a group of people, or even the majority of a class to just change. And to go from "can't do, won't do, hate it", to "yes I wanna do it, can I do this?, now I'm trying get above where I should be". I don't think there is one thing that defines being here. It's almost like a satisfaction every year when you've changed someone's perception of maths. (Interview 3, 5min 43s)

Julia expressed, in many ways, how she was and how she felt responsible for her lessons. If students did not understand she suggested that it might be her fault, saying that she did not plan the lesson well enough. She felt responsible to also look for ways to improve the

students' self-esteem and their attitude towards mathematics. Julia took the initiative towards that goal, for instance, when she talked about an INSET (in-service education and training) project about pupils acceleration[19] that she had done in 2013/14:

> So I start doing my own mini sort of project. I wanted them to do really well. It was for me, and for the kids obviously. And then in the October, part of the performance management was that we had to do a project, which ran for a whole year. Because I was kind of already doing a project, which I hadn't done any research on, I was just thinking "What can I do to motivate these kids?". I then said to David [the head of department] that can be my project. (Interview 1, 7min 05s)

Julia's **commitment with her job** was an important factor in fostering her engagement with the project, which she saw as a way to improve some of her practices that she was not comfortable with.

On top of that, there were many examples where Julia demonstrated that **she believed that any student can change their attitude**:

> I think **once they trust you**, once they understand that you want to help them, I think kids will do anything for you. I do genuinely. I think any child can be converted. (Interview 1, 12min 33s, emphasis added)

Significantly I felt she rarely mentioned students' ability to be hindering their learning. She claimed that students' growth would come from fostering good attitudes toward mathematics. Asking her about the major challenges when she was teaching the low-sets groups, she answered:

> Confidence, or getting the pupils' confidence, their self-esteem, changing their perception of maths and how they think about maths,

19 INSET was how Julia called any initiative which involved teacher training offered by Purple Valley. The pupils acceleration project was one of these initiatives aimed at accelerate the progress of underachieving students. Julia was in this project during the RP period, the project finished before the beginning of my main data collection.

> and also being able to break the work down, but for me, not to a junior school way of teaching. (Interview 1, 23min 21s)

Since she always seemed to be trying to improve her lessons and students' attitudes, she sought opportunities that might help her, such as the pupils' acceleration project mentioned above. Her enthusiasm and sense of responsibility towards students might encourage her to look for ways to improve as a teacher. Therefore, **being curious with novelty** was one of the reasons to get involved in the project; when I asked her why she started participating in the project, she said, "It was just something different at the time. It was just something new, something different. And I just said, "Why not?"" (Interview 3, 10min 27s)

Also related to being an experienced teacher was the appreciation of different strategies for teaching mathematics. Julia might have been at the point in her teaching career when she was still motivated to learn, and at the same time, she was in control, knowing that she was capable of dealing with unforeseen situations and able to get back on track if some lessons were not as good as she expected.

> I feel like I am at the point now, where if something is not going right, I don't panic. If I'd have been like ten years ago, I'd have been panicking, "Oh my god, what am I gonna do?" Whereas now, I just like "Oh yeah, hasn't gone quite as we..." What can you do? It is just life. I don't think there was ever a point where I was panicking and thinking "Oh it is not going how I wanted it [the project lesson] to go". (Interview 3, 15min 32s)

Experienced teacher	Mathematical and pedagogical knowledge
Importance of building a good relationship with students	Enthusiastic about her job
Commitment with students' learning	Focus on students' attitudes and emotions towards maths

Any student can grow	Identification with students background

I am not claiming that any teacher teaching for as long as Julia will achieve the confidence in the job that Julia had, but simply reporting her personal characteristics that have an impact on how she engages with novelty and with changes in practice. More features supporting her confidence are mentioned in following sections.

6.3.3. Reflections and actions influencing change

This section is about how the classroom experimentation within the project lessons fostered change in Julia's practice. However, it is also about other moments when Julia was reflecting about her practice, which I was able to capture during interviews and during informal talks with her. In the project, teaching the project lessons plans was naturally established as a fundamental and (almost) obligatory stage. The setup of the meetings was designed to discuss lesson plans, and after that, the teachers would choose a date to teach the lessons. Therefore, the teachers trying the project lessons in the classroom was, in a way, guaranteed.

The initial meetings, in the RP, culminated with **Julia planning and teaching lessons we had discussed together**. This phase allowed Julia to engage with the whole process of planning lessons, developing resources and teaching. The lessons, although planned by Julia, were heavily influenced by the researchers' ideas of visual representation and our approach to how the tasks should be presented to the students. All these details were discussed during the meetings and Julia brought versions of the lesson plans to be commented on and altered according to the group's agreement. This experience helped Julia to engage with the design principles we were adopting, and teaching the lessons allowed her to experiment with this different style of tasks.

Overall, the experimentation with these lessons seemed to be positive for Julia. In our interview and after these initial lessons, Julia was very happy with the result and looking forward to the next year of the project (see Chapter 2 about the RP).

The positive experience Julia had during the RP might have opened the possibility for her to fully commit to the ideas of the project, especially the silent animation and the attempt to not give students too rigid steps to solve the tasks. These aspects were a novelty in Julia's practices in the classroom. During our final interview, I asked Julia if she remembered saying, "Do whatever you want", regarding teaching the project lessons. She mentioned that she wanted to do the lessons as they were meant to be done. Many of her comments suggested that she appreciated the opportunity to test new strategies in her lessons:

> Yeah, yeah. I am quite happy with that kind of thing, because if we hadn't had taken any risks along the way, we wouldn't have known what was going to work and what wasn't going to work. And you know, we have had lessons since, where we're kind of like "oh it is not going quite so well", but we wouldn't have known that unless we had done it. So I think taking those risks along the way was okay. (Interview 3, 14min 50s)

Aligned with the Innovation Zone discussed in Section 2.4.2, Julia explicitly mentioned that she was willing to take some risks in relation to her teaching, more specifically, using the silent video and the different tasks in her lessons.

By following the lesson plans rigidly during the academic year 2015/16, Julia was able to experience teaching lessons that were very different from her usual practice, and the fact that no adaptations were made to the lesson plan, not before, nor during most of the lessons, ensured that Julia was having a truly new teaching experience. This created a great condition for Julia to **evaluate her own teaching** of fractions, contrasting her previous lessons about fractions with the project lessons.

In the beginning of the year 2015/16. Julia was teaching the project lessons to her Year 8 set 4 group, and at the same time, she was also teaching fractions operations to her Year 9 set 5 group. The lessons with Year 9 were **"her other way to teach fractions"**, not using cut-outs and diagrams, only showing the procedures to get to the final answer for each one of the four fraction operations. When we talked about it during the third interview she said:

> If there is something now that is just in my mind, it is like... I remember saying "When I was teaching the other way," the rote learning that I did with my Year 9, it was making me kind of cringe 'cause there were parts of me thinking, "They don't really know what they are doing here, they are learning a method, and fine, that might get them marks on the exam, but they didn't actually have any idea." (Interview 3, 37min 40s)

The involvement with the project helped Julia to re-evaluate her teaching of fractions within her personal framework. She perceived differences between the two ways of teaching (her other way and the project lessons) that troubled her beliefs about good teaching. Experiencing a "cringe" about her way to teach fractions indicated that Julia reflected on her own practice and concluded that it was not the best way to teach her students.

This reflection and re-evaluation process might have led her to realise the impact her teaching could have on students' understanding, and she also tried to consider the reasons why she did not always teach "in the best way" she could:

> For me it has been a realisation that sometimes we do things and they [students] don't really understand what we are doing, but we do it because time is limited. You have to get exam grades. So I think I will be always conscious of not necessarily going back to default mode with fractions. (Interview 3, 37min 50s)

By **comparing between "rote learning" and "understanding", Julia generated a dilemma**. This dilemma suggests that Julia perceived the lessons with "rote learning" as being easier to plan (and to teach), at

least for the topic of fractions, in comparison to the project lessons. As her comments suggested, the "default mode with fractions" was related to rote learning, and students **not** understanding the procedures they are applying. Lack of time, both to prepare lessons more carefully and the pressure to teach only enough so students can solve the questions in their examination, prevented Julia from changing her teaching.

These two factors, pressure for time and for results in the examination, hindered the decision to change her focus on teaching procedures, even considering the benefits it could have regarding students' understanding. Julia initially tried to justify her way of teaching fractions, but she was already struggling with her decisions in our first interview:

> I mean, fractions is one of those topics where kids, I don't think really understand what they are doing. Like what are they doing when they multiply the numerators? I don't think they understand. What are they doing when they flip it around? But, I don't know, for some classes and again, this is maybe a culture, like a practice change almost, the amount of effort you have to put into that just for 2 marks in an exam. But then, I don't know? Is it right? Do you see what I am saying? (Interview 1, 42min 32s)

These situations suggested how Julia was re-thinking her practice and looking for legitimation for her choices. Teachers have great responsibility in their profession and it might be fundamental that they be equipped with as many alternatives in their teaching repertoire as possible. Julia was experiencing the need to justify her practice, but it was very important for her to also be able to change her mind and convince herself and others that their choices are the most suitable for the context and goals they have at that moment.

Another consequence of the engagement Julia had with teaching the project lesson plans, was that **the verbal interactions with students were altered**. As mentioned in Section 6.2.1 about changes, Julia talked a lot less during the whole classroom interactions. Julia mentioned during one interview that she taught the lessons the way they

were expected to be, even if that meant acting differently from what she would usually do:

> I very much enjoyed the [project] lessons. I kind of stood back maybe more than I would normally have done. I just let them go on, and let them get on. (Interview 3, 23min 48s).

Julia also spoke of benefits she perceived students had after being taught fractions with the project lessons. She connected some of these benefits to the tangible (cut-outs) and visual (diagrams) aspects of the lessons.

She **perceived that the cut-outs helped students to engage** during the lessons, because they "had something tangible to play with" (Interview 3, 46min 37s). Julia had not used cut-outs to teach fractions before. In relation to the diagrams, Julia had just checked their homework when we had our second interview:

> Rita: And why do you think they got it? Because the way they were solving the homework?
> Julia: Because, for some of them, they're clearly just visualizing it. They are just being able to visualize the diagram, do it in their head. Some of them have got good diagrams to support their working out, so they've understood the idea to be able to draw a diagram and obviously how the two connect. (Interview 2, 1min 19s)

In the comment above, Julia revealed her own awareness of the **importance of being able to understand the connection between the representations**: the diagrammatic and the algebraic (working out). Considering the way Julia previously taught fractions, this represented a different awareness about how students can be taught addition and subtraction of fractions. The homework mentioned was entirely developed by Julia, and I had had no input into it. From what students solved in their homework, Julia was capable of describing a mathematical connection (diagram and algebraic symbols), which she did not see in her "other way to teach fractions". Apparently, the comparison of the different lessons was again useful in raising Julia's awareness.

Julia was also impressed with **two specific transition moments** that happened during the project lessons:

> […] they [the students] could just switch to subtraction without having been told how to do it. And the fact that they were able to go to a functional problem without having to be shown. (Interview 2, 10min 14s)

Another significant feature about the quote above is the expressions used by Julia: "been told how to do it" and "having to be shown". These expressions suggest how her other way to teach fractions was highly based on the teacher presenting the procedure for a task by solving an example and the **students being (only) able to repeat that procedure**. This is in accordance to the styles of lesson that Julia usually taught, as described in Section 5.1.1.

Since the beginning of the project, this new option for her teaching had been mentioned by Julia several times during our interviews, and referring back to the initial lessons in 2014/15, she said:

> The idea that if you just give them a go, they might be able to do it. 'Cause it hasn't had too much teacher led work at all, and it is very investigative […] there's been no need to have a lot of intervention. (Interview 3, 13min)

She also mentioned some overall benefits for students learning after teaching the second set of lessons, in 2015/16:

> It definitely had an impact. I have never known a second bottom set, very low ability students, to be able to recall and do fraction work quite as well as some of them can do. So yeah, I definitely think they were worthwhile. (Interview 2, 8min 44s)

Julia had prepared cut-outs for the initial lessons in 2014/15, suggesting she was already willing to try cut-outs as a tool to enhance students' experience in the lessons. Nevertheless, she was still surprised with transitions students were able to do after the cut-outs were developed into diagrams. This suggests that Julia realised that an

association of the visual aids and the different style of teaching generated a valid and promising way of teaching.

Regarding the principles that the new lessons followed, the first feature that reinforced what Julia already appreciated in a lesson was "students will have opportunities to use their knowledge to solve the tasks". Although Julia sometimes struggled with it, she would like students to use their own knowledge to solve the tasks:

> I don't know. I just think I didn't... I get to the point that I don't want to just give them the answer, I want someone to work it out, I want them to realize what they've got to do. Maybe the questions that I was asking were obviously not that great. (Interview 3, 1h 16min 59s)

Julia had been teaching this group since they were in Year 7. During the RP, 2014/15, she mentioned how good her relationship was with the group in general. But in Year 8 Julia did not exhibit the same enthusiasm. She sounded disappointed about her own work with them, and during the third interview she said:

> It does frustrate me, because that Year 8 are my Achilles heel this year, and they are the one class that I think are still hard work. None of my other classes are hard work. (Interview 3, 1h 42min 15s)

Julia developed her comments on this particular group, suggesting that they are a special case. She mentioned three situations that might have caused that class not to develop as she wanted them to: over the year this class received many new students, who came to the group due to problems with other teachers; specific students' mood, which was capable of influencing the whole class; and **Year 8 groups are, in general, complicated**. Julia did not suggest that any of those issues were to do with the project lessons, but her appraisal of the project lessons was that they were sometimes impaired by some students:

> […] it is really easy to tarnish the whole class, 'cause it is not the whole class. It is about 3 or 4 of them [these 3 or 4 students were disrupting the lesson]. […] I know in my own head that there are only

> a few of them, and it is really difficult to see past them in some of those lessons. Almost needed to ignore them in those lessons and just focus on what the others were doing. (Interview 3, 21min 15s)

The sources of concern for Julia did not seem to come directly from the project lessons, but from the year group. This was also evident when Julia gave the first step in solving the multiplication questions for the three lessons she planned after the project (see Section 6.2.3.b). She said that **"it would be chaos" if students did not know how to start solving the items.** Julia wanted to guarantee some level of control during the lesson.

Planned and taught the initial lessons in 2014/15	Teaching the new lessons as planned
Re-evaluate her own practices	Other ways of teaching
Dilemma: understanding and rote learning	Different interactions with students
Cut-outs to engage students	Mathematical connections
Seamlessly transitions	Retention problem: repetition
Not telling nor showing how to do first	Behaviour problems

6.3.4. Other features influencing changes

The meetings were the main source of external support for Julia. My data shows that the meetings specifically were fostering change, with

Julia's engagement in the meetings illustrating considerable commitment on her part. For example, Julia attended all the meetings, and she participated in all activities that were suggested during those meetings, including solving tasks and giving her opinion about lesson plans and about previously taught lessons. Additionally, she arranged two more meetings for us to talk about her extra lessons (see MJ in Table 5.2).

Julia's comments about the meetings included her appreciation of aspects related to peer collaboration, such as sharing ideas and knowing about how the lessons were running in other groups. Julia's emphasis was on aspects related to the lessons themselves, such as discussions about students' errors, justifications for the order chosen for the tasks, and comments about the tasks when she was solving them.

My constant presence in Julia's lessons was another external source of support. The fact that Julia was always arranging time before or after the lesson observations for us to talk suggested that this support was well received.

The school environment was also fostering change. The head of department, David, who was participating himself, was the one who first invited Julia to participate in the project. In general, the school has INSET projects that teachers have to take part in, which is another example of an external source of incentive for teachers' development. My project was seen by the school as an INSET initiative, as Julia was not taking part in any other project in 2015/16.

I consider that David's involvement and the school's requirements were fostering the impression that teachers are encouraged to seek improvement and renovation. The fact that the school allowed my presence also reinforces that climate, since external people being present means more work for reception (more people coming and going) and more bureaucracy (making sure we were properly registered and up to date with access documentation).

Moreover, apart from the moments when Julia told me that she had shared strategies with the mathematics department, having **David as one of the participants in our meetings**, also provided Julia with within school endorsement. The head of department served as both support, in terms of allowing Julia to do different lessons, and as pressure to teach the lessons as we had agreed during the meetings. Since Julia taught all the lessons and even tried extra ones, the circumstances of the project provided a suitable balance between novelty and support in order to encourage her to try the project lessons.

As mentioned before, Julia followed the lesson plans judiciously and enjoyed teaching the project lessons, with the quote below suggesting some reasons:

> I thought they [the project lessons] were very structured. The difference between how I plan lessons and how Leo [Barichello] plans lessons, is he clearly has a lot more time, and also, it is evident that he's read a lot of research. He makes connections that I would not have the time to give that amount of thought. And I think this becomes a little more evident as some of the lessons I've planned, "Why did you put this here?", and I was "Oh, yeah...". Maybe the real thought process has gone into what he's done, based on literature, based on what he's seen and things like that. But I thought the lay out was very clear, easy to follow, and it was very clear to see the progression of where he was trying to get to. They [the lesson plans] were very usable, workable. (Interview 3, 11min 51s)

The careful structure of the lessons helped her to overcome her dilemmas and any novelty issues with the style of the lesson. Since Julia had begun to teach the lessons as planned, in 2015/16, she was pleased with how carefully they were developed, and noticed that the first time she taught one of them. She mentioned that there were no unnecessary tasks, and that:

> [i]t [the project lesson] was very much playing around. It was about the timing of the questions. (Interview 2, 18min)

Apparently, Julia was comfortable with teaching the project lessons, because she was able to notice the structure that the lesson plan

followed. As described earlier in Sections 5.1.1 and 6.3.1, Julia's regular lessons were structured in terms of how students would solve the tasks, and whenever a new task was proposed, Julia would have to provide extra information to students. Nevertheless, Julia also saw a structure in the project lessons, which I claim is a mathematical structure, related to the mathematical connections between the tasks.

In contrast to her regular lessons, the project lessons were not rigid in terms of how students would solve the tasks, but instead, after solving one task, the student would be ready to solve the next one without needing extra explanations from the teacher. Julia's regular lessons seem to be highly based on some kind of rigidity regarding how the tasks had to be solved, as well as a clear structure regarding the sequencing of items in a task in terms of mathematical difficulty. The lessons presented in Section 5.1.1 are examples of this rigidity.

Despite this difference, **Julia's regular lessons and the project lessons shared the feature of "having a structure"**, which probably facilitated Julia's engagement with the project lesson. Julia was able to follow the project lesson plans and to have a good experience, in part, because the project lessons were sharing a feature that kept her in her Confidence Zone, and there was some congruence between Julia's regular lessons and the project lessons.

Apart from seeing opportunities, Julia also had concerns about the project lessons. The most frequently mentioned concern was related to **the influences the outsiders in the classroom might have had on the development of the project lessons**. During our second interview Julia was reluctant to assume that the lessons would work the same way with fewer people in the room. She mentioned two aspects: (a) students were more engaged because it was someone else's lesson and (b) the extra people in the room were crucial in helping students during the lessons.

> I don't know whether it is just [an impression]. Mike[20] was one of the pupils who said, "Oh, where is Leo [Barichello]?" and he is new to the class. I don't know. There are certain individuals... I found Anne seems a lot more engaged as opposed to in other lessons, where we are not doing that [the project lessons]. I don't know, it will be interesting to see. They are not being like naughty or anything since we've not been doing it, and they've kind of been engaged, but there is no like them running up to me the end of the lesson going, "Look what I have done!" Whereas I think they want that sort of praise from Leo or yourself. (Interview 2, 5min 02s)

She also mentioned that with the extra people in the room, students always had someone to give them prompts whenever they were struggling with something. Julia showed some concerns regarding how dependent the tasks on the project lessons were on these prompts:

> And there is also, how would that lesson have gone if I'd been in the lesson on my own? Because I felt at times there were a lot of points where pupils needed a question, or they needed someone to just give them a nugget, a piece, something that they could move on with. (Interview 2, 18min 07s)

It is important to notice that Julia did not mention this issue in any other interview. Not even during the third interview, when we mainly talked about the experience of teaching the project lessons. A possible explanation is that by the end of the academic year (2015/16), Julia had had the experience of teaching some of the project lessons with only one extra person in the room, and they gave her the impression it would be manageable to teach the lessons with fewer people in the room.

Also, Julia not mentioning the outsiders' influence problem in our third interview might be because she realized that she had other issues with this specific group (Year 8 set 4).

Another problem that might have hindered Julia's changes, but enhanced her engagement, was the fact that **the lesson plans and resources were designed by someone else**. This lowered the teacher participation and cognitive engagement with the whole process of

20 All names of teachers and students from the school are pseudonyms.

planning and developing resources for different lessons. Nevertheless, the project was aimed at teaching fractions with a pre-determined set of assumptions (see Section 4.2.2). This is not a barrier in general, it is just a restriction on the areas the teacher might have changed. In the case of Julia, this is less relevant considering she planned and developed materials, as well as teaching the initial lessons (2014/15) and the lessons about fraction multiplication at the end of 2015/16.

A constant concern that Julia regularly mentioned was the examinations students have to take at the end of secondary school. **Julia focused many of her lessons on exam-type of questions**, especially with Years 10 and 11. This focus on examination questions might hinder teacher change, because, the questions were usually solved quite procedurally, focusing on the grade each step would give, instead of having a lesson where students have the chance to see many ways to solve the question or discuss in groups how to find a solution.

Julia understood that good marks can have a great impact on the students' future. The focus on examination results might have reduced the usefulness of the new lessons in terms of preparing students for the examination.

> So the fractions questions, sometimes is worth 3 marks first questions, then there might be a functional element but that's normally finding fractions of an amount, rather than the actual adding and subtracting. The four ops [operations] in fractions sometimes don't even come on the exam. And if they are, they are like two or 3 marks. (Interview 1, 43min 17s)

Julia's worries about examination results sometimes influenced how she taught. As the quote above suggests, she tried to balance time spent on each topic and the examination marks students could get with that topic. Julia believed that teaching a procedure was, somehow, easier and students still would get the marks. This apparently had been a dilemma (as mentioned elsewhere) in the topic of fractions since our first interview, when Julia pondered:

> I don't think they understand that by doing the smile bit at the bottom [in the procedure of cross and smile for adding two fractions] they are finding the common denominator and they're actually turning something into 12s and something into... whatever the fractions I just gave. I don't think that they know what they are doing at all. Will they know enough to answer the exam question? Probably. (Interview 1, 40min 17s)

Time was another cause of dilemma for Julia. In our third interview, when we were talking about an episode when students were having trouble giving her the next step to solve the equation $8x = 30$, she did not comment on their understanding of equations, but about students trying by themselves:

> The thing is, that is bizarre, because there is part of me that thinks "Is it just easier to tell them?" but then I am sure I have been observed in the past and someone has said to me, "Why did you tell them? Why didn't you let them work it out by themselves?" But there's got to be a point where you just think "Right, enough is enough! They need to be told now." But then there is also a part of me in that class, that thinks they just don't... they don't think enough, it's like they want to be spoon fed. I don't know. It is like they don't have that kind of zest. (Interview 3, 1h 19min 53s)

Lack of time was the only constraint mentioned by Julia when talking about planning the project lessons. She regarded the lessons as something highly time consuming to plan.

Normal to have external people observing her lessons	Recognition from other members of staff
Meetings: Think and discuss about the new lessons	Commitment with the project
Head of department	Congruence
The lessons were pre-planned	Outsider helping in the lessons

Focus on examination results	Time

6.3.5. Final remarks about these influences

In this section I provide evidence from my data on the influences that emerged and which had an impact on Julia's practice and in her engagement with the project. The influences are divided into four groups, but this division is somewhat arbitrary as the process of change I am capturing has many overlaps and interactions. The explanations I provided above present some of the relationships between the different influences acting together.

The tables at the end of each section bring the categories I created during the analysis of my data. These categories are labels to the groups of influences I presented earlier in the format of text. The 34 categories presented so far enabled me to explore Julia's change process. However, after finishing writing this section, I was not yet convinced I had reached a comprehensive explanation about the process Julia went through during the project. This feeling was not unexpected, since I knew that I had other two participants, for whom the process of change was not the same. For instance, I found out that Julia's identification with students' backgrounds was a relevant category of influences affecting her, but I expected this was probably not the case for Alice (I had already coded all her interviews).

Before moving on to another teacher, I will try to summarise the process of change in practice for Julia, considering the main influences I have discussed so far, bringing relevant literature into the discussion. Some of these sections, may sound repetitive. However, writing about how Julia changed at different stages of my data analysis was the way I found most effective to deal with the amount of data I had and its complexity.

6.4. Julia: the process of change

Before I present justifications for some of Julia's changes, it might be important to present a short review of her background (presented in earlier sections of this chapter and in Section 5.1.1) and connect the influences listed above. Julia is an experienced teacher working in the same school for 12 years. A personal characteristic, either natural or developed, is that she is comfortable as a teacher and confident in her profession. Additionally, Julia is committed to her job, including having a sense of responsibility for students' learning, and being curious about novelty in her practice, which opened up the possibility for her to take risks as she planned and taught the initial lessons in the RP. This experience enhanced her commitment to the project and her trust in the new ways of teaching being suggested in the project lessons.

During the RP, Julia and I built a relationship of support and trust, which allowed her to be comfortable in 2015/16, in teaching the new lessons about fractions exactly the way they were planned. Her engagement with the project proved to be productive, and we achieved a balance between novelty and common practices during the project lessons that allowed Julia to have a genuine new experience when teaching the project lessons. Julia was in her Innovation Zone.

In order to achieve this balance, we decided to keep some congruence between the project lessons and her regular lessons. For instance, the general structure of a lesson, with *starter* and tasks, was maintained, the project lessons were highly structured, and students were in the same seats as usual.

From the experience of teaching the project lessons, Julia expressed positive outcomes. She had a good experience teaching the lessons up to the point of considering similar approaches for other topics in the future. She planned lessons with a slide animation (Section 6.2.3.a) and to teach fraction multiplication with strategies that followed up on the project lessons (Section 6.2.3.b).

Teaching the project lessons also exposed problems, such as students' difficulties and the influence of external people being in the classroom during the lessons. Time was mentioned as a constraint to her, preventing her full engagement with the new style of teaching. Nevertheless, Julia saw positive outcomes from teaching with the project lessons and she perceived that there were different ways of teaching.

The meetings and my presence created moments when Julia reflected on her own practice, especially contrasting old and new teaching strategies. Having re-evaluated her own practice, Julia felt the need to justify her choices in the classroom and consider situations where she could change her practice to try to improve her students' understanding.

The genuine new experience with the project lessons played a crucial role in the process of change. A similar conclusion was presented by Smith, Smith and Williams (2005). They pointed out that exploring and testing alternative practices was one of the natural phases in the change process of their 13 teacher participants. Moreover, Smith, Smith and Williams (2005) considered three different levels of experimenting and a subsequent phase of reflecting on the success of the experimentation. In Clarke and Hollingsworth (2002), the domain of practice is associated with the teacher trying new activities (or any professional experimentation), see Figure 3.1. In fact, teachers trying new practices in their classrooms is presented as a fundamental part of effective professional development, such as in Desimone (2009) (active learning), Clarke (1994) and Joubert, Back, De Geest, Hirst & Sutherland (2009). Unfortunately, not much information is provided on how to encourage teachers into trying different lessons. Normally, generic mentions of support and collegiality are related to teachers taking risks.

6.5. Closing remarks on this chapter

Even with all these considerations of Julia's change process, I was still unsure about what influences were actually acting on the process and

what were elements due to Julia's personality. For instance, was her connection to students a real influence? If Julia was teaching other students perhaps she would not act in the same way, or was this fundamental to her engagement with the project, since we were suggesting lessons for the low-set groups?

With many loose ends in the analysis of Julia's data, I decided to move on to analyse the data from another participant. Looking at the data from another teacher might enabled me to better answer the questions above. Moreover, for the iterative process of analysis I was following, it was natural to move to other parts of my data (another teacher, in this case) and to come back to the findings from Julia in the light of the new analysis.

I chose to look first at Alice's changes. At this point I had already coded all the nine interviews with the teachers and that gave some initial, but general, impressions about the whole picture. I still needed to develop the individual analysis further, in order to look for differences and similarities that might help identify what influences were actually affecting teachers' change in practice.

The decision about which teacher to focus on next was made by considering who might add more features to the picture, i.e. which participant, Alice or David, was more different from Julia. This choice might also be important in terms of analytical strength because a similar participant might lead to similar findings. A participant with potentially more differences might help to test the findings from Julia, pushing the explanations of the process of change and the influences affecting it further.

This criteria pointed to Alice, her limited years of experience, her social background, her attitudes to low-set groups, etc. were all very different from Julia's (see Table 5.10). Therefore, the next chapter is about Alice.

As expected of any interpretative research, the analysis presented in this chapter is a consequence of my own perspective on the data. Although I recognize this is not the only possible interpretation someone could have, the thoroughness of the analysis presented here is aimed at showing that my findings (Chapters 8 and 9) are strongly tied to my data, to convince the reader that this connection is trustworthy.

Chapter 7 Alice

In this chapter I focus on Alice. I have previously introduced her, and described features of her teaching in Section 5.1.2. I now focus on analysing Alice's changes in practice during the project, and attempt to understand the influences on these changes, considering her background, the context of Purple Valley, and the project.

As mentioned before, Alice was not fully qualified when the project began. The programme she was following was called Teach First[21] and was one of the many routes available in the UK to becoming a qualified teacher. Briefly, Teach First is a programme run as a charity, which has schools and universities as partners. The aim is to recruit people with leadership potential and allocate those people to teach in schools facing challenging circumstances.

Alice never told me about the social aspects of her training, not even when I asked her why she chose to be a mathematics teacher. One possibility was that she was not particularly proud of these features of Teach First or she was not attracted by this aspect of it. In any case, the Teach First strategy of placing young people in challenging schools from a very early stage of the training has been criticised (Allen and Allnutt, 2017; McIntyre and Thomson, 2016). Throughout this chapter I discuss possible implications of the fact that Alice was selected to participate in the Teach First programme.

In the classroom, Alice acted with confidence and seemed to be determined in her actions. In our first few conversations she always had quick answers to justify her choices of tasks and her reasons for acting in this or that way in the classroom. Sometimes this behaviour suggested that Alice was answering without a lot of reflection, trying to sound confident, as if she did not need to consider the topics further and did not

21 https://www.teachfirst.org.uk/

want to show she had doubts. This behaviour changed over the year, and Alice became more comfortable in sharing her doubts with me.

The programme she was taking, Teach First, was third in a list of the most sought-after destinations for graduates in England, and it has been in the top ten for the last eight years according to The Times Top 100 Graduate Employers (The Times, 2017). There is a selection process for the programme, and a focus on creating leadership as one of their aims. Apparently, the confidence and determination in Alice's personality matches well with the leadership goals of the programme. This, and her good grades at school explain her being selected by Teach First.

After graduating from university, she felt that the Teach First programme was interesting for her purposes:

> I needed to get qualified. Teach First was the obvious way. The cheapest way of doing that, so that's why I did maths. […] Yeah, because Teach First will pay for me to do that [get qualified in mathematics]. (Interview 1, 44s)

In relation to the subject, Alice apparently did not have any strong preference for mathematics. She told me that "The maths is not a problem." She mentioned that she wanted to teach A-level after she finishes her teaching training, and that she did not feel her work was mathematically "challenging" when she had to teach some of her lower-set groups this year. Alice commented:

> Yeah and also I prefer teaching maths, which is more complex. Like it is boring teaching someone how to do column addition for a whole day, so if I have Year 7, 8 and 10 bottom sets and we're doing something really simple then it's not challenging me at all in terms of my maths. I know none of it is because I know it, but there's a difference, like I'm not even excited by it in the same way that some, like, the lesson with my Year 7's earlier today, my Set 1, Year 7's are about angle properties, it's more like, "Look, this is really cool what we can do here," whereas with them [the bottom sets] it's like, "You should be able to do this". So I think that's maybe part of it as well. (Interview 1, 13min 05s)

Alice did not have experience of students from disadvantaged backgrounds, either in her own schooling, or in her teaching experiences as a teacher assistant in a boarding school. It was a shock for her to teach the lower-set groups. As the quote above suggests, she seemed to be frustrated with the lack of engagement of students. This feeling arose in many other situations over the academic year, as mentioned in further sections.

A possible source of this frustration might come from the limited view of Alice's own experiences of school. Remembering her experience as a student, Alice told me about the kind of lessons she would have enjoyed, and she commented that they were not having a similar effect with her low-set groups.

These preconceptions Alice held about teaching might be the manifestation of her own experiences in school. This phenomena was discussed by Lortie (1975) when he suggested the term "apprenticeship of observation" to highlight the influence on her own practice of the experiences a teacher had when she was a student.

During our first interview, I was curious about some strategies she used in her lessons and I asked her why she questioned students about the meaning of some terms at the beginning of the lesson:

> Because I think, two reasons, one I think that's the sort of lesson I would have enjoyed, so it's like fun because it's like, "Oh, I've got to actually think about this now". (Interview 1, 7min 36s)

Dilemmas related to teaching and students' engagement (attitudes) were already evident in Alice's comments. She explained the second reason for doing the 'questioning about the meaning of some terms' further and said:

> I never really expect them to get it [the questions at the beginning of the lesson], so when they do it's a bonus, and the fact they haven't doesn't matter. I think there's also something about it makes it very clear to them that you're teaching them something because you say, "What's this?" and they're like, "I don't know," and then you explain

> something and then you go, "What is it then?" And then they, "Oh okay, it's this." So it's an easier pattern to follow for them. […] I try and make it very obvious that they're learning something in another way and that's maybe one way of doing it. (Interview 1, 08min 05s)

Alice had perceived many differences among her groups and one way of dealing with some of the issues in her low-sets was to simplify, "to make it easier" and "make it very obvious" as she suggested above. Also with low-set groups' homework, Alice's views suggest that she was intentionally removing the challenge. She said:

> […] most of the time I'll set homework that doesn't need a calculator, that doesn't need any equipment, doesn't need anything apart from a pen and the paper. I wouldn't even like setting graph type homework particularly just because automatically that's just reasons for them not to do it and I want to make it as easy as possible for them to do the homework, because all I want … the only aim for me from homework is just making sure that when they go home they think about it again to remind them. (Interview 1, 10min 29s)

The process of teachers simplifying topics in mathematics for their low-set groups has been reported by Zohar, Degani and Vaaknin (2001) and Boaler and Wiliam (2001). When with her top-set, Alice found out that a similar approach that led herself to success in school worked nicely, i.e. use the example the teacher showed to solve questions and then move to the next type of question.

Apparently, the focus on procedures and repetition was what she perceived as being what students enjoy and it was acceptable in terms of the final goal of solving examination questions.

Regarding her relationship with students, Alice did not seem to have any major problems, and her lessons tended to be run smoothly. In my observations, I saw her interactions with her groups as being pleasant and respectful. As she commented:

> Whereas even though my Year 10's are very weak, they're weak at maths, they're not stupid people, so we can have a conversation about anything as part of the lesson. I don't feel like it distracts [the students] from the work. (Interview 1, 16min 21s)

Alice had a different background to her students in Purple Valley, but she showed confidence in the classroom, even being inexperienced in the job and still training to be a mathematics teacher. This positioned her in an interesting situation for my research, opposing some of the features that were prominent in Julia, such as being a very experienced teacher; from a similar background as the majority of students; and with the belief that "any child can be converted" (Julia, Interview 1, 12min 33s - see Section 6.3.2).

After the third meeting, Alice asked if she could plan the initial lessons herself, although she wanted to use the ideas we discussed. One of the reasons she gave was that she wanted these lessons to be the ones she would present as her assignment for the teacher training programme, for which she needed to prepare the lessons herself. As a trainee teacher, she also saw it as an extra opportunity for her.

> Because it's very rare you're going to have someone probably ever again who's going to have the ideas of what they want to do and then be prepared to put the work in to make it, and then also to come and help you teach it. You're never going to have that again. Whereas you are going to have lots of times you'll read this is an idea and then you've got to take it and do all of the rest. So it was quite good experience from that point-of-view, I think. (Interview 3, 7min 10s)

There might have been other reasons for her to choose to plan those initial lessons, such as having more control over the lesson. It might have been too risky for Alice to teach the lesson plans we had developed during the meetings, as she was not then ready to move to her Innovation Zone with these lessons. Unlike Julia and David, Alice had only just started participating in the project, so she was probably not fully aware of the approach we were suggesting and she might not have been comfortable teaching them yet.

I accepted Alice's request, Barichello sent her the ideas for the tasks (not the completed lesson plans) discussed during the meetings, and we brought all the cut-outs Alice would need during the lessons. We also went to her classroom for these lessons, helping the students and

supporting Alice in the implementation. For the second and third set of lessons in the following terms, Alice asked to use the complete lesson plans we had developed during the meetings and she followed them very closely. Apparently, she had developed some confidence in following suggestions while teaching the project lessons.

7.1. My rapport with Alice

I was always welcomed in Alice's lessons, and she never had a problem in letting me in to observe any group. Alice would go to the staff-room every break, so we usually went together after her lessons, commenting on what had just happened. In the staff room, it was usual to have the company of teachers of other subjects, not only mathematics. Therefore, the topics of our conversations normally changed to more generic subjects, such as the elections, English culture and issues related to the school in general.

That scenario, having conversations with Alice and other staff members, provided me with more personal knowledge about Alice, for instance, that she was going abroad during the spring break, compared to the topics I discussed with Julia, who preferred to stay in her classroom during breaks and rarely went to the staff-room. Nevertheless, the relationship we built was good and I felt comfortable when observing her lessons.

Our first interview was very short compared to how long I spent talking to Julia and David using the same interview schedule. Hearing the audio again, I felt I was less able to use Alice's answers to improvise other questions or to ask for more clarifications. Thinking back, and considering my voice during the interview, I was a bit nervous, and this was probably clouding my thinking. Alice was answering every question very briefly and providing definite explanations, i.e. not showing signs of doubt or uncertainty, which would probably slow down the pace of the conversation and signal issues on which I could have asked further

questions. To some extend, this behaviour of being certain and without considering alternatives might be a reflection of her lack of experience therefore not being able to notice as much as an expert teacher would (Bransford et al., 2000, p.31; Mason, 2002, p.1). This is also compatible with what Borko and Livingston (1989) concluded in a study with expert and novice teachers. Compared to the novice teachers the,

> expert teachers have larger, better-integrated stores of facts, principles, and experiences upon which to draw as they engage in planning, reflection, and other forms of pedagogical reasoning (Borko and Livingston, 1989, p.475)

Additionally, this first interview might have been the fist time Alice was interviewed as a teacher, and she might also have experienced some anxiety. For the other two interviews the situation changed, allowing me to probe some topics further, asking for clarification about some of her answers. For the second and third interviews, Alice seemed to have used the interview questions to analyse and ponder the issues, rather than providing an answer straight away, which was similar to how the interviews with Julia had been. Probably, we were both more comfortable with the situation and were able to use the time as a discussion of the topics.

Our talks before and after lessons evolved similarly, and after some time Alice wanted to show me tasks she was excited to try, or to ask my opinion about a lesson. Those situations were indicating that our relationship was growing in trust and respect.

7.2. Alice's changes

Alice had changed her practice over the year. This had been her first year teaching mathematics, so she was still getting used to the profession and her previous experiences of school were very different, in both the school she attended and in her first job as a PE teaching assistant.

I mentioned above and in Section 5.1.2 some features that were commonly observed in Alice's lessons, but apart from this project, she had a lot of other influences around her during this year; her mentor (Julia), the Teach First instructors and the University lecturers. In any case, I report on Alice's changes in this section and about features that influenced them in the next. Most of the changes I observed happened during the project lessons. The process that Alice went through is worth reporting and analysing in the sense that it contributes to understanding how novice/trainee teachers might engage in initiatives that suggest innovation to their practices in the classroom. Being a novice teacher, Alice was in a different situation from the other two participants (Julia and David), but they all experienced the same stimulus regarding the project. Having a participant with clear differences helped investigate the features that could explain the change process of teachers in more depth.

This section is divided into two parts depending on how the change was observed: Changes when Alice was teaching the project lessons (7.2.1) and Changes in her regular lessons and reflection on her practice (7.2.2).

7.2.1. Changes when Alice was teaching the project lessons

As mentioned previously, Alice chose to plan the four initial project lessons herself, so she could use them for an assignment in her teacher training programme. Those four lessons were not very different from what Alice normally taught, so the changes below were observed during the second and third set of project lessons, when Alice followed the project lesson plans closely. In total, there were 13 lessons when she followed the project lesson plans (see Table 5.5). I observed all these lessons and compared them to those Alice normally taught. They had many differences, which I comment on below.

a) Examples, not procedures

During the project lessons Alice did not provide students with a list of steps to solve the tasks, as Alice herself described during one of our interviews:

> It was that idea of here's an example, because never really did I go through a method, like you split it [the square unit used in all the project lessons] in half etc, so they just saw a picture or an example of how something could be done and then they just used those skills to then discover what else they could do. So they were always given that one tool or one example at the beginning and then they discovered what they could do with it. (Interview 2, 16min 21s)

In many lessons I observed, as mentioned before in Section 5.1.2, it was common in Alice's lessons to have students following a fixed procedure that she had shown on the board before handing out the worksheets. According to her, the repetition of a procedure was a strategy to improve the chances of students memorizing it. Nevertheless, Alice did not see the procedure-oriented approach as the only way to teach. After teaching the project lessons with no procedures to follow, Alice had something to compare to her other lessons about fractions:

> That's interesting, when I first gave adding fractions to my Year seven set one they couldn't do it. Then I taught them a very numerical method and then they could do it straight away. The thing I found interesting with that was I think if you can add fractions and you understand it, then doing something like converting a mixed number into an improper fraction, like one and a half into three halves, is like so easy. I don't think there is anything [extra] in terms of understanding, there isn't and yet they couldn't do it until I showed them how to do it. So that was very illuminating for me. […] They couldn't see that to add 3 and a half and 2 and a quarter, you just add 3 and the 2 and add the… they just were completely thrown by the question because they hadn't been taught the method. Whereas if they'd have been taught it this way [using the project lessons] I don't think that would've been a stumbling block for them. (Interview 2, 9min 37s)

Apparently, Alice now had an experience that allowed her to compare, at least for the topic of fractions, two different approaches, and

she perceived that too much focus on procedures would limit students in terms of what type of questions they could solve.

When Alice followed the project lessons, she experienced teaching addition of fractions in a different way from before. During the project lessons, Alice did not provide a procedure to the students and she was able to see how students were still progressing through the tasks. Being able to compare the two approaches to adding fractions, with numerical procedures or with the visual approach, was only possible because she was willing to follow the lesson plans we developed during the meetings.

It is important to notice from this change regarding teacher development, that Alice was able to teach differently from how she normally did, she was experimenting or, in terms of the Zone Model discussed on Section 2.4.2, she was able to move to her Innovation Zone.

b) Visual and tangible materials

Alice had many lessons with diagrams or images and some lessons with tangible objects, such as plastic pieces for 3D shapes and pieces of paper, but they were usually utilized only as accessories or supplementary material rather than a tool that could be used to reason mathematically. However, during the project lessons, Alice relied on the cut-outs and accepted diagrams as answers and justifications for the items in the tasks.

Following the lesson plans, Alice expected students to answer the tasks using drawings of diagrams, which was not common in her regular lessons, not even for other lessons about fractions. Alice was using the cut-outs and the diagrams as a central feature of her lessons: using them to reason, to give answers and to justify those answers.

Alice commented that during the project lessons, students would benefit from the pictures and the diagrams in case they were not comfortable with what she called “theoretical maths”, written symbolic

mathematical expressions. This change allowed Alice to perceive that students might not have all the previous knowledge they should, particularly low-set students, but the teacher can develop strategies to overcome these gaps. Alice followed the lesson plans and noticed that students were referring to the cut-outs and drawing diagrams as they had done on previous project lessons.

Building on the idea of diagrams being something students can rely upon, the next changes are related to how Alice developed a different way to interact with her groups during the project lessons.

c) Alice was doing less talking

The first set of lessons about fractions with Year 8 set 5 was planned by Alice and the result was that she solved items on the board as an example in a whole group format, which was structurally similar to her regular lessons (see Table 5.6). For the following sets of project lessons (see Table 5.5), Alice took the project lesson plans and followed them closely; during these lessons she gave fewer explanations than she usually did in her regular lessons to the class as a whole.

> For me the obstacle was just trying to talk as little as possible, which I do try and do anyway, but it was even more obvious that I needed to not talk that much, because the whole point was a discovery thing like moving pieces. So that was a bit of an obstacle, I suppose. (Interview 3, 9min 32s)

Even being a risk, or an obstacle as she described above, Alice managed to give fewer explanations in a teacher led format, so she was again acting in her Innovation Zone in relation to how much she talked during lessons.

d) More discussions with students

When Alice was following the project lessons plans she noticed students' attitudes to be different from other lessons:

> I think they were keener to ask for help […]. I did think they were more willing to ask for help […] generally speaking. When they got to a question they couldn't do, they were much more keen to say, I can't do this, and it was that problem solving element that they saw as just a problem to be solved rather than as something that they couldn't do, which was nice. Again that was something where you just want to say to them, it's always like this actually. You need to approach it every time with that mindset and you'll enjoy maths a lot more. (Interview 2, 6min 20s)

I also noticed this change in students' attitudes during the lesson observations and I noticed how Alice was helping students individually. During the project lessons, the interaction between Alice and the students was usually more individualised, i.e. Alice was not repeating the procedure to solve the item for the whole group, she was looking at what students had done and asking questions to help them move forward.

My conjecture is that the main aspect of the project lessons that allowed that to happen was the fact that Alice was looking at the students' cut-outs or diagrams and formulating her comments and questions accordingly. She had to do that, because there was more than one way to answer the items in the tasks, and also it was apparently simpler for most of the students to make an attempt when they had the cut-outs or through diagrams than when they had only been presented with the numerical approach.

Moreover, since Alice was normally using what students had done, and the fact that the cut-outs and the drawings were still available in front of them, the teacher and the students would start a conversation with a common (and arguably simpler) language and reference point, with many of the elements being easily referred to by pointing to the drawings, or picking up a piece for students to check.

This different way to interact with students in the project lessons helped Alice to consider students' engagement, as she mentioned in the quote above. Alice also appreciated that students were getting a "mindset" she perceived as valuable and better for learning.

e) Independent learning

When Alice was teaching the project lessons, her students were more independent in progressing through the tasks, i.e. students did not have to wait for Alice to explain how to do the next task. The structure of the project lessons, as presented in Section 4.2.2, were usually the same: after an initial example in the format of a video or a whole class discussion, students started working on their worksheets, while Alice would be helping students individually at their tables and not showing procedures, nor lecturing in front of the classroom. This teaching approach throughout a sequence of lessons was different for Alice. She had given some other lessons that followed a similar structure, but they were infrequent. As Alice described the project lessons:

> It's nice having a lesson where you're not having to stand at the front and talk. […] They [Year 8 set 5] don't do that very well, they don't do the sitting and listening to my explanation. [...] In fact going forward, I would say that's a goal for my teaching. Is more independent learning the better, because obviously it's nicer for you if you can have a class who can independently learn, but equally it's just so much better for them, because whenever they're put under any kind of situation where we're assessing them, they're having to work independently, so holding their hand through a question is kind of pointless. (Interview 2, 3min 56s)

Alice began to notice that the lessons were working after she taught the original project lesson plans for the second set of lessons. The experience with the first set, when she planned the lessons based only on ideas for each task, did not cause the same impression on Alice and she was concerned about how students would progress in the topic.

This experience of teaching a sequence of lessons that allowed students to progress independently in the topic, as she mentioned, was an experience Alice appreciated, and represented a change in her practice. I will discuss the consequence of this experience in later sections of this chapter.

7.2.2. Changes in Alice's regular lessons

I did not observe as many changes in Alice's regular lessons, as I had with Julia. As mentioned earlier in this chapter, Alice was still training to be a qualified teacher and she had many extra influences (her tutor in the school, her lessons at the University, and her tutor from Teach First, just to name a few). Apparently Alice tried a lot of different strategies in her lessons that came from suggestions and evaluations of these different people. In any case, there was one situation when I perceived that Alice was influenced by the project that I considered especially important. It is discussed below.

a) Teaching the project lessons again

After Alice taught all the project lessons plans to her Year 8 set 5, she asked to use them again with her Year 7 set 5/6. This Year 7 set 5/6 was the original group she wanted to try the lesson plans with, but she changed her mind because this group was shared with another teacher, who was not participating in the project, and the timing did not work. At the end of the academic year, Alice wanted to review fractions with this Year 7, and decided to use the project lessons plans.

We talked about it and we altered the project lessons plans so that the progression up to adding fractions was faster. Alice wanted only a review, because she had already taught fractions sums for this group.

After the lessons, Alice declared that she enjoyed them and considered that students had learned something about the meaning of fractions, which apparently she considered they did not learn from her regular lessons about fraction sums. She perceived that students were now able to see fractions as quantities, being able to compare them, rather than just as symbols that can be operated following fixed rules.

Alice taught three lessons for her Year 7 set 5/6, and after each of them I had time to talk to Alice and comment on how the students were

doing and if we needed to change something for the next one. This was the second time Alice had taught these project lessons, the first was when she planned the lessons herself. This time Alice followed the project lessons plans very closely, which led to the changes in her practice mentioned in Section 7.2.1. Alice chose to use the project lessons to review fractions, as she was apparently confident with the strategies and results of the project lessons, which were initially different from how she normally taught.

The features that might have influenced Alice to engage with the project are the topic of the next section.

7.3. Alice: Constraints and affordances to change

In order to enhance the investigation of how Alice changed, here I focus on the analysis of features and events that might have influenced her throughout the process of change, the actual changes having been discussed in the previous section (see Section 7.2).

I have described and commented about the analysis process in Section 5.3, but what follows is a brief summary to explain the structure of this section. After coding Alice's interviews, I sorted the codes into two groups: one with the codes related to the Alice's changes and the second with the codes related to the influences on those changes. This section is focused on the codes related to the influences, but also the features of the PDI that I consider to have had an impact on her engagement with the project.

The division of this section follows four areas, similar to the ones in Julia's chapter. These areas are not independent and many of my tentative explanations of the influences overlap. From the previous sections in this chapter and in Section 5.1.2, when describing the teacher, some features were already evident, such as Alice's confidence in the

classroom and her experience in handling games and competitions among students, but some of those characteristics will be considered in these sections again, this time reflecting on how they have influenced change in practice and Alice's engagement in the project.

7.3.1. Alice's classroom practices

In this section I present the features that came from my observation of Alice throughout the project. I describe how I arrived at each one of them and develop an argument about why they influenced Alice's change and her engagement with the project.

Alice taught many lessons where she asked students to engage in activities in which they were competing with each other, or against time. Those activities indeed fostered student engagement in the lessons and also showed that Alice was confident in handling them. Alice was open to the use of non-traditional tasks in the classroom. Also, being confident that she could handle conflicts that might appear with these different activities can be seen as fostering Alice to try different teaching strategies. Hindering change for Alice might be that most of those activities were based on repetitive mathematical tasks.

Based on the lessons observed, I can say that the majority of lesson Alice usually taught a procedure, solving an example on the board, and students were given a sheet where they had to practice that procedure (see Table 5.6, for a detailed example). Even the learning outcomes from Alice's lessons suggested how she heavily relied on repetition, as she told me:

> I mean, for example, my Year 10's. I'm pretty sure that in all of the learning outcomes (looking for a slide in her computer with the learning outcomes in it), so in this one, 'collect together like terms' and then the next one, 'collect together like terms' and then the next one, 'collect together like terms.' Tomorrow, 'collect together like terms'. Like we've done that every single week because they still can't do it properly so that goes in there. Every single time we do an

> algebra lesson, 'collect together like terms', learning outcome number one, and that's fine. (Interview 1, 17min 59s)

The repetition of procedures was the focus of most of Alice's tasks, both in her top-sets and her low-sets groups. This approach was not what the project lessons suggested, and it might be a constraint for her. Alice actually asked us to include more repetitive items in the project lessons. Her reasons were two: (a) because that was what students were used to, and (b) she perceived that:

> [students] maybe need more questions before it advances... so like, the first thing they are doing is adding 1/2 and 1/8, I just think the first question should be 1/2 + 1/4, then the next one should be 1/4 + 1/4, and the next should be 1/4 + 1/8, so they really get it. Then should be 1/2 + 1/8. More of the same thing... so they can get motivated and have time to engage more with the task. Much more than two, like ten. (Talk after the lesson 15/03/2016, 1h 16min 23s)

Yet Alice saw that the project lessons were giving students an example, not a method (more on Section 7.2.1.a and Section 7.3.3), i.e. not always following the same sequence of steps to reach the answer, students had to decide what to do in order to solve each item. We included some more items in the project lessons as Alice had requested, and she felt that more students in the classroom were able to progress independently.

Another possible constraint for Alice was the fact that she was used to planning her own lessons at Purple Valley. Having the project lesson plans ready to use was something quite different for her, so that she asked to plan the initial lessons herself. We discussed the tasks during two meetings and we agreed on what the students would do. With that, Alice finalized the lesson plan, as discussed in the beginning of this chapter.

Observing these lessons I noticed that Alice followed all the tasks, but she interrupted students more often than we had agreed in the meetings. Apparently, Alice felt that it was too risky to let students progress without some degree of guidance.

In those situations Alice interrupted the students and gave an explanation on the board for the whole class. She told me she wanted to make sure students were following. They happened mostly during these four initial lessons, and there were only a few other situations in which a similar phenomenon happened, such as in the final minutes of a project lessons when Alice asked students to stop what they were doing and solved one or two of the items from the final task.

In any case, by doing so, Alice gained some self-assurance about students having been taught something. During our talks I perceived that she could not predict what students were getting out of it, or what they were able to do after the project lessons and that was the reason she wanted to solve an item on the board. Again, this might be a consequence of her lack of experience as a teacher. Considering that those situations happened less and less over the year, Alice was able to stick to the lesson plan, which allowed her to experiment with a different teaching strategy when she was teaching the project lessons.

This experimentation with the project lessons gradually evolved with time. After a while, Alice was able to minimise the moments when she explained the tasks in a whole class format, moving towards her Innovation Zone and being more confident with the new elements of the strategy and with how students would react to them.

Alice did not feel that these initial lessons (the ones she planned herself) worked very well. Apparently, she needed more evidence that students had learned something and that she reached the goal of the lesson. Alice did not have a lot of teaching experience and maybe she needed more immediate feedback, or clear evidence that the aim of the lesson was accomplished. After the fourth lesson she planned herself, PLA 1.4 in Table 5.5, I talked to Alice and she said:

> Yes, they worked very well today. I don't think... I don't know... I don't think it is making them understand fractions, really don't. I think it's making them understand how to use the pieces, but I don't

> think it is making them understand fractions. I might be wrong. (Talk after the lesson 08/12/2015, 1h 47s)

We did not have all the lesson plans at that time, as one of the aims of the project was to build the lessons based on what had happened in previous lessons. We discussed a general scheme of all the phases of the project lessons, but it might not have been enough to convince Alice of the benefits of the strategy, or even to ensure that Alice had understood the aim of the lessons, after all the other teachers were more experienced and had had more discussion time with me. This could have been a problem for her engagement with the next sets of project lessons, but the support and discussions with the other teachers, telling how the lessons were going in their groups, might have helped her to continue. This, together with her own view that she needed to experience the whole process in order to be in a position to evaluate its efficacy (being curious), ensured that she kept using the project lessons and eventually decided to use the lesson plans we developed during the meetings instead of preparing them herself.

Another influence was that Alice relied a lot on verbal explanations. The way Alice regained control was through whole class exposition, usually solving an item under the visualiser. Alice herself perceived that this was different in the project lessons, and she was finding it challenging to talk less during these lessons (see the change presented in Section 7.2.1.c).

The heavy reliance on verbal explanations was evident during my observations of her regular lessons. Although Alice recognized that she needed to minimise her talking to let students follow the project lessons appropriately, she commented on her reliance on verbal explanations in general. I discuss this in the next section because it is related to Alice's beliefs about teaching and learning.

7.3.2. Personality and personal aspects

In contrast to Julia, I identified more aspects that might have influenced Alice's changes that fitted in as personality features. One possible explanation for that is the fact that Julia was already more stable in her job, and had already developed a set of teaching strategies she used frequently. In other words, Julia had a bigger Confidence Zone than Alice, who was still experimenting with many different strategies.

Also, Julia came from a similar background as her students in Purple Valley, and this was the school in which she had spent almost all her teaching life, which was not the case for Alice. I will comment on the contrasts between Alice's background and her experiences in Purple Valley, which might help explain the occurrence of more features in this section about Alice than I had found for Julia (presented in Section 6.3.2).

Alice chose to teach as a pragmatic option, not as a passion, since Teach First gave a scholarship to people qualifying to teach mathematics, she chose it as her subject. But this apparently distant attitude to the subject did not seem to hinder her commitment to the school and the teaching job. She had had good experiences in school as a student herself, and as a teacher assistant in another school. Additionally, she told me she liked Purple Valley and that she was committed to the school.

Another positive attitude from Alice was how she sought good relationships with students. She mentioned many times about how she had friendly talks with students:

> So equally sometimes we'll have the last five minutes of the lesson when we'll just kind of chat and do nothing and that's fine because actually we've covered a lot and they appreciate that time. (Interview 1, 17min 09s)

I can say that I observed Alice and her students developing closer relationships than I observed with Julia and David. For instance, students knew Alice's birthday; she got a present at the end of the term from a

student in her Year 9 group; sometimes a student talked about a topic unrelated to the subject, and Alice was okay to engage in the conversation for a few minutes. I rarely witnessed these types of situations with Julia and David.

Alice was also confident, although arguably a different kind of confidence from what Julia had. It would come through during her lessons and probably had the effect of making students' behaviour better in general. As mentioned earlier, she applied and was selected by the Teach First programme, which reinforced the fact that she was confident and knew how to act as a leader. In her initial years in Purple Valley she was already in a co-ordination position[22]. The quote below illustrates Alice's confidence:

> […] Not to blow my own trumpet, but I reckon the department are quite lucky. I reckon a lot of the other people I know from Teach First, if they'd have been in this situation I don't think they'd have coped very well, because I've seen what they've been given, which is full lessons, all planned, plans written, PowerPoints made, resources made and they literally just have to deliver the lesson. All of key stage three across numerous schools have Teach First maths participants I know have that. (Interview 3, 32min 17s)

Additionally, Alice's attitudes towards learning were remarkably positive. She expressed her willingness to learn many times when I asked her why she decided to take part in this project. She said that David invited her, but added that she would have asked to participate "because it's more experience of seeing other things, which is exactly what you want to do always probably, but particularly in your first year of teaching" (Interview 3, 3min 43s).

Alice was committed to the project. She engaged with all the activities proposed, even with her tight schedule as a Teach First participant, which required Alice to visit her University many times over the year and also take on extra work in relation to writing reports, aside

22 This information was available in the school's website and I confirmed it when I visit Purple Valley more than a year after my data collection had finished.

from her regular planning for her 17 lessons per week. Overall, Alice agreed with the importance of research, and she was willing to participate as expected. She was committed to the profession she had chosen to follow.

During the initial meetings, it was explained to the teachers what the expectations were regarding the amount of time they would have to dedicate to the project, and Alice followed that plan, even teaching more lessons than initially agreed.

Alice came from a different background to the students at Purple Valley in general, and students' attitudes related to answering her questions and their lack of willingness to learn were not what she remembered from her time as a student, nor from her experience as a PE assistant. She had noticed the complexity of the problem, as she said during our last interview:

> My Year 8s were just like, "Oh well, you told me to fill in the shapes." It was always their answer to every question, in a way that they think that you're telling them off, when actually you're just trying to establish what's happening, what are you learning. I think that probably just comes down to them being used to in their lessons across the school constantly being like, "Why haven't you done more work? Why haven't you done this? Why haven't you done that?", so then they tend to associate any questioning from teachers as a bad thing. (Interview 3, 27min 11s)

But she was apparently considering possible reasons for that behaviour, which indicated that she had at least thought about the issue and begun to reflect on the situation. Still, Alice was affected by some situations related to differences in her own teaching to the low-set groups. She described one episode when we were talking about moments of frustration she had had in her lessons:

> We've [her and students in Year 8 set 5] been doing area and perimeter for two weeks. Friday morning, "Lucas, what does perimeter mean?", "Don't know." He won't even try and come up with an answer. That was last Friday that happened and I was just like, "We've been doing it for two weeks, you've been here six hours".

> Imagine doing something for six hours and still not being able to give you that basic definition. (Interview 3, 41min 35s)

Alice automatically transferred her own values related to learning attitudes to her students. But as the two quotes above suggested, these values were in conflict with what was happening in her low-set groups. Teaching lessons that she is not used to was maybe even more challenging in such a delicate scenario.

The focus of the project (Section 4.2) in general and the design principles of the project lessons (Section 4.2.2) in particular were not aligned completely with Alice's view of teaching, even towards the end of the academic year, after Alice had taught 17 project lessons. For instance, regarding Alice's focus on understanding as being an issue of merely verbal communication and not about pedagogy:

> If you're good enough at explaining things, which I hope I am, I think I am, then I think that this is fine as a stock thing. You are able to explain something well enough that actually through them [students] listening and talking to you about it they can get some understanding, and then they can do some practice on their own. And I think they can actually learn a lot through that method. (Interview 3, 1h 16s)

But the project was focused on limiting verbal communication and increasing the use of visual aids. Even with this apparent misalignment, Alice was capable of teaching the project lessons. Alice was acting in a different way, suggesting that she was capable of teaching differently, even if that seems to conflict with some of her exposed beliefs.

I asked Alice if she could remember her initial impression about the project lessons when we showed the first ideas. She told me:

> I thought they were going to be too easy. I think the reverse was the case. I just thought things like using the pieces for like three hours I was like, 'Come on'. I also thought the kids would be more bored by it than they were. Particularly those first lessons where there was quite a lot of repetition using the pieces, making them on the grids and stuff. I thought they'd be a lot more bored with that, but actually they weren't. (Interview 3, 4min 25s)

Alice had problems in predicting what low-set students would enjoy doing in a lesson and what would be easy or not for them. Therefore, using a different approach might have been an experience for Alice to consider new strategies in her practice.

Lastly, Alice constantly questioned what the low-set groups should be learning:

> And it is just that ... in my opinion is it just that thing of not everyone can achieve everything, and actually we should already be thinking with these kids what maths skills do they need to know for their life. What numeracy skills do they need to have engraved within them, and how are we going to go about teaching them that? […] we know already that they're [some students in the low set] not going to pass a Maths GCSE. So let's stop trying to focus on that, let's just think about what they can achieve and what things are going to be important to them. Is it important to Jane and Tina and whatever that they know how to add four quarters and fifths? No, it isn't. Is it important they understand what 50% of something means? Yes. (Interview 3, 36min 57s)

The dilemma about what low-set students should be learning appeared as an issue for Alice, even leading her to try different lessons with the low-set groups. Regarding the project lessons, Alice commented that they were more effective in providing students with daily-use type of knowledge on fractions, which she appreciated, but at the same time, they did not provide efficient methods to get grades in the examinations. The role of schooling and what teachers teach in their own lessons are complicated issues that teachers ought to face in many moments in their career (Lampert, 1985) and Alice was not an exception.

Although it seemed that her beliefs were conflicting with some features of the project, she engaged with the project as evidenced by her participation in all activities and willingness to use the lesson plans with another group. My perception is that the experience with the project lessons was stronger than the conflict in terms of beliefs. This analysis provides extra support to my choice, described in section 3.2.1, of not focusing on beliefs on my study.

7.3.3. Reflections influencing Alice's changes

Alice was less enthusiastic about the project lessons than Julia. The lessons in her Year 8 group had more issues compared to those of the other two teachers, such as students not finishing all the tasks and disruptions because of behaviour, but this was true in general when comparing Alice's regular lessons to Julia's and David's regular lessons. Nevertheless, after discussing these issues with Alice, we incorporated some changes into the tasks, aiming to develop a lesson plan with tasks more congruent with how Alice normally taught. The changes were: less demanding *starters*, Alice wanted students to be able to solve the *starters* without too much help; and adding items to the tasks, Alice asked for more items so students had more chances to repeat what they were doing.

Although moving away from the project lesson principles (Section 4.2.2), these features were still aligned to them. In any case, I wanted to incorporate Alice's suggestions for two reasons. First, we were in her classroom and she was teaching, so I wanted to preserve her agency in making decisions about how she taught her groups. Secondly, as Alice argued, and I agreed, these changes would guarantee a little bit more similarity between her regular lessons and the project lessons, a congruence that might help Alice to teach the project lessons as they were, and have a good experience with them. From my point of view, these changes could foster Alice into moving towards her Innovation Zone.

Another possible explanation for the difference in enthusiasm is that Alice had not had much experience with teaching mathematics to be able to compare the project lessons with other lessons. Being a novice teacher, it might be harder to consider when a lesson has worked immediately after that lesson and the reasons why that has happened, as mentioned before regarding the lack of immediate results in Section 7.3.1.

Nevertheless, the project allowed many situations for Alice to reflect about her job. Alice talked about her own teaching and she verbalized some situations where she could have done a better job. For instance, in our first interview I asked about a *starter* she did in a regular lesson. I was curious about her choice regarding the order the items, and I just wanted to have Alice's thoughts about it. After telling me that she did not expect all the students to solve all the items, she said:

> the way I taught them this was, like, not how I would want to teach fractions, like divide by the denominator, times by the numerator. They don't understand what they're doing there. (Interview 1, 6min 10s)

This was our first interview. We had had three meetings and she had not started the project lessons at that point, but she was already conscious of an undesirable way to teach fractions. This is similar to Julia's cringing (6.3.3), to a less intense degree, but still not feeling proud about the way she was teaching fractions.

During our last interview, Alice compared her students' being stuck in a task to herself being stuck when solving a difficult problem. She recognized the many influences that were acting on the classroom environment: students might not be in the mood, the lesson plans might not work and the teacher might be to blame. This reaction to a bad lesson is important for Alice to be willing to persist with a new approach in her lessons even if an initial attempt has gone wrong, which was apparently the case when she taught the first set of project lessons.

During our second interview, when I asked Alice what she takes into account when deciding if a lesson was good, she said:

> I think the main thing of that is the engagement thing. If I feel that they've just been engaged with it for whatever reason, it's nothing to do with what they produce, and it's never really to do with behaviour […]. When you're not having to ever say "Ssshhh", "don't talk about that", that for me is good because it means that they're engaged with the work. (Interview 2, 44min 11s)

Alice was concerned about students' engagement, looking for ways to engage students might foster her use of different strategies in the classroom.

Even though Alice did not seem explicitly enthusiastic about the project lessons, her attitude towards different approaches was quite positive and constructive. She was aware of the fact that new approaches needed time and reflection, telling me:

> Also, I thought it's the sort of thing that you needed to see through really, because you've still got to do the whole work and then you look back, and some things maybe you'd change or whatever, but you've got more wealth of experience of taking something from beginning to end to than actually feel like then you're better placed to make a judgement about them. (Interview 3, 5min 51s)

Throughout the year, she was not discouraged even after a bad lesson, and even with her negative evaluations of some of the project lessons, she did not question the usefulness of the lessons and was more willing to try and discuss and suggest alterations, which are better attitudes for someone trying new strategies. Alice seemed to be resilient in relation to the project lessons.

As a result of something Alice had perceived as bad during a project lessons, what usually happened was that we would try to come up with a solution that could be implemented in the next lesson, for instance, we made small changes in the *starters* and Alice decided to use the introductory video differently. Again, these were moments when Alice was reflecting on the project lessons and evaluating them.

She was actually engaging in considering ways to improve her lessons in general. In the quote below, Alice was comparing the project lessons with her own lessons and pondering what the reasons were behind her choices.

> I always try. When I'm teaching a fractions type topic, I will draw a picture to go alongside. So when I was doing mixed numbers, improper fractions, I would draw a picture, but naturally the thing I always draw is a circle and I don't know why because actually a circle

> is really bad at showing any fraction other than halves and quarters, really. [...] I don't know. I don't know. Yeah. The reason I like circles I think actually comes down to, if you think of the progression of the topic, when you come on to doing things like pie charts and probabilities. (Interview 2, 26min 21s)

Alice also noticed aspects of the project lessons in terms of their approach to the topic and how students were expected to learn from it. During the second interview our discussion was suggesting that Alice had experienced a different way of teaching from the 'example-task' cycles illustrated in Table 5.6. I asked her how she would describe the project lessons, and she said:

> So they were always given that one tool or one example at the beginning and then they discovered what they could do with it [...], which is a very different way of doing it. I'm trying to think of a way that you could use that same structure with different topics. Obviously it must be possible, but I'm trying to think of ratio or something. How would you give them an example with no method, which then they would be able to answer more questions other than just this specific example type, because that's' the uniqueness of this. (Interview 2, 16min 21s)

Alice's description of the approach in the project lessons highlighted a dichotomy. I was curious to know what Alice meant by these definitions, so I questioned her further during this interview. We also talked about it during the next meeting with all the teachers and in conversations before her lessons. Alice's definition was that a *method* is something that has a list of procedures that have to be carried out in the same order all the time to solve some particular set of problems; an *example*, on the other hand, is modelling the rules of a certain situation, but it leaves to students the decision of which actions they are going to engage with, and in which order.

The actual words, 'method' and 'example', might not carry all the meaning Alice was giving them, but being aware of these differences and able to articulate them, as Alice did, shows that she can choose consciously some features of a lesson, and consider their consequences.

During our last interview, Alice pondered about other strategies to teach fractions. Some of her claims seemed to come from her experience with the project lessons:

> I think the Bar [Singapore Bar method] is quite nice because there's less room for error in the way that you draw it, but it only works for small numbers [denominators] so you can't... Because you're only ever going to split vertically, right, so if you've got fifths and fourths, fifths and quarters, you'd go to twentieths, wouldn't you? Singapore Bar you're not going to be able to "ch-ch-ch-ch". But for like halves and thirds it's quite nice being split one bar on the top into threes and one bar at the bottom into half, and then you can see that if you draw those lines there and those lines there. I don't really know to be honest. (Interview 3, 17min 59s)

Apparently, participating in the project provided Alice with the opportunity to experiment with a different approach, time to discuss and reflect about it, and to reconsider other approaches she was planning to use in the future. Considerations of this nature should be common and fostered in teachers (Clarke, 1994), as being able to account for the benefits and limitations of different strategies can work as a starting point in triggering teachers to try these strategies in the classroom.

Still comparing the project lessons and her other practices, Alice told me that after teaching her Year 7 set 1/2 group how to add fractions with a numerical method, she was expecting them to be able to add mixed numbers, but they could not. She was surprised that being able to use the method for adding fractions was not enough for students to extrapolate to mixed numbers, particularly for a top-set group. She was then predicting that the approach of the project lessons to the addition of fractions would allow students to be able to also add mixed numbers (this episode was also discussed earlier in Section 7.2.1.a).

Alice's expectation described above suggests that it is not straightforward to Alice what her students would be able to solve after being taught a topic, as in this case, being taught a method and solving items of addition of fractions. One way to look at this is that the connections Alice (and many other teachers) see as obvious between

topics, are not that clear to students learning those topics. This might sound obvious, but being able to answer the question: "What are the other items my students will be able to solve rather than the ones they have solved in the lesson?" with certainty, might be very difficult. This awareness can develop with experience (Mason, 2002), but there is no reason to expect it will naturally develop with the increase in years of teaching. Teaching with a different approach might have worked for Alice as a trigger (as discussed in Section 3.2) to begin to think about issues of connections within the topic of fractions.

Also, during the second interview, Alice began to consider other topics of the curriculum, where she could:

> give them [students] an example with no method, so then they would be able to answer more questions other than just this specific example type, because that's' the uniqueness of this [the project lessons] […] you could do it with percentages, you could just do one example where you just find 1% and then using that, they should be able to find any percentage and they should be able to do any percentage increase or any percentage decrease. (Interview 2, 17min 56s)

Alice's reflection did not provide clear solutions about how to teach addition of fractions, but trying the project lessons in her classroom opened up the possibility for Alice to consider the causes of students' difficulties with a topic. In this case, she considered her teaching approach (the numerical method for addition of fractions) to be problematic. This is building a promising scenario for change.

Similar to what Julia mentioned, Alice also commented that lessons with more students' exploration and careful sequencing are time consuming. On our third interview we talked about this, and Alice mentioned she had been teaching circles that morning and was trying to discuss the topic with students, but that was more time consuming than when she just verbally explains it herself:

> All they can do as a result of that [discussion] in terms of an exam is label the parts of a circle. If you'd have given me an hour and they'd

> just been sat listening to me they probably could have all found the area and the perimeter of a circle. That's the decision you're always making. (Interview 3, 1h 01min 50s)

Alice chose to teach this lesson with fewer moments in which students had "just been sitting listening" to her, so she probably saw some benefits in this approach, but she struggled with issues related to time. This is a common constraint on teachers implementing new approaches in their classroom.

Also related to time, was Alice's impression that the project lessons takes a long time to plan. Both teachers, Alice and Julia, had the impression that lessons based on verbal explanations and on showing fixed methods were faster to plan. One possible benefit of these lessons, apparently, was that it has clear features that show accomplishment of what is expected from the teacher, such as I told them how to add fractions (the teacher taught), and from the students: they solved these 10 items of adding fractions (the students performed addition of fractions). A lesson without these moments is less clear in revealing what the teacher had taught and what students had learned and might be a problem for when teachers are evaluated during observations of short duration.

In Alice's case, she considered that the verbal explanation was an important part of the lesson and would spend a lot of time thinking about it. Talking about something you know seemed to be natural and easy for her, and also a good teaching strategy. This might be one of the constraints on Alice's change, as she had considered this issue during the project, but it was still a dilemma, since it seemed faster and simpler to verbally explain the topics she was teaching, and that was effective in helping students to perform the expected tasks.

Considering Alice was able to teach the project lessons and that she perceived them as a positive experience, I argue that the project had features to support her in overcoming these issues. Section 7.3.4 is about the project influences.

What makes Alice a special case in this study is that she was new to teaching mathematics. It is possible to argue that many of the features I mentioned so far have strong links to her lack of experience and it is impossible to separate them. In any case, there are some specific features that are strongly related to being a novice teacher. Being able to consider and use a new strategy in the classroom might be easier for an expert teacher who, as Borko and Livingston (1989) suggest, can see more connections across the curriculum and are usually better at predicting students' difficulties in a topic. The data from Alice, and my analysis of it, increased the range of influences that I could identify when only Julia and David, two experienced teachers, were participating.

During our informal talks, it was common that Alice had justifications for everything that should be done in the classroom, or how students learnt better, or why something did/did not work, although these justifications were broad and general. Such claims were sometimes strong in terms of her beliefs and her knowledge, but they suggested Alice's lack of alternative explanations for the events she had to deal with within the school. Her lack of experience could be a possible source for this limited view, as argued by Borko and Livingston (1989) and Mason (2002).

These situations limited Alice's reflection on possible solutions to problems when she was trying something new, for instance. This stance of having a justification for every issue in the classroom can hinder ideas for improving her practice. Alice might not see her teaching of mathematics as the source of problems for students, but neither as a possible solution. Students' problems (e.g. lack of previous knowledge or not paying attention to her) were regarded as much more complex and broader and there might be little for her to do as a mathematics teacher. Alice might not see reasons why she should change her teaching.

At the same time, I have already mentioned many examples when I considered that Alice was able to reflect on her teaching and about students' learning. The project was encouraging her to reflect, despite

her initially definite opinions on some topics. She was apparently successful in dealing with the conflicts and contradictions that naturally emerge during a process of change (Wood et al., 1991).

As mentioned before, Alice's lessons did not seem to work as she expected when she was teaching the low-sets groups. This imbalance caused her to change her teaching strategies for those groups. She told me that:

> I suppose those two groups I have which have any kind of bad behaviour, which is the Year eight class and my Year 10 class, they make it... it means that I like having a more structured thing, less group work, a lot less time spent with me feeding back from them, because I don't think they listen to each other very well. (Interview 2, 41min 28s)

Although Alice mentioned bad behaviour, I only observed what she perceived as bad behaviour in her low-sets. The situation was different in Julia's classroom. Julia also followed a rigid structure that her students had apparently got used to, but she embedded in the structure moments where they were expected to give her feedback. This might explain part of the reputation Julia had in relation to improving her groups' overall grades.

Another feature hindering changes in Alice's practice were her teaching strategies. Three characteristics were constantly mentioned by Alice, and also observed in her lessons: focus on repetition; focus on verbal explanations; show a method first. These were mentioned in relation to teaching in general, not only for low-set groups.

Specifically for low-sets, Alice commented on simplifying things, making topics easier, and using strategies so students know they are learning something:

> I think there's also something about it makes it very clear to them that you're teaching them something, because you say, "What's this?" and they're like, "I don't know," and then you explain something and then you go, "What is it then?" And then they, "Oh okay, it's this." So

> it's an easier pattern to follow for them. They understand they've learnt something. (Interview 1, 8min 05s)

These simplified versions, or reductionism (Foster, 2013) in many aspects of the lesson – tasks, learning outcomes, explanations and homework – were a way for Alice to deal with her low-set groups when students were "not getting it". One of the aims of the project lessons was to suggest an option not based on reductionism to deal with issues that were common in those groups, in particular, the use of visual representation to minimise the problem of lack of vocabulary for students learning about fractions (Gates, 2015). I discuss how Alice embraced that aspect of the project lessons in the Section (7.3.4) when I am considering external influences. Additionally, as mentioned earlier in Section 4.2.2, my study was trying to achieve a balance between risk and control, that is, to push teachers to their Innovation Zone. This condition of 'supported uncertainty' for teachers was intentional and enabled me to observe some level of change in their practices in the classroom.

Alice frequently mentioned differences between her top-sets and her low-set groups. Many of her claims were placing the responsibility or agency on low-set students for not acting in the way they were supposed to: not bringing homework, not remembering what was taught in previous lessons, not knowing basic mathematical topics, not working properly in groups, not listening to her explanations effectively, not engaging with the lessons and not participating in the lessons as they should. Alice differentiated students according to these actions and behaviours just mentioned, and this had an impact on how she taught: simpler homework tasks, lots of repetition, slower progression, less group work and more structured lessons. This feature could hinder Alice from trying different approaches that do not follow this teaching style, and in transferring part of the learning responsibility to students, Alice might not trust the low-set students to be responsible for their learning, however, with the project lessons, Alice saw how her Year 8 set 5 was progressing in the topic and being able to do some independent work.

During the interviews, it was not common for Alice to comment on changes in her own teaching, which she might not have noticed. However, she mentioned how she was still discovering ways of teaching and trying different things in the classroom. Apparently, in many situations, the experience of teaching the project lessons was the stimulus on which Alice based her claims about her discoveries:

> Yes, because we never gave a method, did we. […] Yes, which is a very different way of doing it. I'm trying to think of a way that you could use that same structure with different topics. Obviously it must be possible, but I'm trying to think of ratio or something, how would you give them an example with no method which then they would be able to answer more questions other than just this specific example type, because that's' the uniqueness of this. (Interview 2, 17min 44s)

This quotation was also discussed earlier in this Section, and it suggested that Alice was able to notice differences in the approaches to teaching and to evaluate approaches in relation to their classroom outcomes: students' behaviour, learning, or engagement. Even if Alice is not completely aware of specific aspects that allow a lesson to work, which were not clear even for the more experienced teachers, being able to engage productively with the project lesson plans (a novelty for her) might help her develop the capacity to change and model her teaching in diverse circumstances.

7.3.4. Other features influencing change

Throughout this section, I will comment on similarities and differences between Alice and Julia in relation to external and project influences. They were not always the same for both teachers, even though they participated in the same project while teaching in the same school, but understanding the similarities and differences may enrich my conclusions.

Similarly to Julia, Alice mentioned my presence in the classroom as something that fostered students' engagement. Alice was less concerned with that aspect than Julia, but Julia was preoccupied with the idea that

the lessons would not work the same way without those extra people helping students. Nevertheless, as mentioned in Julia's chapter, she stop mentioning this after the second set of lessons, see Section 6.3.4.

Alice brought up a different aspect on which Julia did not comment: the fact that she, as a teacher, was getting a lot of help through the project. When I asked her why she planned the initial lessons she said:

> Because it's very rare you're going to have someone probably ever again who's going to have the ideas of what they want to do and then be prepared to put the work in to make it, and then also to come and help you teach it. You're never going to have that again. (Interview 3, 7min 10s)

This reinforces the fact that the project had some impact on the teachers, but this impact might be different for each teacher, even when teachers participated in the same PDI.

Another external influence was David and Julia. David's (the head of department) presence in the project as one of the participants might have encouraged Alice to engage with the meetings and to keep her commitments with teaching the project lessons. Julia was Alice's mentor in the Teach First program and they had regular meetings. Alice knew that Julia was seen as a successful teacher in the school, but she recognized how prescriptive Julia was when she commented:

> Obviously Julia is an amazing teacher, she definitely is, she gets great results and stuff but she is cross and smile, she's full of the methods. When you ask her about teaching a topic, she never will say "they need to understand this", she will be like, "it's just change over original, times 100, percentage change". Or, oh it's just… and it's like, no I know how to work it out, that's not what I'm asking.(Interview 2, 20min 25s)

Alice was noticing differences in how you can talk about mathematics topics: Julia was talking about the procedure for solving items and during our meetings we regularly would focus on what students would understand from each task.

Regarding her position in the school, being an unqualified and inexperienced teacher, Alice told me she was not expected to follow specific lesson plans. She mentioned that the school had a scheme of work which was sparse, and they did not have any bank of resources. She told me she was free to teach in any way she wanted, and even confessed, "More so than I thought I would be" (Interview 2, 29min 54s). This impression Alice described was reinforced by how many times she told me she had had her students' books checked, only twice in seven months, and that she had been observed teaching just five lessons in two terms. Julia and her University tutor were the only two people observing her lessons and Alice mentioned that she was surprised by how little they had been inside her classroom. She said she liked the freedom to teach whatever she wanted, but there was a sense of loneliness in some of her comments, and a worry that she was not doing what was expected.

The project apparently worked as source of ideas for Alice, and even as a source of support. As she mentioned, I was the person who observed more of her lessons than anyone else, and she felt that I knew more about them than anyone else did. The activities in the PDI (e.g. lesson observations, informal talks and meetings) allowed me to stay in touch with Alice and be familiar with her lessons. My constant presence in her classroom, and the familiarity that emerged from this, according to my analysis, fostered her engagement with the project in general. Our relationship definitely became closer over the year. Alice frequently asked my opinion about a lesson I had just observed. She apparently trusted me as a mathematics teacher, because firstly she was happy with me helping students during the lessons; secondly we had some conversations during our interviews, when she would reflect on my questions and ponder my arguments (see Section 7.3.3).

Although I was gaining trust from Alice, the meetings when we were all together to talk about the project lessons were not always useful in Alice's opinion. Alice appreciated the fact that we talked about the thinking behind the ideas for the lesson plans, and that everybody could

make suggestions on them and on how to deal with some issues when teaching the lessons, but she said she would prefer to have the project lessons plans and an agenda of the meetings beforehand:

> I think it's just that thing of meeting time should be kept to an absolute minimum. An hour for a meeting is very long. I think you only really take an hour for a meeting if you've got an awful lot of things to decide, not to discuss. So I think the discussion time, which most of that I think is independent thought, that should be done separately when other people aren't there, Which is why you should send the lessons before. You read it, you're kind of knowledgeable about it, so you can talk about it, and you already have your questions in mind. (Interview 3, 15min 47s)

Differently from Julia, Alice was not seeing the meetings as allocated time to think about a specific topic. Alice wanted the lessons in advance, so she could have time to think about questions, as maybe being a novice teacher, it is harder to evaluate a lesson plan and ask questions about it just after a first read in the middle of a meeting. This might be different for Julia and David who are already experienced teachers, as neither of them mentioned the fact that the meetings were too long and that they wanted the material beforehand. On the contrary, Julia and David saw the meetings as opportunities to allocated time to think about the project lessons and about teaching them.

As mentioned above, the behaviour of students influenced Alice when it took time away from other activities in the lessons. It also affected the way she was teaching a lesson. When I asked her, "*To what extent do you think the behaviour of the student has an impact on the way you teach?"* she told me:

> it means that I like having a more structured thing, less group work, a lot less time spent with me feeding back from them, because I don't think they listen to each other very well. […] So that changes quite a lot which means that you end up talking more, which isn't great. So it does. (Interview 2, 41min 15s)

This way of dealing with poor behaviour in Alice's lessons would not encourage her to use different strategies with these groups. Actually,

during some of the project lessons, Alice was disappointed with students' behaviour. Her reactions showed that the Year 8 set 5 was regarded as a complicated group, which was confirmed during our meetings, with David and Julia commenting that the group had many complicated students. Teaching the project lessons for this Year 8 set 5 group might have been a less positive experience, but Alice perceived many benefits, and I was helping her to see past the behaviour by commenting on individual student achievement and the overall progress.

Moreover, an important aspect of the project was the focus on low-set students, therefore we were expecting this sort of situation. I had been observing Alice before she began teaching the project lessons and I knew she was generally able to create a good classroom environment with her Year 8 set 5 group.

The problems with behaviour preventing Alice focusing on other aspects of the project lessons were minimised when she decided to teach the lessons again to her Year 7 set 5/6. She perceived differences between the two groups, as she explained:

> The biggest difference was when you went and asked them about it they [students in Year 7 set 5/6] all had something to say. They could all give you some kind of justification in their words as to why I can do this and this and what implication that has on the answer. (Interview 3, 26min 56s)

Other than her new attempt with a different group (still a low set group), Alice attended the meetings to discuss issues from the project lessons beyond behaviour. The three teachers were able to focus on the teaching and learning of fractions during the periods we were gathered to discuss the project lesson plans.

As mentioned in the section about reflection (7.3.3), Alice was willing to commit to the whole project. That commitment was not just to teaching all of the lessons, but also to following the lesson plans. In that context, the project lessons plans were pushing Alice to change her practice. Alice commented on how the project lessons plans were easy to

follow, and she noticed some features of the lesson that were useful for engaging students, such as the cut-outs, the diagrams and the consistency on the layout of the worksheets.

The fact that Barichello brought the initial ideas of the tasks for the project lessons lessons, might minimise Alice's engagement with the planning and developing processes of the tasks. However, Alice was confident enough to make suggestions during the meetings and during our conversations, which demanded a deeper level of engagement beyond merely reading the tasks. Having something pre-planned also had the advantage of freeing time for her to think about the teaching of the lesson, and she did not have to worry about planning the next lesson.

When I asked Alice about how much she felt she was in control of the lessons when she was teaching the project lessons, and whether having students working independently while she was just walking around was a problem, she told me:

> No, not at all. In fact going forward, I would say that's a goal for my teaching, more independent learning the better, because obviously it's nicer for you if you can have a class who can independently learn, but equally it's just so much better for them, because whenever they're put under any kind of situation where we're assessing them, they're having to work independently so holding their hand through a question is kind of pointless. (Interview 2, 5min 08s)

Alice was pleased with the way students were learning during the project lessons and the style matched her aspirations as a teacher, as she described in the quote above. This congruence with Alice's ideal about learning might foster changes in her practice.

Alice and Julia showed engagement with developing students in low-set groups, but there were some differences in what they perceived as the means to achieve it: Julia was concerned with helping low-set students get better grades in their examinations and she believed students could do it; Alice, on the other hand, wanted students to be fluent and have better understanding of mathematical concepts that

would be useful for them outside school, and we should just forget examination results for some of them.

In any case, they both showed some kind of ideological motivation aiming at developing a fairer society, which is in accordance with them seeking better alternatives to their current teaching practices.

7.4. Alice: the process of change

Alice changed her practices during the project lessons, especially during the second and third sets of lessons (Table 5.5). I discuss these changes in details in Sections 7.2.1 and 7.2.2. Generally, Alice did not show a procedure that students were supposed to repeat. She adopted cut-outs and diagrams as acceptable tools to explain and justify answers in questions about fractions. She had fewer moments of whole class explanations and was able to interact with students using the vocabulary and the diagrams provided to talk about fractions of a square.

Looking at the change in Alice's practice through the Zone Model (Section 2.4.2) allowed me to say that she moved from her Risk Zone slowly into her Innovation Zone during the project lessons, i.e. she was trying strategies and approaches that were not familiar to her.

This process was gradual. Initially, Alice was not satisfied with the project lessons. Her evaluation about them was that students would not be able to move away from the cut-outs and would have difficulty in dealing with the word problems and symbolic representation. In any case, Alice was committed to her job and she told me that she wanted to see how things would go before considering leaving the project. Alice continued to attend the meetings and allowing me to observe her lessons. Eventually, she change her mind and considered the project lessons to be beneficial to students' understanding of fractions.

In order to better understand how Alice was able to move to and then act in her Innovation Zone, I tried to elicit and discuss the main factors that apparently influenced her changes and her engagement with

the project lessons in Section 7.3. These factors came from a variety of sources. They can come from the culture of her work – outside the classroom (such as the head of department endorsing the use of the project lessons), they happened during a lesson (such as student engagement) or came from her personal features (such as a desire to know different teaching practices). I organized these factors into four sub-sections above as a way to organize my analysis of the data, but most features are linked to each other.

Similarly to what had happened when I finished analysing Julia's data (Chapter 6), I was not able to formulate any firm and clearly delineated conclusion that explained the changes in practice I observed for Alice. The discussion presented so far suggests many possible features influencing her changes in practice and engagement with the project. An initial attempt to move forwards was to identify the situations (during the project) that could explain the development of Alice's engagement in the project. In general, the structure of the project showed many benefits for Alice, such as:

- The initial engagement between myself and Alice, such as observing lessons in her groups, allowed us to build a closer relationship;
- With time, and my constant presence in her lessons, Alice began to trust me, which generated more trust in the lesson plans she was asked to use;
- Using the lesson plans during many lessons (not only one task) ensured that Alice had a different experience in the classroom (in practice);
- My presence in the classroom while Alice was teaching the project lessons naturally generated comments afterwards as we both always had something to say about the lesson;
- Our discussions were easier because they did not have to rely on description, as I was there observing the lesson and

experiencing first-hand how students were getting on with the tasks;

- We frequently discussed changes for the next lesson and they were implemented and commented upon. This helped build Alice's agency and sense of ownership of what was happening in her classroom.

Since these situations were also true for Julia, I decided to look at the two chapters together. Reading the analysis presented on Chapters 6 and 7 and connecting it to the literature, I began to pull out factors that were influencing both teachers. The list varied from 13 up to 32 factors, and for each one I would consider what it represented, and check how it was influencing both Julia and Alice. After many rounds of analysis, I was able to finally identify the set of categories discussed in the next chapter.

Differently from what I presented in this chapter, the discussion in Chapter 8 theorises these categories and relates them to previous research. Also, as an attempt to strength my findings so far, I revisit the categories taking into account the data I have from David. Finally, I revise the categories of the change process in Section 8.2.4.

Chapter 8 Discussion

As discussed in the previous sections, I observed changes in Julia's and Alice's practices. The data showed that many of these changes were influenced by the project, and especially influenced by the fact that they were teaching the project lessons and following the lesson plans. I described the changes in practice while Julia and Alice were teaching the project lessons in Sections 6.2.1 and 7.2.1 respectively. Investigating the paths they travelled for each to be teaching in their Innovation Zone (2.4.2) helped me begin to answer the research question: *How do secondary mathematics teachers change within the context of a professional development initiative to innovate in their classroom practices?*

My approach to the analysis of the data was iterative, exploring the reasons behind one single teacher's change initially, then moving onto a different teacher to develop the analysis (see Section 5.3 for more details of the process).

In Section 5.1 and at the beginning of Chapters 6 and 7, I present the teachers, and explain characteristics that were apparently influencing their change in practice and engagement with the project. In Sections 6.3 and 7.3, I focus on building justifications for the changes considering teachers' characteristics and the PDI features. For instance, one change (described in Section 6.2.1.b) is about when Julia was following the lesson plan, particularly noting how students were progressing in the topic without extra help. One tentative explanation for this change is that Julia was following the lesson plan with the support of the PhD researchers (me and Barichello (2019)), whom she also trusted. This is evidenced through her allowing us to help students, and because she was implementing the lesson plan without any alterations. In that situation, Julia had a good experience in the classroom. She was positively surprised by how students were able to progress from adding fractions to

subtracting them. She said that students were able to "seamlessly transition to subtraction" (Section 6.3.3). Since there were other people in the room helping the students, she was comfortable in letting students try for themselves, probably allowing her time to walk around and check individual students' progress. In this short summary of this change, I elicit the categories of influences on it, 'following the lesson plans', 'positive experience', 'support', and 'trust'.

These tentative explanations are part of an account for the changes. It is obviously impossible to be certain about all the reasons affecting the change, considering the data available, but Section 6.2 onwards for Julia and Section 7.2 onwards for Alice present other changes and possible explanations. Comparing these tentative explanations for each change from Julia and Alice, has enabled me to propose a change process that encompasses both Julia's and Alice's characteristics and features of the PDI. I will call the categories discussed in this chapter 'components', because they are elements of my final version of the change process my participants went through. I want to differentiate the terms I use in this chapter from the previous categories I mentioned earlier, especially because for some of them the wording is similar, although they have different meanings. For instance, I used 'time' as a category that hindered Julia in changing her regular lessons (see Section 6.3.4), in this chapter I use 'time' as a characteristic of the PDI that allowed the participants and me to build familiarity and trust.

Additionally, as a way to strengthen the change process (presented below), I use the components as a lens through which to look at David's data. In other words, I investigate whether the components of the change process were also present for David, using his data to explore and expand the components further.

8.1. The change processes for Julia and Alice

The change processes I describe here are illustrative of the experience that both Julia and Alice, had during the project. The components of the process are the common influences acting on both teachers. The nature of these components are not always the same, as would be expected in any complex process, such as teacher change (Avalos, 2011; Opfer and Pedder, 2011). In order to explain how each component is acting, and how they might affect each other, I divide them into three areas: the cycle of experimentation, professional characteristics and the professional development initiative (PDI). Each section below will focus on one of these three areas.

8.1.1. The Cycle of Experimentation

When Julia and Alice were following the project lesson plans they were teaching differently from usual, as discussed in Sections 6.2.1 and 7.2.1. The teachers followed the project lessons plans for more than 10 lessons each. The project pushed the teachers to their Innovation Zone (Section 2.4.2), experimenting with something new in their practice. This was possible because they chose to participate in the project, and once part of the project, they followed the lesson plans and had a positive experience in the classroom that they were willing to repeat.

The sequence 'follow the lesson plan' and have a 'positive experience' is what I called **cycle of experimentation** of the change processes for Julia and Alice. These two components appear in many models of teacher change in the literature. One example is Guskey's (2002, 1986) model of teacher change. Guskey was one of the first to suggest that changes in the classroom would happen early in the process of teacher change. His model, shown in Figure 8.1 below, has the sequence "*change in teachers' classroom practice*" followed by "*change in*

student learning outcomes", highlighted in the red rectangle (added). This sequence of events can be seen as similar to the sequence I observed in my study: '*follow the lesson plan'* and have a '*positive experience'*, respectively.

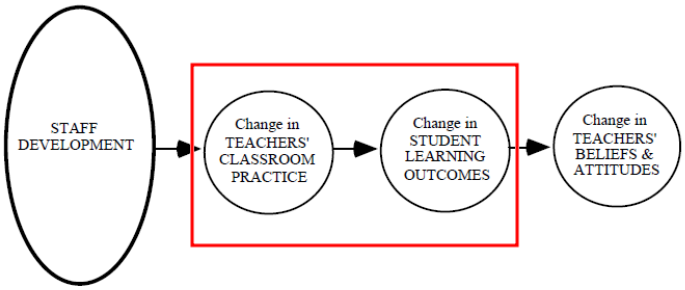


Figure 8.1: Guskey's model of the process of teacher change (Guskey, 1986, p.7).

Clarke and Hollingsworth's (2002) model contains Guskey's, but as discussed in Section 3.2, it includes many other possibilities for the path that teacher change can follow. Considering this more comprehensive model, again the red rectangle (added) highlights the part of this model (Figure 8.2) that matched my analysis of the changes I observed in Julia and Alice. However, this time, adding to the sequence the process by which change in one aspect of the teachers' world (or domain, as Clarke and Hollingsworth called it) is transferred to the other domain through enactment (continuous arrow), or through reflection (dashed arrows). Clarke and Hollingsworth (2002) explain that the term "enactment" can refer to the teacher's exploration of a strategy, and "reflection" can refer to an "interpretation as to what constituted the outcomes of that exploration" (p.960).

In my data, '*follow the lesson plan'* can be seen as the process of "enactment" and I also found that "reflection" was fundamental to teacher change in practice, not only to foster a '*positive experience'*, as I am arguing in this section, but also as a way to encourage teachers' curiosity and motivation to change (Section 8.1.3.g below). During my project, this process was not straightforward and came with more

difficulties for Alice than for Julia. Alice might not have changed without the external support, while Julia seemed much more inclined to accept and adopt change during my main study since we discussed the initial ideas about fractions in during the Reconnaissance Period (RP).

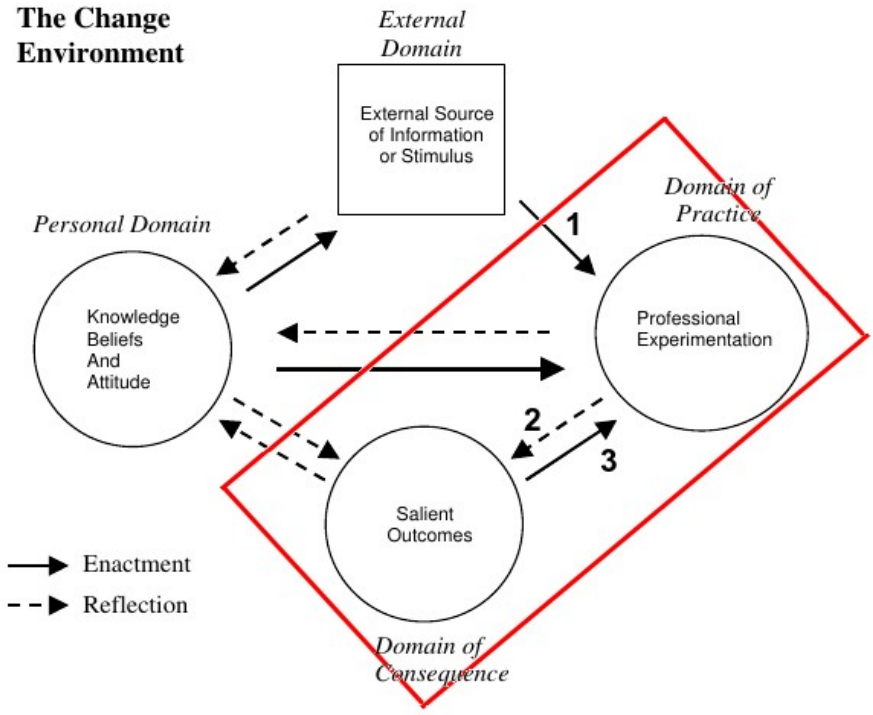


Figure 8.2: Clarke and Hollingsworth (2002, p.951) the Interconnected Model of professional growth.

A description of what I am calling 'the cycle of experimentation' of the change process in Julia and Alice, using Clarke and Hollingsworth's terms, would be that the teachers participated in a PDI (change in the external domain), then enacted a lesson plan (arrow 1). This enactment led to a change in the domain of practices, and through following the lesson plan, teachers reflected about the salient outcomes (arrow 2) and considered it a positive experience (change in the domain of consequences), and finally they enacted the other lesson plans again (arrow 3). This was just one example of how the Interconnected Model (Figure 8.2) can be used to describe changes in teachers. It allows descriptions of the changes I perceived from Julia and Alice, as exemplified above, but it does not explain the influences affecting them.

The components I am naming: 'follow the lesson plan' and 'positive experience' were already highlighted by different studies as fundamental steps in teacher change, but to the best of my knowledge there is no consensus regarding nomenclature. They form the cycle of experimentation of the changes in the models just mentioned, and also for Julia's and Alice's change process. Through considering the data from my study, I can investigate further into why Julia and Alice have '*followed the lesson plan'* and what fostered them to have a *'positive experience'* in the classroom.

The authors of the two models mentioned above, provide possible influences on the changes their models describe, but these influences are separate from the model itself. Guskey (2002, 1986) focused on aspects of a PDI, and mentioned clear presentation of the innovation, a credible facilitator, external support or pressure, feedback on students' learning progress, and personal concerns about how the teacher will be affected (Guskey, 2002). He also mentioned the importance of teachers' motivations for the success of professional development, but Guskey did not suggest how these aspects exactly affected the model (or the change process), nor how they related to each other, and how to achieve them in a PDI.

There is a similar limitation in Clarke and Hollingsworth (2002), when they present the Interconnected Model. The "change environment" (see Figure 8.2) consists of all the factors influencing change, such as staff and external tutors, resources and equipment, mathematical ethos, and professional development culture (Clarke and Hollingsworth, 2002, p.964). They finish the article recognizing that identification of these factors is important and relevant if we want to facilitate teacher change (Clarke and Hollingsworth, 2002, p.965), and this is as far as their study goes. They do not focus on how the factors affect the model.

So far in the literature these models illustrate accounts **of** the change process, presenting possible stages and paths of a change. I am

interested in accounts **for** the change process: specifically, what has influenced change to happen and explain the influences affecting change.

This section has focused on describing the two components of my study, 'follow the lesson plan' and 'positive experience', which can be seen as the cycle of experimentation for the change process. In previous studies they would be characterised as a change sequence, describing events that happened when a teacher was changing (explaining something that has already happened). However, I argue that these components would be more helpful in explaining reasons behind the changes if they are seen as desirable events that foster teacher change, that is, the project acted towards helping Julia and Alice to 'follow the lesson plan' and have a 'positive experience', as they were events that could enhance the change process. In this case, they represent the teachers moving towards the Innovation Zone and being able to experiment with something different in their practice, without it being too risky.

Julia and Alice did not follow the project lesson plans from the first day. Julia had the lessons she planned during the RP (Chapter 2) and Alice planned the initial lessons herself during the main project, but both of them kept engaging with the activities of the project, and chose to follow the lesson plans at some point: Julia since the first set of lessons of the main project and Alice from the second set. With the analysis of my data, I can suggest why.

The next section, 8.1.2, brings components related to teachers' characteristics that influenced them to move into their Innovation Zone, or to 'follow the lesson plan'. Section 8.1.3 focuses on the influences of the initiative that acted to ensure that Julia and Alice stayed in their Innovation Zones, or to have a 'positive experience' and sustain their participation. The following components will help explain how Julia and Alice achieved the balance of experimenting with new strategies in their classrooms without it being too risky.

Of necessity, I am presenting the components as a linear sequence in this text, but they were actually combined and mixed, appearing in various degrees and at different moments during the project. When all the components have been presented, I will be able to trace connections between them using the data, which will help to illustrate how they were acting simultaneously.

8.1.2. Professional characteristics

Julia and Alice had different agendas for their engagement with the project, as discussed in previous chapters. Julia wanted the low-set students to improve their learning and attain more than their perceived potential and to do better than they were expected to do (Section 6.3.2). Alice, on the other hand, told me she wanted her low-set students to learn only what they were going to use in day-to-day life. This statement is arguably naive, and it suggests that Alice is only repeating of-heard mantras. The issue of what mathematics is actually used for in real life is complex (Bakker, 2014). She did not think that the students would be going to pursue any mathematics related careers, and that they would be better off with understanding mathematics enough to be literate members of society (Section 7.3.2).

Even though their claims showed they had different beliefs about students and about mathematics, they both participated in the project and changed the way they taught fractions during the project lessons. This resonated with my decision of not considering teachers' beliefs as fundamental for achieving changes in practice, as discussed in Section 3.2.1). I agree with Clarke (1994) when he suggests that one of the 10 key principles from the literature for designing and planning a PDI should be to:

> recognise that changes in teachers' beliefs about teaching and learning are derived largely from classroom practice; as a result, such changes will follow the opportunity to validate, through observing

> positive student learning, information supplied by professional development programs. (Clarke, 1994, p.6)

My focus in this section is not on *beliefs* that were held by the teachers when they started to participate in the project, but on *features* much more directly related to their practices and that seem to have influenced their engagement with the project. In summary they are that both teachers were committed to their jobs; they were curious to discover ways to improve students' learning, and they both had good control of the classroom, i.e. behaviour management and time keeping.

a) Commitment to the job

Julia and Alice were both dedicated professionals, as far as my data could show. They were on time with their obligations in the school (e.g. book checking and marking), and complied with school procedures (e.g. implementing consequences, checking students' planners and attending meetings). They did not miss one day of school without justification, and did not arrive late or leave early.

Planning lessons is a big part of the duties of a teacher, and Julia was known in the school for spending many of her evenings planning lessons at home. This level of commitment seemed to be the result of her beliefs that any student could achieve and of the fact that she shared similar background to the students in Purple Valley. This commitment could also be seen in practices, such as making sure everyone had their notebooks in order, checking homework every week, developing many extra materials, and keeping her room very tidy.

Alice was a novice teacher (Chapter 7), still participating in a Teach First programme to get fully qualified. She had many obligations due this training course. Although she sometimes mentioned a meeting that had not been useful, she would attend and be prepared for all those occasions accordingly, e.g. preparing reports, lesson plans and schedules. In Purple Valley, Alice also seemed to be committed to the job. As a personal

characteristic, Alice believed that school was very important in general (Section 7.3.2). She was normally on time with her duties of checking students' notebooks, although she found the task very time-consuming.

In summary, Julia and Alice were good professionals although they did not seem to overload themselves with work during the school day. Julia might seem to be particularly dedicated when she planned her lessons in the evenings, but she was always spending breaks and free periods talking to the me or with other members of staff in her room, which might suggest that she felt more relaxed at the school and just preferred to plan lessons at home. What I am suggesting here is that "commitment to the job" did not mean that they worked more than was expected of them, it meant they respected the profession and complied with their obligations.

b) Curiosity

Alice and Julia first came to the project because David, the head of department, asked them to join the group, but they also mentioned that they were curious about the suggestions we were going to give (see Table 5.10).

Julia had met Dr. Gates before, during her teacher training degree and having him in the school fostered her engagement from the beginning, but she was still curious (and engaged) after he withdrew. Since the beginning of the project (even the RP), Julia recognized that low-set students had problems with retention (Section 6.3.3), and she had developed strategies to try to deal with that, such as having a *starter* covering previous topics, spending less time on the same topic and coming back to it over the year, as she told me during our interview in the RP.

Alice told me she wanted to seize every opportunity to learn about different strategies in the classroom. She mentioned that now, while still training to be a teacher, was the best moment to learn about different

ways of teaching. She seemed very enthusiastic about her own learning opportunities (Section 7.3.2).

The two teachers also expressed concerns related to their students' achievement and seemed motivated to find strategies to tackle these concerns, considering things they could improve on in their classrooms. For both of them I had the node "Dilemma" when coding the interviews. The difficult issue was about teaching procedures just to pass the examination, or teaching for understanding. In the analysis (Section 6.3.3 and 7.3.3), I found that this issue for Julia and Alice apparently worked as a motivation for them to maybe change their practice.

They were both curious to improve their teaching, and the focus of the project on teaching fractions with visual representations appealed to them as something worth pursuing. Curiosity, for Alice and Julia, is related to acknowledging that there is a problematic situation, not out of control, but that might be dealt with in a better way than they were doing. They both recognized that they applied methods that simplified topics to cope with pressures of time and students' lack of previous knowledge, such as using smaller numbers, showing an example first, providing a list of procedures, and asking students to work on repetitive tasks (Sections 5.1.1, 5.1.2, 6.3.1 and 7.3.1). The project might have attracted the two teachers because they were already concerned and interested in improving their practices.

c) Classroom management

As described elsewhere (particularly in Sections 5.1.1 and 5.1.2), students' behaviour in Alice and Julia's groups was good. I observed their lessons with different groups (see Tables 5.2 and 5.5) and it was rare to have any lesson with more than two moments of disruption; when this happened, the teacher would normally take only a couple of minutes to deal with it.

Other signs of their good classroom management were:

- **Julia** was an example to the department in terms of behaviour control, being asked to present her strategies for other members of staff, and having other teachers coming to her lessons to observe her teaching.
- **Alice** received positive feedback in relation to behaviour management during her lesson observations from Julia and from her tutor from the University.

Finally, they both mention being confident in controlling behaviour in their groups and both maintained a peaceful environment in their classrooms most of the time, which suggests a good relationship with students in general. They were also attentive to their students' attitudes in the lessons, both teachers demanding that students always pay attention, and not accepting what they considered to be unnecessary interruptions.

This component gains relevance when compared with the other two teachers in Purple Valley who did not participate in my research. During the RP (Chapter 2) I observed lessons from Otto and Omar, who did not continue with the project for the main data collection period. I will discuss some considerations of the reasons behind this in the section below.

d) When "no data" is the data

During the initial months of the RP (Chapter 2), there were two other teachers, Omar and Otto, involved in the project besides Julia and David (Alice only came to the project the next year). These two teachers did not participate in the main study, and did not even stay in the project during the whole of the RP. Because they left the project, although there were some meetings that one of them took part in, I did not interview them, and had only a few lesson observations and informal talks with them. In this section I will discuss the possible reasons behind their participation only in the RP. At the time, I merely set their data aside and

did not imagine that these reasons would resonate with the findings I have now. However, on looking back it seems to me that the reasons for their non-inclusion in the project were consistent with the outcomes for those teachers who remained.

The claims I am about to present are not in any way confirmatory proof of my findings, but similar to David's data being used to explore the components of the change process (see Section 8.2.3), the case of these two teachers allows me a different perspective with which to scrutinize this phase ('professional characteristics') of the change process.

I observed Omar twice before it was decided that he would not be part of the project. He was new to Purple Valley, and relatively new to teaching. I immediately noticed that students' behaviour was an issue for him, and he spent a lot of time focusing on it in his lessons. He expressed the view that the techniques he was trying to implement were not yet effective.

Considering the lack of data about Omar I cannot say a lot about his curiosity, although I remember some conversations when he mentioned that he wanted students to understand mathematics and not just memorize a procedure, which could be associated with commitment to the job. David, the head of department, advised against Omar's ongoing participation in the project a couple of months into the RP. Omar left Purple Valley some time after that.

The situation was different for Otto, the other teacher who decided not to participate in the main project. I observed seven lessons in his classroom during the RP, and although he was able to manage behaviour, he often had to use techniques to bring students' attention back to him, such as raising his hand and waiting until everybody in the room had raised theirs and stopped talking.

Otto's situation might be harder to interpret with the data (or the lack of data) about him, but some indications might suggest that he was not sufficiently curious about changing the way he was teaching. Otto

was an experienced teacher, with almost 20 years teaching maths. He told me he had taught in many schools, never staying in the same place for more than a couple of years.

During our meetings, I felt Otto was very assertive and used to offer names of books and authors to share his knowledge on matters we were discussing. He gave me the impression that he did not see his teaching as being the problem, but rather this was due to students' attitudes and limited prior knowledge. This might be interpreted as lack of curiosity to improve. Otto stopped attending the project meetings through his own choice after the third, and also did not come to the first lesson Julia was teaching. There was no big event triggering his dropping out, but David said that Otto was engaged with other things in the school and was no longer participating in the project. He also left the school shortly after that.

While Omar and Otto were not participants in the main project, they were briefly part of the RP, but with only a few lessons of theirs observed, I do not have data to make strong claims. Additionally, they were always very receptive to me and I am grateful for them for allowing me into their lessons. However, the situations I witnessed suggests that Omar still had issues with students' behaviour up to the point that it prevented him from teaching the way he wanted. For Otto, the classroom management was apparently under control, but he did not seem to be looking for ways to improve his practice. Although tentative, this interpretation of the 'missing data' from Omar and Otto reinforces the relevance of the three professional characteristics I identified as components from Julia's and Alice's change process, this time by omission.

Additionally, that they both ended up leaving the school, maybe is an indication that there were issues that needed attention before they would gain from the implementation of a PDI focused on change in practice. Otto and Omar might need different types of intervention before trying to change their practice in the classroom. This investigation of the

conditions of the teacher before implementing an intervention is not, to the best of my knowledge, largely considered in research initiatives.

My study only retained and used data of the teachers from whom it was possible to collect extensive data, since I was interested in understanding the process of change in practice. However, studies focusing on effective PDI are losing important information if they do not also focus on those teachers that do not attend the PDI.

e) Professional characteristics as pre-condition

I begin this section with two reasons why the professional characteristics presented here might not be commonly reported in other studies. Firstly, many studies regarding teacher change and PDI are focused on the implementation of a new curriculum or reform (e.g. Anthony et al., 2014; Edwards, 1994; Franke et al., 1998; Golding, 2017; Hodgen and Askew, 2007; Wood et al., 1991). A reform can be seen as the implementation of a policy, usually backed by administrators or governmental institutions, which places the initiative as official, differently from my study. My project was not mandatory, and no teacher was forced to participate. It is possible that this situation created conditions for the professional characteristics to be more evident, with teachers having agency and ownership in their engagement with the activities of the project. In research with compulsory curriculum implementation, issues related to curiosity, motivation and commitment to the job might be overtaken by issues related to understanding the new policy or thinking about how it would look when enacted in the classroom.

Secondly, the literature on PDI report almost exclusively on teachers that agree to participate in studies in the first place, suggesting they are more motivated and/or engaged than those teachers who do not. Desimone (2009), in her research on the impact of studies about teachers' professional development, briefly comments that the lack of

research with non-volunteer teachers as a problem to the generalization of studies about effective professional development. Bobrowsky, Marx and Fishman (2001) also showed that there is an absence of research that consider non-volunteer in the case of science teachers. They argue that results of effective PDI are based only on volunteer teachers, who tend to have similar characteristics and motivation. The scenario tends to be similar in mathematics.

In order to relate these components to other studies, I include some other concepts that are related to my components in the literature. Table 8.1 below summarises both the components grouped as 'professional characteristics' as well as the extra ones:

My components:	Commitment to the job	Curiosity	Classroom management
Similar terms used in the literature:	Motivation; Engagement; Self-efficacy; Take responsibility; Job satisfaction		Students' behaviour

Table 8.1: Components of the 'professional characteristics' in my study and in the literature.

In the literature on mathematics teacher development, it is common to have a mixture of the concepts above, with little distinction among them. These three components in my study are describing a dedicated professional, someone who enjoys and is committed to the job they have and will probably stay in the profession.

In my study, 'commitment', 'curiosity' and 'classroom management' were manifested through the teachers' behaviours. Research on PDI often mentions these components being influenced by the PDI, but not as a main component that influences change itself. For instance, Guskey (2002) mentions that support is necessary to promote encouragement and motivation when teachers are implementing changes (Guskey, 2002, p.388), but he does not suggest how support is translated into encouragement and motivation, nor how to tell when teachers are encouraged and motivated.

In a survey of 82 teachers participating in a self-declared effective PDI in England, De Geest et al. (2009) reported that among the factors contributing to effective PDI are:

> [t]o provide stimulation and challenge, the content of the [PDI] should be of interest to teachers and should aim to provide enjoyment through appropriately supported intellectual challenge (De Geest et al., 2009, p.80)

Their conclusions suggest that teachers themselves perceived enjoyment as important to an effective PDI. De Geest et al. (2009) reported enjoyment when teachers were engaged in working together in planning lessons with the appropriate support, suggesting some connection to 'commitment to the job' and 'curiosity' to learn about teaching.

Curiosity, meaning being aware of problems in one's own classroom and being willing to improve (as I described here), can be related to the search for a solution of tensions suggested by Chapman and Heater (2010). The authors reported on a teacher change process, where the teacher had to experience a cognitive and emotional tension, recognize the existence of that tension, interpret it as a problem, and search for a solution (Chapman and Heater, 2010, p.456). This process is similar to Julia and Alice being aware that there were things in their practices that could be improved and deciding to participate in the project to seek ideas for improvement.

This idea of creating and recognizing tension that will foster motivation to act is not new. Cobb, Wood and Yackel (1990) argue that their participant teacher only engaged in their project "when she began to realize that her current practice might be problematic" (Cobb et al., 1990, p.132). They suggested that the researchers were responsible for making the teacher aware of the problematic aspects of her practice.

Shaw, Davis and McCarty (1991) suggest a model for teacher change in which one of the three main components is perturbation. They argue that "a teacher will continue teaching a similar way unless

perturbed by something or someone" (Shaw et al., 1991, p.164). Following Shaw, Davis and McCarty's (1991) model, and the need of a perturbation to initiate change, Pehkonen and Törner (1999) investigated experienced teachers change in Germany. Considering a similar principal of "unfreezing; moving; and refreezing" from Lewin (1947), Kaasila and Lauriala (2010) investigated pre-service teacher change in Finland, and one of the first goals of their course was to create a disequilibrium in student teachers' views in order to prepare them to accept that they needed to change.

As these studies show, external sources can work as accelerators for uncovering problematic situations to teachers, but evidence from my data also showed that teachers themselves might notice dissonance in their own practices (Sections 6.3.3 and 7.3.3). Therefore, I choose 'curiosity' as a term to represent both possibilities for developing cognitive conflict: external sources or teachers themselves bringing up a problematic situation (awareness) that triggers their motivation to act, and sometimes this act can be change in practice.

As shown above, these professional characteristics are mentioned in a good deal of research, but most of the time they are not considered together and, apparently, they are considered less central in the process of change.

An exception to this is a study by Smith, Smith and Williams (2005) that placed *level of curiosity* as one of the elements aligned with the level of teacher change. The authors investigated change in 13 elementary teachers participating in a PD initiative. They found different levels of change among participants and suggest *initial interest* as one of the phases for the change process of teachers in which *level of curiosity* is the first construct in that phase: "those participants who had higher levels of initial interest and more fully engaged in each of the change processes, experienced greater changes in beliefs and practices" (Smith et al., 2005, p.11). The authors focused only on teachers' beliefs as personal aspects and the article did not provide information related to the

participants' classroom management or their commitment to the job, but the authors found links between participants' *initial interest* and the level of change in practice.

Lastly, the source of these features may not be the same for the two teachers. For instance, Alice might have effective classroom management in most of her lessons, because she had a background in sport, and being a participant in Teach First, and had to be confident and demonstrate leadership qualities (Chapter 7). Julia, on the other hand, might have developed classroom management skills over her many years of teaching experience. She mentioned in an interview that she is much more relaxed now than she was six years ago. Julia and her students share a common background, and this amongst a number of other factors, might foster their communication and improve her ability to maintain a positive classroom environment.

Even considering that Julia and Alice's professional characteristics described here were coming from different sources, they provided a similar starting point for both teachers. Having different sources for these professional characteristics is plausible if we consider how many people with different personalities, and diverse backgrounds, etc. choose to be teachers, and manage to do the job. It would be useful to teacher education to have a set of important characteristics that with adequate training could be developed into professional characteristics desirable for teachers who are able to change.

These three components, 'commitment to the teaching job', 'classroom management' and some level of 'curiosity' were common to both teachers when the project began, and they remained fairly constant during the year to the extent that both teachers decided to teach extra lessons related to the project (see Table 5.1). These components were key aspects for the development of the project, leading the teachers to 'follow the lesson plans' and to have a 'positive experience' with the project lessons. Additionally, it is important to notice that these components were not the only ones acting on Alice and Julia when the

project began, but they were present for both teachers and apparently absent for the two teachers who only participated in the RP. In all, this suggests they might be a requirement for a PDI focused on changing teachers' practice, to work. Therefore, as possible pre-conditions for a PDI to work, I suggest that having these professional characteristics in place facilitated Julia and Alice to move to their Innovation Zone during the project lessons.

I will discuss how these components of professional characteristics and the cycle of experimentation components (Section 8.1.1) were combined and sustained during the whole project, after I describe the influences emerging from the characteristics of the professional development initiative, which is the focus of the next section.

8.1.3. Professional Development Initiative

The plans for the professional development initiative (PDI) in my study were described in detail in Section 4.2. Many episodes where I describe each of the two teachers also include features of the PDI that fostered or hindered teacher change. While analysing the influences on both Alice and Julia, I found that the role of the researcher in this project played an important part. In this section I explore components for the change process that came from my actions during the project, observing lessons, planning and mediating meetings, interviewing and engaging in informal talks. I named this group of components as 'professional development initiative'

Critical features of a PDI are widely described and discussed in the literature; for instance, Garet et al. (2001), Borko (2004), Desimone (2009) and De Geest et al. (2009). Desimone (2009) suggests that there are five critical features of every PDI that should be measured in order to allow comparison between them. She presented these five features as being the ones well established by researchers, using diverse perspectives and methodologies, to be characteristics of effective PDI: content focus, active learning, coherence, duration and collective

participation. While Desimone was focused on developing better conceptualizations and measures, with the goal of comparing PDIs, she did not focus on how these features related to each other and how they made the PDI more effective.

Other researchers noticed this gap. For instance, Opfer and Pedder (2011) in a review of the literature on teacher development suggested that many studies in the area lack "explanatory ability" (p.376) and they added:

> What should determine which set of activities, systems, structures, and so on are necessary for teacher learning to occur should depend on an understanding of the different ways that **these elements interact with each other, with contexts, and with characteristics of individual teachers**. (Opfer and Pedder, 2011, p.394, my emphasis)

In this section, I explain the components of the initiative in my study that were most prominent in my data as affecting teacher change in practice. The lack of definition of the terms was also problematic when reviewing the literature (Sztajn et al., 2011). Simply listing the terms, or presenting short sentences explaining the features of a PDI masks the clarity of what studies meant by those terms. For that reason, I explain each of the components below using episodes observed during my data collection to illustrate their meaning. The single words used as titles of the subsections do not bring out their full meaning, as they just summarize the concepts.

a) Time

As discussed at the beginning of Chapter 7, Alice asked to plan the initial lessons of the project, and I did not push her to use the project lesson plans. For the initial four lessons (see Table 5.5), Alice planned her own lessons with the ideas we discussed during the previous meetings, deciding the order of tasks and preparing the worksheets, rather than using the lesson plan we discussed during the meetings. For the second

set of lessons, Alice decided that she was going to use the lesson plans we developed. Julia also took a similar path, as she planned the lessons for the RP (Chapter 2), and for the main project she said she was open to doing anything I suggested.

These situations suggest that the two teachers did not fully engage with the project from the beginning. Only after some meetings discussing the project lessons they agreed to teach using the project lesson plans. It is important to mention that the time elapse itself was not making teachers use the project lessons, but during this initial period we had more meetings to discuss the project lessons plans (Section 5.2), allowing teachers to learn more about them, building familiarity and confidence in teaching the project lessons. Additionally, I was also observing their lessons and teachers saw, and trusted, that I was willing and able to provide useful support during the implementation of the project lessons.

In the episodes above, time is regarded as not rushing the teachers, so Julia and Alice decided when they would start to use the project lesson plans. I observed a different use of the term 'time' than in other studies. Time is commonly mentioned in terms of the time-span of the PDI or, as Desimone (2009) called it, the duration of the PDI. Also, De Geest et al's (2009) participants mention allocated time to engage in the PDI as a feature to foster effectiveness. According to Julia and Alice's comments during the last interview, these two aspects of time were also important to them.

> Julia: I think having the time to think and reflect is something that I quite appreciated about those meetings, because sometimes, for me, if you just give me something to read, where do I find the time? It is almost like being forced into reading and talking about it, just like that time is allocated to that. For me, I think that was quite useful. (Interview 3, 26min 26s)

A different aspect of time is what Hargreaves (2005) called *change takes ages*, in a study considering teachers' age and their stage in the

career, where he suggests that it is an important factor to consider when trying to implement change. According to Hargreaves' classification, Julia was a mid-career teacher and Alice an early career teacher. It is not surprising to have them acting similarly towards change in general, but their reactions to change might differ dramatically depending on other circumstances, such as the type of school, and the generation of the teacher.

Additionally, it was clear during my period in the school that with the longer duration of the project, more happened (more meetings, more familiarity being developed, and more lesson observations), all of them leading to more changes in teachers' practices, and yet making it harder to isolate the influences that time, duration, and teachers' pace had on the overall development of the project.

b) Trust

After the RP for Julia, and the first term for Alice, both teachers trusted the project enough, to the point of agreeing to teach the project lesson plans as they were. I believe this trust was built alongside the lesson observations: when I did not judge the teacher, but demonstrated an honest interest in what the teacher was doing in the lessons. Also, a trust in terms of content knowledge was developed when we discussed mathematics during the meetings, or after a lesson. The interviews were confidential situations that valued teachers' opinions. Finally, their views and experience as teachers were valued when they gave their suggestions for the project lessons, which were implemented into the subsequent lesson plans.

Many studies consider the role of the facilitator as being someone that teachers need to trust (Borko, 2004). This aspect has been brought up a lot in research on PDI that focuses on video, with examples being the studies from Coles (2014, 2013), where noticing and discussions are key elements, and the use of non-judgemental comments is identified by

Coles as key for the effective development of the meetings with the teachers. Also, some PDI have group discussions as their main focus. For instance, Crespo (2006) investigated study groups with a facilitator being responsible to take the participants into a productive cycle of discussion. Group discussion is also one of the phases of the Japanese Lesson Study (Silver et al., 2006; Yoshida, 2008), involving an experienced teacher as facilitators with other teachers planning a lesson.

The role of a facilitator or a knowledgeable other in leading the session (meeting) and planning material (lesson plan, task) are similar to what myself and the other PhD researcher were doing in my study. Although I might not be an experienced teacher in this context, I had a different type of knowledge than the teachers, and probably could not teach a lesson as smoothly as they could, being less knowledgeable about the English context, curriculum and of the school context in general, but I had read more research about the topic they were teaching.

Considering these diverse roles I had, trust at different levels was important to implementing the project as planned. Some obvious areas in which trust was achieved, were as mathematician, as observer and as facilitator in meetings. The three teachers, after some time, became comfortable in discussing mathematical topics with me, even if it was not fractions. They constantly asked my opinion after a lesson, and the atmosphere of the meetings were light and relaxed. We asked each others' opinions and impressions, demonstrating respect and interest.

We developed trust over time, with me being cautious not to overload teachers, but still providing useful suggestions. I was constantly aware that circumstances might change due to external events, such as examinations, visits from Ofsted and parents' evening. Additionally, I always valued teachers' views, knowledge and experience.

c) Familiarity

Familiarity was developed mostly through the many lesson observations I had from each teacher, up to the point that I knew most of the students by name. In this respect, the time fostered the building of familiarity. Julia and Alice were aware of how much familiarity I developed with their classrooms, and Alice told me once that,

> I don't feel like anyone really knows what happens in my classroom actually. You probably know more than anyone else, seriously. (Interview 2, 30min 18s)

This high level of familiarity afforded us the opportunity to talk about the particularities of each group with a shared knowledge of the situation that the teacher did not have with anyone else in the school.

With familiarity being built and reinforced throughout the year, Julia and Alice were both comfortable in taking suggestions from me. They were aware that I knew their lessons and their students and was in a privileged position to suggest practices they found acceptable for the specific context. This adequacy of suggestions was also one of the design principles of the lessons, mentioned in Section 4.2.2, and it helped to enhance the congruence (see Section 8.1.3.e below) with the teachers' own lessons.

Publications on how to do qualitative research suggest that familiarity with the context is needed to increases the trustworthiness of the study (Shenton, 2004). Although I have already discussed this issue in relation to this study in previous sections (Sections 2.2 and 4.3), what I am suggesting here is a parallel between familiarity, as a component of my conclusions, and the criteria to increase trustworthiness of a qualitative study. The fact that I knew a lot about the specificities of Julia's and Alice's groups increased the credibility of my comments and suggestions to them, at the same time that it increased the trustworthiness of my analysis.

Julia and Alice often asked my opinion about their lessons, as I just mentioned, and they said they liked it when I was in the classroom. This indicates that they were aware of the familiarity we had built, and they seemed happy to take advantage of it, since they trusted me (and my opinions) as a teacher.

d) Support

There was support for the teachers in the project in different situations. One common situation when I was consciously focusing on supporting the teachers was just after the teachers had taught one of the project lesson plans. Aiming at enhancing Julia's and Alice's experiences with the project lessons, I focused on:

- allocating time to discuss the lesson considering what worked and what did not work during the lesson;
- listening to teachers' impressions and suggestions for changes for the forthcoming lessons;
- supporting by encouraging the teachers to focus on the positive moments in the lessons;
- suggesting ways around the problems teachers had mentioned.

During the project lessons, and many other lessons observations, I reserved some moments to help the teacher in general. This support was appreciated by Julia and Alice, as after some time I was not a stranger in the classroom, and I knew the teachers' routines, helping with small jobs, such as distributing worksheets, reminding teachers to do the register, helping students at their tables and even pointing out issues or mistakes I saw on the board or on a worksheet.

The head of department, David, was another source of support. His participation in the project highlighted that the project was valued by the school. Therefore, the support provided for Julia and Alice was at many levels: administrative (David), knowledge (discussion in the meetings),

emotional (conversations) and in the implementation (lesson observations).

Support is mentioned in many studies investigating teacher change and effectiveness of PDI. It is among the characteristics in studies that summarize effective features of PDI, such as in Clarke (1994), Borko (2004) and Joubert and Sutherland (2008), but explanations of how this support can be implemented and/or sustained are very broad and brief. Clarke (1994) even points out that:

> Many examples of change projects can be cited that put almost all resources into the in-service aspects of the project but failed to provide appropriate support in the actual implementation. (Clarke, 1994, p.9)

I opened this section by listing the actions we took that apparently fostered teachers' feelings of being supported. My constant attention to the issue, respecting teachers' timing and limits, was effective for Julia and Alice, who also had their professional characteristics in place (Section 8.1.2), encouraging them to maintain engagement with the project.

Julia planned and taught a lesson using a slide animation to teach equation of a line, see Section 6.2.3.a. My support influenced her during this episode. After one of her lessons, we talked about students only memorizing how to find the 'raise' and the 'run'. The same afternoon, Julia wrote an email with the slide animation she developed to use in the next lesson. I answered her email with other ideas and she incorporated them as a *starter* activity. The next day, I observed this lesson and we discussed the results of the use of the slide animation, and how the next lesson should be. I was a source of encouragement and someone to talk to about events that had happened in that lesson. Nobody else had the knowledge about her lessons as I did, and since Julia was unsatisfied with her practice, with my support, she felt safe and encouraged to try something else.

Alice clearly enjoyed having feedback on her lessons, as she always asked me for my thoughts. She frequently commented on the

tasks she had used and contrasted her expectations with the reality. My presence represented someone Alice could to talk to and reflect about her practice.

e) Congruence

Knowing the teachers and their lessons facilitated the design of project lessons that suited the teachers by including some of their common practices, as we did not want to put Julia and Alice in their Risk Zones (2.4.2). The project lessons were designed to have some innovations, but still allow the teacher to teach the lesson in a dynamic similar to their regular lessons.

As Doyle and Ponder (1977) suggested as a phase of their practicality ethical model in terms of recommending innovation for teachers, congruence is "the extent to which a proposed procedure is congruent with perceptions of their [teachers'] own situations" (Doyle and Ponder, 1977, p.7). In the project, for instance, in Julia's lesson students were kept at the same tables as usual, and the feedback was similar to that in her regular lessons: Julia showing the worksheet under the visualiser and asking students for suggestions. The innovations (Section 4.3.1) were mainly that Julia did not show what students had to do to solve a task (there was not a list of steps to follow); there were many ways to reach a solution for most of the tasks; students could use, and were actually encouraged, to use shapes and diagrams to justify their solutions.

For Alice's group, the innovations were the same as for Julia, but students were asked to sit in groups, since she was more used to having her students changing seats. Alice felt better solving one of the final items at the end of the lesson as a way to ensure every student had seen a way to solve that task, while Julia on the other hand did not feel the need to do that with her group. The project lesson innovations allowed the teachers to experience slightly different elements in a lesson, but my

data showed that this was only possible because I knew the usual way the teachers were used to teaching, and, most importantly, offered the possibility for the teacher to decide: Julia and Alice had the final word on the lesson, and the project did not take away their agency and/or ownership of their decisions in the classroom.

Some congruence was also maintained in the teacher-student relationship. Although Julia and Alice were not showing a procedure to solve the items on the tasks of the project lessons, the general dynamics of the lessons did not change completely. The teachers were still the authority, walking around the room helping students progress.

My data did not suggest that students struggled because they did not have a clear procedure to follow. On the contrary, the visual elements were apparently enough to allow students to solve the tasks, which suggested that the careful design of the project lesson plans was also affecting students' engagement positively. The issue of design is discussed further in Section 9.2.

Abrupt changes in the norms in the student-teacher relationship seem to be problematic. Wood et al. (1991) described how a teacher had to reconstruct and negotiate new classroom social norms with students, as part of the evolving change. Lubienski (2002b), when she tried to implement whole class discussion in her group of students, found barriers to engage all students, because not all of them could cope with their new role in the classroom. Anthony, Hunter and Thompson (2014) also mentioned that the teacher "needed to regularly reiterate or model the norms for group work" (p.285) in order to help students to work productively in the new arrangement.

The three studies mentioned above suggest that the norms of teacher-student relationships should be considered when investigating changes in classroom practice. This topic has been under research for some time. The paper from Doyle and Ponder (1977), mentioned earlier, is about the teacher decision-making process, when it comes to adopting and continuing the use of an innovation in their classroom. The authors,

drawing from data of previous studies, argue that "many procedural recommendations for the classroom simply lack ecological validity" (p.5). The teachers need to see that the innovation is practical, so that it can be used in the classroom. The authors ask "What determines practicality? In other words, what attributes of a change proposal tend to elicit the perception of practicality from teachers?" (Doyle and Ponder, 1977, p.6). A tentative answer is the "practicality ethic" model, formed of:

1) Instrumentality: referring to what the teachers need to know about the innovation;

2) Congruence: is similar to what teachers already do; the teacher recognizes the previous experiences with the innovation as having been done in a similar setting as his/her own, or the person talking about it is someone to be taken seriously (similar to trust in Section 8.1.3.b); the innovation maintains the teachers' "preferred mode of relating to students" (p.8);

3) Cost: related to the benefits of implementing the innovation.

Doyle and Ponder (1977) conclude that these ideas could be used to inform "how to construct materials, which will have a greater chance to change classroom practice" (p.9), which was the goal of the design-principles of the project lessons (Section 4.2.2).

Although this issue of congruence has been around at least since the 70's, to the best of my knowledge not many PDI take it into consideration. Moreover, studies investigating PDI also give little attention to this. My data suggests that maintaining some balance between practices with which teachers were already familiar, and novelty, was beneficial in allowing teachers and students to have a smooth acceptance of the different lessons.

f) Discussion

The project had meetings and interviews planned in order to foster discussions about the lesson plans and the experience of the teachers

while teaching the different lessons. The planned agenda of the meetings included teachers solving items from tasks of the forthcoming lessons, looking at some selected students' solutions and answering questions about the previous project lessons (Section 4.2.1.a).

This variety of discussion triggers was planned to elicit conversations about aspects of the lesson we thought were important at each moment. The teachers' participation was fairly constant and balanced between the three of them.

During the meetings, having teachers commenting on their experience with the project lessons in their own classrooms was especially important. For instance, Julia rarely observed lessons from other teachers, and hearing how the lessons had developed in Alice's group was showing problems that Julia did not expect.

This suggests that sharing practices with colleagues was helping teachers to become more aware of their actions in the classroom. Hearing about Alice's issues in the classroom, after teaching a similar lesson, allowed Julia to describe her actions to avoid or overcome undesired situations. This was only possible because each teacher had a similar experience in the classroom and then came together to talk about it.

Other researchers suggested sharing practices with colleagues will influence also teachers' beliefs. Goldsmith et al. (2014), in their synthesis of research on mathematics' teachers learning, summarised one of the findings of research regarding teachers' collaboration:

> Collaboration with colleagues can spark the need for teachers to explain their practices and to articulate rationales for instructional decisions, help teachers to make tacit ideas visible, subject ideas to shared scrutiny, and develop deeper, more widely shared understandings of students' learning, thereby influencing teachers' beliefs. (Chazan et al. 1998; Horn 2005; Kazemi and Franke 2004, in Goldsmith 2014, p.15)

Although my study does not focus on beliefs, I argue that the actions described in the quote above also influence teachers' practice, as my data showed. My aim in promoting discussion of the teachers' practice is aligned with ideas presented by Jaworski (2008) when she talks about community of inquiry. Jaworski suggests that:

> through goal-directed action in communities of practice, participants explore, inquire into, their own practice with the motive of learning how to improve the practice (Jaworski, 2008, p.320)

Again, my study was not focused on creating a community of practice, or a community of inquiry, but our discussions were apparently pointing towards the development of some degree of collegiality among the teachers focused on their practices.

Additionally, one of the reasons that Alice was encouraged to continue using the lesson plans after the first term, was the account of the lessons Julia and David gave in the meetings, since Alice was not fully satisfied with the salient results of the first lessons (see the beginning of Chapter 7). Hearing positive accounts from the other two teachers encouraged Alice to follow the project lesson plans in the second term. This is similar to what was found by Britt et al. (2001) regarding professional conversations encouraging teachers to try new approaches in the classroom.

The possibility of talking to others about the project also allowed the group to create a shared understanding of the project lessons. This can be seen in teachers' actions that naturally emerged throughout the project lessons, such as teachers accepting visual arguments from the students; asking questions of a different nature than they are used to in regular lessons; and identifying students' answers that would enrich further discussions.

The component 'discussion' includes two aspects that are largely reported in research on the professional development of mathematics teachers. The first one is the role of the researchers as facilitators,

leading the group into important topics and maintaining the focus of the meetings. This is seen as a key feature in Clarke (1994) and in Borko (2004) who both mention that it has to be a credible person; Desimone (2009) mentions that the facilitator's expectation might be also critical in PDI effectiveness; and De Geest et al. (2009) found out that teachers themselves consider the leader or tutor an important factor in an effective PDI.

The second aspect of discussion during the meetings is that this was one of the few moments when all three teachers were together and talking about the project. These moments constitute opportunities for teachers' collective participation (Desimone, 2009), networking (De Geest et al., 2009) or the creation of a professional community (Borko, 2004). It is difficult to distinguish between these terms, but in these three examples the researchers associate the encounters of teachers with teachers' learning. In my study I perceived that teachers' discussions opened up the possibility for teachers' learning about the following: the new lesson plans; teaching strategies; students' common misconceptions; and content knowledge about fractions. I discuss teacher change as learning as one of my assumptions for this study in Section 3.2.

Although there were other situations where learning might have happened (the component 'reflection'), the moments in my study of guided discussion, talking about topics related to their practices, provided further evidence of why putting teachers together to talk about their practice can lead to effective professional learning.

g) Reflection

Reflection can be a result of discussion, but it can also be an independent act of the teacher. In this thesis I use '*reflection'* to refer to the latter. Julia told me that she was reflecting more about her lessons (Section 6.3.3), and this helped her to choose more suitable tasks for the

goals of the lessons she was planning apart from the project. Besides this self-reported example of reflection, both Alice and Julia commented on the fact that students were solving the items of the project lessons without being shown a method first (Sections 6.2.1a and 7.2.1a). This is reinforced by the fact that during our interviews they both suggested other topics that they thought could be done using a similar strategies as the project lessons (e.g. slide animation to show gradient and slope in Section 6.2.3.a, cut-outs and diagrams in Section 6.2.3.b, showing an example and not a procedure in Section 7.2.1.a).

The reflection moments happened during interviews and informal conversations. The interviews had a semi-structured format (Section 4.3.2) and I frequently tried to encourage teachers to expand their comments on the topics we were talking about. On the other hand, in the informal conversations that were expected, though not planned, it was common that teachers had questions they wanted to ask me or comments on the lessons they had just taught, suggesting that they were reflecting on those lessons.

My data suggests that Julia and Alice were able to notice and reflect about the design principles of the project lessons (4.2.2). They both realised they were teaching differently from how they normally did during the project lessons. This might have fostered their understanding of the innovation they were using and consider that innovation for other topics, as they did in our interviews.

In many other studies "reflection" is related to teacher learning (Reinholz, 2016), the teacher being able to change (Clarke and Hollingsworth, 2002), and the teacher considering the benefits of changing (Clarke, 1994; Smith et al., 2005). This was the case for Julia and Alice in my study. Reflection about their practice in general (about old and new practices, possibilities, impressions and future practices) helped the teachers to keep the cycle of experimentation and positive experience.

Reflection was manifested many times during the project in the form of comparison, when Julia and Alice were comparing the project lessons with their own practices. For instance, in the episode when Julia mentioned her other lessons about fractions, (Section 6.3.3), she said she cringed thinking that students only memorized mechanical procedures and did not have any understanding of what they were calculating when they performed the procedures. A similar situation happened for Alice, when she compared what her students in Year 7 set 1/2 were not able to do. They knew how to add two fractions, but not a fraction and a mixed number, and she attributed that to the way she taught fractions to them. At the same time, her Year 8 set 5 (the lower set in Year 8) did not have the same difficulties, because they were taught with the project lessons and they understood the meaning of a fraction and a mixed number, concluded Alice.

Comparison between their regular ways of teaching fractions and the experience of teaching the project lessons was apparently powerful in highlighting weaknesses and strengths of the two different methods, fostering the impression of a *positive experience* (Section 8.1.1) with the project lessons.

Julia and Alice taught the project lessons following the lesson plans, allowing themselves to have the experience of teaching the same topic in two different ways. That situation eliminated issues of only presenting hypothetical new practices to teachers, such as, when teachers say that "this will never work with my group", "this teacher has fewer students", "this school has more resources", etc. Actually, teaching both ways, having a clear example of how it can be done differently, enabled Julia and Alice to re-evaluate their practices, and potentially change the way they teach.

The comparison of the new practice (the project lessons) with their own previous practice, allowed Julia and Alice to see more concrete evidence of the differences in both experiences, making them more meaningful to the teacher, because the practices happened in very similar

contexts (same school, same teacher, similar students), see example in Section 6.3.3. I argue that these comparisons can be a way to allow teachers to access their tacit knowledge (Polanyi, 1966). Julia and Alice had the impression that the project lessons worked better than their regular lessons and they tried to tell me some reasons, but they probably "kn[e]w more than [they] can tell" (Polanyi, 1966, p.4), and the cringing episode from Julia suggested that this was the case for her.

Therefore, I suggest that creating the opportunity of comparison, in reference to the possibility of comparing one's current practice with a new practice implemented by oneself, might be a powerful tool to foster the understanding and incorporation of the new practice, without the need for the teacher developing an articulated and precise vocabulary to explain the two practices.

h) Closing remarks

In the sections above, I have described seven components of the process of change observed with Julia and Alice: time, trust, familiarity, support, congruence, discussion and reflection. I provide examples from my data to elucidate the meaning of each term. I also discuss other research that presents similar ideas in the area of teacher professional development. As it is easy to present literature for all the components, it could be argued that the individual components discussed here are not a new contribution to the field of professional development. The novelty lies in the suggestions about how these components influenced each other, as I began to show in some of the discussions above, and in the relationship of the three areas of influence discussed in this chapter: The cycle of experimentation (8.1.1), Professional characteristics (8.1.2) and PDI (8.1.3). The next section will describe the change process as a whole, highlighting how the components elicited from my data explain Julia's and Alice's changes in practice.

8.2. Explaining the process of change

The descriptions of the components in the previous sections were already revealing connections among the components in each section. In this section I present two episodes, one from Julia and one from Alice, to further illustrate these connections. I am not claiming that these episodes are always the path a teacher will follow in a similar context, nor that these sequences of events are guaranteed to happen, or that they are the steps to achieve teacher change. My aim is to illustrate the complexity of the phenomena, highlighting that the influences presented here were key for Julia and Alice's engagement, and that they were key aspects of the project enabling them to enter their Innovation Zones.

I also present a discussion about David, my third participant. His data allowed me to strengthen and refine the components elicited previously from Julia and Alice's experience.

8.2.1. Julia

In the beginning of the academic year 2015/16, Julia was teaching the project lessons to her Year 8 group, and at the same time, she was also teaching fraction sums to her Year 9 group. The lessons with Year 9 were based on "her other way to teach fractions", not using cut-outs and diagrams, but only showing the procedures to get to the final answer for each one of the four fraction operations. When we talked about it during the third interview she said:

> If there is something now that is just in my mind it is like... I remember saying "When I was teaching the other way" the rote learning that I went with my Year 9, it was making me kind of cringe 'cause there was part of me thinking "they don't really know what they are doing here, they are learning a method, and fine, that might get them marks on the exam", but they didn't actually have any idea. (Interview 3, 37min 40s)

The involvement with the project helped Julia to re-evaluate her teaching of fractions. She perceived differences between the two ways of

teaching (her other way and the project lessons) that troubled what could be called her beliefs about good teaching. Experiencing a "cringe" about her way to teach fractions, indicates that Julia reflected on her own practice through comparison, and concluded that it was not the best way to teach her students.

This reflection and comparison process might have led her to realise the impact her teaching can have and what prevents her teaching the way she sees as the best for students:

> For me it has been a realisation that sometimes we do things and they [students] don't really understand what we are doing, but we do it because time is limited, you have to get exam grades. So I think I will be always conscious of not necessarily going back to default mode with fractions. (Interview 3, 37min 50s)

The reflection generated a dilemma between "rote learning" and "understanding" for Julia. This dilemma suggests that she perceives the lessons with "rote learning" as being easier to plan (and to teach), at least for the topic of fractions, in comparison to the project lessons. As her comment suggests, the "default mode with fractions" is related to rote learning and students not understanding the procedures they are applying. Lack of time, both to prepare lessons more carefully and the pressure to teach only enough so students can solve the questions on their examination, prevent Julia changing her teaching.

These two factors (time and examinations) make the decision of not focusing her teaching on procedures harder for Julia, even considering the benefits of other approaches to students' understanding. Julia initially tried to justify her way of teaching fractions, but she was already struggling with her decisions in our first interview:

> I mean, fractions is one of those topics where kids, I don't think really understand what they are doing. Like what are they doing when they multiply the numerators? I don't think they understand. What are they doing when they flip it around? But, I don't know, for some classes and again, this is maybe a culture, like a practice change almost, the amount of effort you have to put into that just for 2

> marks in an exam. But then, I don't know? Is it right? Do you see what I am saying? (Interview 1, 42min 32s)

These situations suggest how Julia was re-thinking her practice and looking for legitimation for her choices. She was experiencing the need to justify her practice, and this process made her more aware of its characteristics and consequences. This awareness is very important for teachers to be also able to change their minds, and to convince themselves, and eventually others, that what they are choosing is suitable for the context and goals they have at that moment.

Julia trusted me enough to share this struggle, which also suggests her curiosity and commitment to her job when she is trying to work through what is the best for students in this situation.

8.2.2. Alice

During our talks and interviews, Alice displayed concern about some complex issues related to teaching, learning and knowing. The quote below is a good representation of Alice's dilemmas that appeared in many moments throughout the year. This specific example was part of our second interview, which happened just after she had taught the second set of the project lessons. Alice was talking about her Year 7 set 1/2 group, which was not taught fractions with the project lessons:

> When I first gave adding fractions to my Year 7 set 1 they couldn't do it. Then I taught them a very numerical method and then they could do it straight away. The thing I found interesting with that was I think if you can add fractions and you understand it, then doing something like converting a mixed number into an improper fraction, like one and a half into three halves, is like so easy. I don't think there is anything [extra]. […] No, not really, in terms of understanding there isn't and yet they couldn't do it until I showed them how to do it. So that was very illuminating for me […]. They couldn't see that to add 3 and a half and 2 and a quarter, you just add 3 and the 2 and add the… they just were completely thrown by the question because they hadn't been taught the method. Whereas if they'd have been taught it this way [with the project lessons] I don't think that would've been a stumbling block for them. (Interview 2, 9min 37s)

After teaching her group how to add fractions with a numerical method, Alice was expecting them to be able to add mixed numbers. She was surprised that being able to use the method for adding fractions was not enough for students to extrapolate their understanding to mixed numbers, even for a top-set. She then compares this episode with her students in her Year 8 set 5, the group with which she followed the project lesson plans, and where most of the students did not have a problem when the task in the project lesson plan presented an item with addition of mix numbers.

Alice just experienced that her lessons based on procedures were not having the effect she expected, and teaching the project lessons gave her an option for how a sequence of lessons could make the connections more explicit between addition of fractions and addition of mixed numbers. This was an example of Alice reflecting about how her teaching affects what students learn based on a comparison between lessons following different approaches. Even probing their learning with many items, she could not be sure of how students' knowledge of addition of fractions would expand for addition of mixed numbers. Having an opportunity to confront these complications might enhance her awareness when planning lessons and projecting what students will learn from them.

Still, during the second interview, Alice was already engaging with these complications after she described the difference between giving a method and giving an example (mentioned above in quote: Alice, Interview 2, 16min 21s):

> I'm trying to think of a way that you could use that same structure with different topics. Obviously it must be possible, but I'm trying to think of ratio or something, **how would you give them an example with no method where then they would be able to answer more questions other than just this specific example type, because that's the uniqueness of this [the project lessons].** […] Yes or you could do it with percentages, you could just do one example where you just find 1% and then using that, they should be able to find any percentage and they should be able to do

> any percentage increase or any percentage decrease. (Interview 2, 17min 56s, emphasis added)

Alice's reflection did not provide clear solutions about how to teach addition of fractions, but trying the project lessons in her classroom opened up the possibility for Alice to consider the causes of students' difficulties with a topic. In this case, she considered her teaching approach (the numerical method for addition of fractions) to be problematic. These ideas seem to be stimulating her curiosity and building a potential scenario for change.

8.2.3. David

In this section I focus on David. Some of his characteristics have already been mentioned in Section 5.1.3, where I generally describe the three participants. David is the head of the mathematics department and had been involved in a project with Dr. Gates since 2013. During the RP he participated in all the meetings and he observed Julia teaching the lessons about fractions, but he did not teach any project lessons in his own groups. For the main project, after the RP, David decided he wanted to follow the project lesson plans from the beginning.

Since the first set of lessons, after each project lesson, David and I would find a moment to talk about it. David was the teacher who asked for more tweaks from one project lessons to the next, adding a video, planning a different *starter* and repeating lessons because only a few students managed to reach the final tasks. David seemed to appreciate my support during the lessons and my familiarity with each student, knowing who was acting differently one day or commenting on students who missed one of the lessons.

David mentioned in our second interview (after two sets of project lessons) that students were working more independently and that he did not have to do many collective explanations. The videos were "doing his job", meaning that students were getting explanations from the animated shapes rather than the traditional teacher lectures. He preferred to play

the videos twice, the first time without pausing and a second time pausing and asking students about it. This was one example of David's appropriation of the project lesson plans, which made the lesson more congruent with his regular lessons, because it was common for him to call students' attention to important parts of a lesson, and to keep their engagement to make sure they were still following.

David noticed how the diagrams were working as "building blocks" (Interview 2, 18min) for students, helping them to try adding and subtracting fractions with different denominators from the ones they were practising before. The teacher used this building block analogy when I asked him to tell me why he thought the students had more resilience during the project lessons:

> Actually I'm saying I gave them another tool. It's not really another tool, I think it's probably their only tool, because they clearly before hadn't really got much of an idea what fractions really, really are. I think now they've started to get a bit of an idea what a fraction is. An eighth is, if you've got a whole square, you split it into eight equal parts, an eighth is one of those but you've got split it equally and all that kind of thing. I think some of them, 80% of the class were quite certain of that really. That kind of thing then gives them a bit of resilience when it comes to a trickier problem, because they can go back to basics, draw a diagram and build from there. It gives them a building block. (Interview 2, 18min)

David also emphasised the consistency of the lessons: the layout of the worksheets, the use of the same diagrams and shapes and the approach itself (showing an example and then students can work out the rest), which he compared with regular lessons, when he did not pay the same attention to these elements and how important they could be to students.

During the project lessons David changed the way he interacted with his students. The lesson observations in his regular lessons suggested that students asked very general questions, such as "I don't get it", and the teacher had to give long and detailed explanations. On the other hand, for the project lessons, the students were able to ask

more specific questions, such as “Are these two sixteenths?” or “What should I do now?” and the teacher could provide only general comments. These following examples were comments David said he used more during the project lessons: “what is this?”; “how would you split the diagram up?”; “what’s the problem with how you split it up?”; “oh it’s not equal”. (David, Interview 2)

The examples above are some examples of evidence in my data that indicated that David had changed his practices during the project lessons. David engaged with the project and perceived benefits for his students who were being taught with the project lessons. After the third set of project lessons, David asked to adapt the project lessons to be used with a different group (extra lessons in Table 5.1). This suggests how much David enjoyed the project lessons, and how confident he was in using the strategies they suggested.

From now on I will comment on each component I developed from Julia’s and Alice’s analysis, and consider David’s experience during the project. These comments are examples from the data I have from David that illustrate the components. I use David’s data to re-evaluate and develop further these components. Any generalization arising from my comparisons should be taken cautiously, since David is in the same school as Julia and Alice, and teaches students with similar backgrounds. Nevertheless, he brings some variation, as shown in Table 5.10.

It would not be feasible to present a thorough account of David’s data. However, when I was writing the chapters about Julia and Alice, I had already coded all David’s interviews, digitalised all his lesson observations and took notes about him from all the meetings. Additionally, I had already written a description of David, his lessons and about his general participation on the project in Section 5.1.3. Therefore, having developed the components based on Julia and Alice, I went back to David’s data to challenge each component, possibly expanding it, considering if the components reached so far were also fundamental to understand his change process.

Commitment to the job: David was clearly committed to his job as a teacher and as head of department. He had management duties, including meetings outside school, on top of the 4 groups he was teaching. But he managed to deal with all his duties as far as I could see.

Curiosity: He was looking for improvement in his own practices (this was the reason of his initial contact Dr. Gates) and he also frequently mentioned his desire to develop "the way they teach fractions in Year 7 at Purple Valley", referring to the possibility that all the teachers would engage with the project lesson plans and all the groups in Year 7 would be taught fractions the same way: with the project lesson plans.

Classroom management: Being the head of department, David had specific managerial responsibilities, which included dealing with behaviour issues. He could frequently be seen talking to students from other teachers' groups, because of behaviour problems.

Follow the lesson plan: David followed the project lesson plans from the beginning of the main project.

Positive experience: As mentioned in 'curiosity', David hoped that the project lessons could be used by all of teachers in the department. He said: "I'm quite keen on us doing this as a whole faculty. This is the way we do fractions basically, and do them with the Year sevens within the first term" (David, Interview 2, 26min 47s). This is a strong indication that he liked the lessons. Additionally, he taught seven other lessons, following similar lesson plans for another group.

Time: David enjoyed having the time during the meetings to discuss the lesson plans. Although he did not need the time to start using the project lesson plans, he recognized that the project lessons took a lot of time to plan.

Trust: David asked me to help students in the classroom after only a couple of lesson observations. Also, he asked for many small tweaks to the project lessons plans, which he seemed very keen to discuss with me after every lesson.

Familiarity: These regular talks after the lessons were basically a summary about how each one of the students had worked that day. The group David was using the project lessons with was very small, with ten students. Taking into consideration the particularities of that group of students and the impressions of them we shared between us, we would decide on the modifications for the next lesson.

Support: The ritual I created with David was that I would arrive ten minutes before the project lesson and go through the lesson with him, talking about important moments and aspects to be aware of. These moments provided extra support to the written lesson plans. Additionally, after a regular lesson observation we would talk and it was common to see David trying something we had talked about in these conversations. The support was working as a source of ideas, and fostering him to try these ideas in his lessons.

Congruence: David asked students to work individually during the project lessons, which was the way he normally worked with that group. He used the videos as a moment to check if all the students were paying attention. David decided to play the videos twice, and he used the second time to call some students and ask questions about what was being shown.

Discussion: During the meetings David engaged in all the activities, especially in solving the tasks and in trying to understand students' solutions. He frequently asked what Julia and Alice's opinions were and how something had worked in their groups.

Reflection: Thinking about the project lessons, David said he was the facilitator, not having to explain a lot and letting students progress more independently. He was reflecting on how this approach was possible, even for the low-set groups to whom he was teaching the project lessons. He also compared his regular lessons to the project lessons:

> I felt that that is how we should generally teach. That's for me what teaching should be, in that the hard work is done beforehand. I know in our case it wasn't necessarily me doing the hard work, it was Leo [Barichello] doing the hard work preparing the resource and thinking about that, but that was done and so the lesson actually was quite easy for me. (Interview 2, 3min 56s)

8.2.4. Altered change process

As I commented before, I do not present a chapter in this thesis with possible explanations about all the influences affecting David's changes, as I have for Julia and Alice, but I coded all of his interviews and analysed most of his data. Therefore, when I developed the change process in Section 8.1, David's main characteristics were in my mind as well. This might be the main reason why, after revisiting his data, I was able to use the components to explain his changes and did not feel the need for many adaptations.

In any case, I tried to identify in the interviews, lesson observations, meetings and field notes, any differences in David's experience of the project, and I found one in relation to the component 'follow the lesson plan'. David did not need to develop his own version of the lessons before starting to use the project lesson plans. But the way he began his engagement with the project was also different. David was working with Dr. Gates even before he came to Purple Valley, so he might had developed trust in the researcher earlier than Julia and Alice. Another difference is that David had time to get used to the ideas behind the project, when observing Julia's lessons during the RP. In any case, these explanations did not altered the change process, because the components 'follow the lesson plan' and 'time' are still present and important for David.

David apparently gave more attention to an aspect that was mentioned by Julia and Alice, but that I initially considered to be secondary: the consistency of the project lessons. This aspect of the lesson plans was mentioned mainly in relation to the layout of the

worksheets, and the fact that this consistency might have helped students' engagement. The three teachers commented that after the initial lessons, students did not look at the worksheets as something new that they did not know about, but on the contrary, the similar layout suggested that the content was familiar and students knew how it would work.

David added to that view when he amplified the concept to the use of the cut-outs, the diagrams and the teaching approach, as all these elements were consistent, and made the teaching of the lessons a lot easier. David's view suggests that there was also a coherence running through the project. The visual approach was stable over time (consistency), and each task kept a clear relationship with the whole sequence of lessons (coherence). David saw these features as contributing to students' resilience during the project lessons.

Other studies mentioned coherence as a feature of an effective PDI, but with diverse meanings. For instance, Desimone (2009) suggested coherence as one of the five critical features of a successful PDI, but different from my interpretation, she mentioned coherence in relation to teachers' learning and teachers' knowledge and beliefs, as well as to reforms and policies in relation to what is taught in PDI.

Garet et al. (2001), in a large scale study about what makes PDI effective, found that coherence was an important element, and explained that in their questionnaire, coherence had three aspects, "including connections to a teacher's goals and experiences, alignment with standards [reform and policies], and professional communication with other teachers" (Garet et al., 2001, p.933). Again, none of these aspects is similar to what I am suggesting in my study. I called Garet's et al. first aspect 'congruence' (connections to teacher's experiences), the second was not the focus of my study, and the third was contemplated in the 'discussion' component (professional communication with other teachers).

Consistency and coherence of lessons are not frequently reported in current research. Venkat and Adler (2012), and Adler and Ronda

(2015) are exceptions, as these studies are examples that considered these constructs with a similar meaning to what David suggested. Venkat and Adler (2012) developed a framework to investigate the relationship among the stated problem, teachers' explanations and the representations used. They suggest that the investigation of connection and coherence among these elements allowed them to consider what was made available to learn. In my study, the careful design of the project lessons and the discussions with the teachers apparently fostered the consistency of these elements in the project lessons.

Therefore, I suggest the inclusion of the component 'consistency' as one of the PDI features. Having Barichello responsible for the ideas and the final version of the project lessons plans allowed more time to focus on this component. It encompasses coherence, as if the initiative is coherent and maintained over a period of time, participants might benefit from the consistency achieved. This is not only in relation to students being more comfortable with the different lessons, but also the teachers knowing how to use the novelty, having discussed them and considered the benefits after experimenting with it in their classrooms.

Another component that was strengthened by David's data was the idea of teachers' agency. In this case I mean agency in terms of teachers having the final decision on their lessons, even if they were project lessons. Julia's and Alice's data already indicated that the autonomy they had in the decisions on the project was encouraging their participation, but it was only when considering David's data that I considered adding it as an extra component of the change process. David had a different path from Julia's and Alice's up to teaching the project lesson plans, and also asked for more changes during the project lessons than Alice, while we hardly changed anything for Julia, as she wanted to teach the lesson as we had planned them. This is just one example of how the PDI was trying to sustain the teachers' agency during the project. Other instances were that the teachers chose the topic of fractions (Section 2.2), they also chose the group with which they were going to use the project lessons

(we asked to be a low-set group), and they decided when they were going to teach them.

I also, therefore, include the component 'agency', representing teachers' autonomy and ownership of their lessons. This concept was already present in the planning of the PDI, but it became salient during the phases when teachers were teaching the project lessons. By respecting teachers' agency, I was able to improve the rapport with the teachers, increasing trust, allowing time, and providing evidence of my support. All these features facilitated teachers' engagement with the project.

Even though Julia, Alice and David seemed to already have agency in relation to their classrooms and lessons, considering the way the school operated, teachers had the schemes of work, but were fairly free to plan their lessons, maintaining that agency seemed to be beneficial for teacher's engagement. The project was not aiming to interfere with the school-teacher relationship, as I was adapting to the conditions the school and the teachers already had in place. In that sense the project was not promoting teachers' agency outside the project, but, at the same time, the teachers were the authority for many decisions during the project. The PDI tried to maintain that agency even though we were providing lesson plans.

Lastly, David's position of management and department leadership stressed these two last components of 'consistency' and 'agency'. His position required him to have a wider view than Julia and Alice. David has expressed how he would like the project lessons to be the way teachers in Purple Valley teach fractions, which can be interpreted as a search for consistency across classrooms. Additionally, David invited all mathematics teachers in Purple Valley to participate in the project, and only Julia and Alice accepted. There were four other teachers that did not want to take part, and David respected their decisions, respecting their agency.

8.3. Summary

In this chapter I describe components of the process of change for Julia and Alice during the project. I exemplify how the components come from the data, suggest definitions, and relate each one of them to previous results from the literature. Using the data from my third participant, I test and expand my previous findings.

'The cycle of experimentation' explains the fundamental process where Julia and Alice showed changes in their practices. By following the project lesson plans they had a positive experience. This process was encouraged and maintained by other components, such as support and curiosity. At the same time, 'the cycle of experimentation' also feeds into further components, such as discussion and reflection. They are singled out in one group, because they can represent teacher engagement with the project, and its ultimate consequence is the final aim of change in classroom practice.

'Professional characteristics'. In order to be able to engage in the process mentioned above, Julia, Alice and David were open to change. Many factors were contributing to their readiness to engage with the project, such as the Headteacher approval of the initiative, and probably many personal conditions I did not know about, but some of these factors were perceptible and could be influenced by a PDI to encourage teacher participation. They were committed to their jobs, curious in finding better ways to teach, and had good classroom management in their groups. These components fostered teachers' motivation, self-efficacy and job satisfaction.

'The professional development initiative' is the group of components related to the project features (time and consistency) and activities (discussion, reflection and familiarity), including features of the relationship between the teachers and the researcher (trust, support, congruence and agency). They are grouped together, because they were achieved by the design decisions of my project. These components

affected the three participants throughout the project, and as with all the other components presented in my study, they influenced each other.

Before moving to the conclusions in Chapter 9, I present a case portrait for each of my participants, foregrounding key aspects of each case. I also include a table (Table 8.2) with a short summary of the components from my conceptual model of teacher change.

8.3.1. Case portrait: Julia

Julia was an experienced teacher, teaching in the same school for the last 12 years. She had a similar background to her students, and this became evident quickly when talking to her about her job. She believed in her students and was proud of her commitment to helping them to reach their potential. She was very committed, loved her profession and usually took roles in school that did not reduce her teaching hours.

As the first impression would show, she was very organized and strict with behaviour. She looked very focused when she was teaching, paying attention to every detail. In all the time I spent with her I noticed nothing unsettled her.

Julia frequently created new materials and tasks based on things she saw somewhere else. She would adapt them to fit her strict lesson style, but she was curious to try new ideas whenever she had time to do it.

During the project, Julia was always eager to discuss before and after any lesson observation I had in her classroom. She frequently had something to show, something she was planning to do or something that worked really well (or that did not work at all) with some of her groups that she wanted to discuss. During the meetings, she gave ideas and commented on the tasks we were developing. However, after the lesson plans were ready, she did not ask for any change or adaptation. She told me she wanted to teach the lessons the way they were planned so we would be able to check if they were going to work. Apparently, Julia is

confident to teach whatever strategy she wants. She just needs some time to prepare.

Her interactions with the other teachers in the meetings were friendly and showing interest. She would give advice, but in general in a "this is what I do" style, which sounded as more empathic and less knowledgeable.

Julia embarked very quickly on the cycle of experimentation. We were working together before, during the RP, when she was already adopting new strategies in her lesson. For the main project, she was determined to follow the project lesson plans as they were. Her professional characteristics (curious, committed to her job and classroom management) were very much in place to enable her to be open to suggestions and to implement whatever she wanted in her lessons.

The main components influencing her changes were: support, reflection, and congruence. Being experienced and an example for the whole department, Julia had many people coming to observe her lessons; most people came to her room to learn something from her. My presence in her lessons had a different purpose, I was not evaluating her teaching, but I would engage in conversations that fostered her to reflect on the reasons why she was doing what she was doing. Julia took advantage of those moments, and she pondered and reflected before answering. That is one of the reasons our interviews were longer. She also commented that she would remember my questions, "but why", when she was planning lessons at home.

The PDI in general (lesson plans, meetings, and my constant presence) was also working as support for Julia to engage with the project fully. Again, as an expert, she was usually the teacher who had different materials to suggest to others. With the project, it was the other way around. The PDI was offering her ideas, materials and teaching strategies to use in her lessons and she enjoyed the opportunity.

Finally, the congruence between her lessons and the project lesson plans was fundamental for Julia. Although she frequently tried different types of tasks, she always adapted them to fit her own preferred ways of teaching arguably losing some of their original features. However, the project lesson plans were congruent enough with her practice, so she was able to use them without compromising features that were different from how she usually taught, such as not showing a procedure first.

8.3.2. Case portrait: Alice

Alice was a trainee teacher, and this was her first year teaching mathematics. Although she was new to the profession, Alice came across as confident and seemed to be determined in her choices during her lessons. She appeared to be on top of her obligations both as a teacher and as a Teach First participant, which included assignments, meetings, seminars and file keeping of her lesson planning.

Most of her lessons followed the "example-task" sequence, with many variations of how to present examples and tasks. Alice used printed sheets, whiteboard, smart-board, slides, and visualiser. At the same time, Alice was very comfortable in handling more active tasks, at least once a week I observed Alice proposing a task in which students were walking around the room, in some sort of competition to finish first, or using manipulatives. However, even then, the tasks would normally be repetitive, following an example she had shown previously.

Alice gave the impression of being worried about students and cared about what they were learning or not. We talked a lot about the lower-sets, and her concerns about these students seemed to be out of her reach, problems that could only be solved by changes in a school or curricular level.

Over the year, Alice and I developed a good rapport, and I perceived that Alice became more sincere during our conversations. She began to talk about issues she did not mention at the beginning of the year, and she became less assertive and more tentative in her opinions.

Alice did not fully incorporate the project lessons right from the start. She planned some of the project lessons herself, and she needed more time experimenting with them before accepting to follow the lesson plans as they were. The practice she had more difficulties to abdicate was the whole classroom explanations. She seemed to take these moments as fundamental for her job: the act of explaining how to solve an item on the board was the definition of what she, as a teacher, should be doing. This strategy also helped Alice to feel in control of what her students were learning.

However, after an apparently slow beginning, Alice did teach the project lesson plans and kept using them during the following terms. She was able to keep the whole classroom explanations to a minimum and still perceive that students were learning something. In our last interview, she told me she was pleased that students had a chance to try and discover for themselves during the project lessons.

She also ended up using the first set of lesson plans (the one she planned herself at the beginning of the academic year) again with a different group. This time following the project lesson plans closely out of her own interest.

My data analysis shows that the cycle of experience was particularly important for Alice since she was less experienced as a mathematics teacher. In summary, she did not know any other options for teaching, making any change quite unlike to happen.

As a first impression, Alice was a self-assured teacher. This feature enhanced Alice’s classroom management, allowing her to have control of the classroom even during activities that were unusual for them and required students to talk to each other and walk around the room. Although her assertiveness could suggest she would not be interested in improving, her attitude to learning directed her to get in touch with as much as she could during her training.

At the same time, she seemed to prefer adapting the lessons to more closely fit her existing preferred teaching style. This preference hindered her engagement with the cycle of experimentation from the beginning. Alice was less prepared to deal with ideas that were not hers. Therefore, experimenting was quite crucial to enable her to get in touch with new approaches to teaching, to have experiences to compare during our discussions and her reflections.

The PDI components enabled Alice to reach the point of being confident to teach the project lessons as they were, recognizing its merits and limitations. For her, I consider that time, trust and agency were significant influences. Over time, with the project lessons being discussed during meetings, keeping the consistency of the approach and some level of congruence with her own teaching, Alice was willing to try the lesson plans as they were. Simultaneously, we developed familiarity and trust, so she started to open up during our talks, sharing some of her hesitations and doubts as a teacher, reflecting on her practices, pondering advantages and disadvantages of the new approach instead of being so certain about her current practices.

8.3.3. Case portrait: David

David was the head of the mathematics department, and he was the one who initiated contact with my main supervisor. He was definitely looking for improvement especially with low achieving students and wanted some guidance. He immediately accepted my project and invited the other teachers to participate. He saw it as something that could evolve and become something for the whole mathematics department.

As a teacher, he had a good relationship with students, regularly engaging in conversation about topics unrelated to mathematics, as he knew a lot about each one them. Nevertheless, his lessons were usually very quiet and followed a similar pattern every time: David solved an example using a whole class format, asking questions to engage students; after that, students were asked to answer a long list of items

very similar to the example David had shown. The way David gave feedback to a task varied. Sometimes he only presented the final answers, or he checked students work individually, or he asked students to check it with each other. However, sometimes, he would ask students for the answer and an explanation while he wrote it on the board. David seemed very confident in improvising in the classroom, coming up with extra items during a lesson that was too short, or creating examples to explain something he felt students needed.

As head of the mathematics department, he had many commitments outside Purple Valley, and he seemed to have a very busy schedule. Nevertheless, once a meeting had begun, he was very committed to it. He always engaged in discussions, solving the items from the tasks and playing with the cut-outs. He was curious about how the project lessons were going on with the other teachers.

David frequently mentioned how interesting it would be to make the group meetings permanent, where they could plan lessons and discuss experiences. These comments suggest his enthusiasm for the initiative, commitment with his job and curiosity. During the meetings he was one of the teachers; he did not act differently just because he was the head of the department.

There were two main changes in David's practice. The first one was that he did not show a procedure to solve the tasks in the project lessons, and he was astonished by how students were able to do by themselves. The second change was about the interactions David had with students. He perceived that during the project lessons he could be only a facilitator, making suggestions and giving ideas to students, rather than giving detailed guidance and full explanations about how to reach the final answer.

David said he enjoyed teaching the project lessons. He embarked on the cycle of experimentation since the start of the main project. He had observed Julia's lessons during the RP, and this opportunity of

observing another teacher teaching with similar lesson plans might have encouraged him to follow the project lesson plans straight away.

Also, after each project lesson, we talked about it and usually agreed on small tweaks for the next lesson. These moments fostered his engagement during the whole process. My familiarity with his groups and lessons enhanced the quality of these conversations and the adequacy of the changes to the lesson plans. David frequently mentioned how easy it was to teach the project lessons. The consistency of the lesson plans throughout the whole year enabled him to be confident to use them after only reading the "comments for the teachers". As evidenced in the interviews, my constant presence was also central in allowing David to have a good experience and he appreciated the support I provided before, during and after each lesson.

8.3.4. Components influencing teacher change

The portraits above highlighted the most prominent influences affecting each teacher in my study. As discussed in Sections 8.1 and 8.2, I am grouping these influences in three different areas, and I am calling them components. The table below provides an overview of these three areas, the components in each one and a short summary of what they represent in the change process I am proposing.

Components of the process by which teachers in my study changed		
Area	**Components**	**Summary**
Professional characteristics	Commitment to the job	Participant teachers' readiness to engage
	Curiosity	
	Classroom management	
The cycle of experimentation	Follow the lesson plan	Cycle that allowed change in practice to happen
	Positive experience	
Professional development initiative	Time	Features that came from the design choices of the project in general
	Trust	
	Familiarity	
	Support	
	Congruence	
	Discussion	
	Reflection	
	Consistency	
	Agency	

Table 8.2: Components affecting teacher change in my study.

Chapter 9 Conclusion

This PhD study was exploratory in nature, and qualitative methods were employed to collect and analyse data. My aim was to conduct an in-depth investigation of the phenomenon of 'teacher change in practice', as a possible response to a professional development initiative (PDI) focused on experimenting with an innovation, but without any imposition of change, in a small number of naturally occurring cases. The sample was three teachers, Julia, Alice and David, from the same school and each teacher was seen as one case (Hammersley, 1992). In general, the research was a *close-to-practice* case study using ethnographic methods.

In terms of data analysis, I started by carrying out the analysis of the interview data for each individual teacher, reaching 645 codes (Section 5.3), before all three were compared (Chapter 8). The adoption of a genuinely grounded approach to the analysis allowed me a more holistic consideration of the influences affecting their individual changes in practice and their engagement with the PDI.

The three teachers are different in many ways (see Table 5.10 and the portraits in Section 8.3), but they were teaching in the same school, and their lessons had some similarities (see Section 5.1). My conclusions should be understood bearing this in mind. As Hammersley (1992) pointed out, conclusions from a case study are limited in terms of generalisation, but other useful knowledge is likely to be generated, such as new connections between variables, events and features with the phenomenon under investigation. My study suggests some new influences and relationships between factors affecting teacher change in practice. Some of them are confirmatory of influences already identified in previous studies, others are new and represent features that teacher educators should be considering in order to guarantee better opportunities for teachers to change. Together, the 14 components constitute a conceptual model for teacher change.

The strength of my claims is rooted particularly in the prolonged length of contact I had with the participants and the analysis combining different sources of data, as discussed in Chapter 4.

The names of the components are a short representation of a deep and broader concept, and there are many different approaches in which each of them could be implemented when one is considering a PDI. It is important to point out that the components are the surface of a very complex phenomenon. I do not expect to transform *teacher change in practice* into something simplistic, rather I want to shed light on issues that were insufficiently considered so far.

This chapter presents the conclusions drawn from the analysis in the previous chapters (6, 7 and 8), providing answers to the research questions (Section 3.4). I make explicit links to existing results and clarify the contributions from this study. I also discuss potential implications of these findings as features of PDI aimed at fostering innovation in practice, and in the processes through which teachers change their practice. Section 9.2 considers a potential PDI format that has come from my role in the project, and it takes into account the conclusions of this study in the light of theoretical and empirical results from the literature on professional development of teachers. Finally, Section 9.3 of the thesis discusses some limitations of this study.

9.1. Main conclusions

Professional development initiatives (PDI) can have many different goals, such as changing teachers' beliefs, promoting the use of new strategies, or introducing a reform. Considering PDI that focuses on change in practice, such as mine, there are still many possible variations: teachers can be presented with a general strategy, such as to promote student talk or the use of formative assessment; the focus can be on a topic such as algebra; or choosing and maintaining tasks with a high cognitive level. My project was focused on promoting different teaching

strategies from those the teachers were previously using, in other words, promoting innovation in their classroom practices. The main difference, discussed at length in Section 4.2, was that my study investigated teachers participating on a PDI over which they had considerable agency, therefore there was no imposition of fidelity over specific strategies (Castle and Aichele, 1994).

My study was looking at the following two research questions (Section 3.4):

1. How do secondary mathematics teachers change within the context of a professional development initiative to innovate in their classroom practices?

2. What are the influences affecting teachers when they try to change their practice?

The teachers in my study changed their practices by implementing innovative practices suggested in the lesson plans developed in collaboration. Based on the lesson observations I did before the project, the practices they were using during these project lessons were not commonplace for them. The changes they were able to implement are described in Sections 6.2.1, 7.2.1 and 8.2.3 for each one of them. In summary, over the course of the academic year, the teachers became more confident in teaching the project lessons. They developed their practices when they experimented with the innovations discussed, and they were able to perceive the benefits of adopting the innovations.

At some point during the project, the three teachers chose to teach the lessons the way they had been designed, not reducing, removing or adapting any of the suggested innovations. They all felt supported and confident to teach those lessons, and they perceived that the changes in practices they were adopting had benefits to students, to the extent that they independently decided to extend the lesson plans and use them with other groups (see Table 5.1).

Goldsmith et al. (2014), in their synthesis of research on mathematics teacher learning, concluded that existing research of PDI are mainly focused on outcomes. However, my study focused on eliciting the influences affecting the process of teachers' experimenting in their classroom practice, and how these influences operated together to promote or hinder change. Table 8.2 contains all the components affecting change I found in my study. Since they all emerged from a grounded approach, it is not surprising that some of them were already well documented in previous research on teacher change, that is, some of my components were confirmatory, and others were not that vastly reported by research.

9.1.1. Addressing the first research question

My first attempt to explain how Julia and Alice changed are in Sections 6.4 and 7.4, respectively. After that, I moved to a process of comparing the two teachers and also considering David's data. Even though each teacher is unique, it was possible to identify influences affecting change in all of them, which allowed me to elicit a more comprehensive explanation for the first research question – How do secondary mathematics teachers change within the context of a professional development initiative to innovate in their classroom practices?

Teachers agreed to participate in the project, fully engaging with it. They tried the project lesson plans in many lessons and kept using them even after eventual setbacks. After some time, they were confident with the novelties in the project lesson plans and decided to teach more lessons with them than initially planned.

Considering the explanation above, the mechanism of change is not yet precise, there is the necessity to go deeper into understanding the process of change the teachers went through. In order to do that, I consider the following extra questions:

(a) why the teachers decided to start teaching the lessons in the first place;

(b) how they managed to deal with the setbacks; and

(c) why they agreed to keep using the next lessons.

For the first extra question, my data suggests that the participants had a level of commitment to the job sufficient to identify problems in their lessons; they were curious to look for ways to improve their practices and be able to tackle some of these problems; they had enough control of students' behaviour in their classrooms to have the flexibility to vary their lessons and consider students' learning, rather than their behaviour, as criteria to evaluate the success of a lesson.

In summary, what I termed teachers' **professional characteristics** were in place before and during the project, enabling them to begin and to sustain the use of novelty in their lessons.

To answer the second extra question, how the teachers dealt with setbacks during the project lessons implementations, we have to consider that they had initial conditions in place, none of the lessons had any disproportionately negative outcomes, but to some extent, that was also a result of the project lesson plans being congruent with their current practices. Since there was support to the teachers throughout the project, it was possible to have immediate discussions about specific outcomes of the lessons. I was in a good position to identify aspects of the lesson that was positive or to discuss what had been the cause of problems and make suggestions for the next lesson. Teachers trusted my judgment because of the familiarity and trust built up between us, and the fact that I was always present and focused on supporting the teachers.

Regarding the third extra question, why the teachers agreed to keep using the next lessons, my analysis suggests that the reason comes from a combination of factors, including their professional characteristics of being curious and a professional commitment to seeing the whole

project through to the end; the **cycle of experimentation** with positive experiences and tangible learning outcomes and the fact that it was getting easier to follow the project lesson plans. Again, **features of the design of the PDI** also contributed to maintaining teachers' engagement with the project, influencing the change process in different levels.

This finding, about the process of how the teachers changed in my study, disagrees with any linear models for teacher change, such as Guskey's (2002) model. It was clear, in my study, that the change process is likely to have setbacks and rejections, which, at the same time, were not permanent and could be coped with in productive ways. The paths that lead to initial rejection from the teachers were still leading to change in practice, and they just took a longer turn. Models such as presented in Clarke and Hollingsworth (2002), with different paths and the possibility of change not happening is closer to the process I identified. The discussion presented in Section 8.1.1 illustrates this claim.

Another model that I could use to describe my findings is the model from Smith, Smith, and Williams (2005). The authors included a phase considering teachers' "initial interest", which is not clearly defined in Clarke and Hollingsworth's model but was salient in my findings. Smith, Smith and Williams' model has levels of adoption or rejection during the phases of the change process. My findings indicate that even if there is rejection in one phase, suggesting that the teacher retreated, they might start over and, in a second attempt, follow a different path that will lead to change. However, in Smith, Smith, and Williams' (2005) model the possibility of slow incorporation of innovations is not salient.

The explanations above suggest how intricate the process of change is, and the importance of considering the cyclical situations, where teachers start over. Additionally, I mentioned some components affecting each other, and it is impossible to isolate them completely. The change process did not follow a linear and fixed sequence of stages, components were feeding off each other, and teacher moved back and

forward in what would be stages of change. Each one of the components is presented next.

9.1.2. Addressing the second research question

During Chapter 8, I addressed the second research question – What are the influences affecting teachers when they try to change their practice? - by eliciting the components affecting change for the three teachers. Table 8.2 summarizes the components identified by the end of this process.

For the professional characteristics I propose **curiosity**, to be related to what other studies called perturbations (e.g. Chapman and Heater, 2010; Cobb et al., 1990; Shaw et al., 1991), when teachers acknowledge the existence of a problematic situation upon which they want to act with the aim of improving it. Perturbations usually are reported as coming from external influences (Shaw et al., 1991), but in my study, I also include in the component curiosity internal perturbations, or awareness coming from teachers' own perceptions.

In my study, curiosity came to light, for instance, when Julia compared her own lessons about addition of fractions with the project lessons and perceived that the project lessons were more beneficial to her students. For Alice and David, the willingness to look for improvement was already there. David initiated the contact with the researchers and Alice promptly agreed to participate in the project.

Curiosity, for me, also includes some level of motivation. All three teachers were self-motivated in my study. Ryan and Deci (2000) argue, from the area of self-determination theory, that people have "inherent growth tendencies and innate psychological needs that are the basis for their self-motivation" (p. 68). They add that this self-motivation is affected by the context, which means that it can be quite particular, being more or less prevailing depending on their personal situation.

The second component of professional characteristics is **commitment to the job**, the teachers in my study were efficient enough in keeping up with their duties at the school, in other words, they were not under extreme stress due to work overload. It is also related to the respect for the profession and compliance with the obligations. Teachers with commitment to their jobs are probably staying in the profession. Julia, David, and Alice showed their commitment by never being absent, never missing our scheduled arrangements, and actively participating in the school's activities. Following Ryan and Deci's (2000) proposals, commitment to the job is also related to positive motivation. However, specifically to mathematics teacher, little attention has been given to it, as pointed out by Desimone (2009). Since research is mainly undertaken with volunteers, no lack of commitment is found, and this can be seen as a threat to generalisation of studies of effective PDI.

The last component in professional characteristics is **classroom management**, which is related to having some level of control over the learning in their classrooms in terms of positive management of students' behaviour. To the best my knowledge, no study related to teacher change has mentioned issues around this topic. Some level of confidence in controlling the behaviour of students, creating and maintaining an environment adequate for learning and being attentive to students' needs in the classroom was essential to allow the teachers to innovate and try the different strategies that were suggested. As I observed in some instances, especially in the beginning of the academic year, in occasions when the control was compromised, and teachers reverted back to their usual approaches or adapted the lesson plan removing or reducing its novel features.

These three components are not very frequent in previous studies. Goldsmith's et al. (2014) review of the literature of mathematics teachers' learning found that most studies are concerned with "the effectiveness of particular programs, curricula, or professional learning approaches […]. Typically, teachers' learning is treated as an indicator of

the effectiveness of the program rather than as the primary object of inquiry" (p. 21). This may hinder the observation of the conditions teachers are at (the professional characteristics I found in my study) and limit the focus on conditions that the program wants to affect.

Beyond the professional characteristics, there was a self-feeding cycle for all participants while they were teaching the project lessons.

In Section 4.2.1, I discussed the design of the PDI and how the phase of experimenting in the classroom with the lesson plans developed collaboratively is a significant moment that will foster changes (Clarke and Peter, 1993). This phase is recognized as a core feature of effective PDI (De Geest et al., 2009; Desimone, 2009). Complementing the experimentation phase, Guskey (1986) highlighted that teachers need to have a positive impression of the experience.

In my study **follow the lesson plan** and have a **positive experience** repeated many times for each participant, which was crucial to enable the teachers a genuinely new experience in their classroom, which developed into material for reflection and discussions about their practices. This is what I called the cycle of experimentation.

The cycle of experimentation is one aspect of my findings that was confirmatory in terms of existent research. As presented in Section 8.1.1, it is part of many models of teacher change (e.g. Clarke and Hollingsworth, 2002; Guskey, 2002). As Thompson (1992) affirms:

> We should not take lightly the task of helping teachers change their practices and conceptions. Attempts to increase teachers' knowledge by demonstrating and presenting information about pedagogical techniques have not produced the desired results. […] We should regard change as a long-term process resulting from the teacher testing alternatives in the classroom, reflecting on their relative merits vis-à-vis the teacher's goals, and committing to one or more alternatives. (p. 143)

Although researchers already consider this a crucial phase of the change process, not many studies suggest how to foster it. In my study, all three teachers eventually began to use the lesson plans as they were,

without adaptations or variations. Julia decided she wanted to teach the project lessons as they are from the beginning of the main project, arguably because she had already developed some confidence to do it due to her experience during the RP, see Section 6.3.3. David also decided to follow the project lesson plans from the first day, he also had some experience from the RP, but not teaching the lessons. My suggestion is that facilitating first contacts with different lessons have to be incorporated as one of the roles of the PDI.

Now I turn to discuss the features of the PDI itself that my analyses revealed as important to promote teacher change. I began presenting the four confirmatory components and are largely reported in research as effective in PDI and in fostering teachers' learning: Time, Support, Discussion, and Reflection.

Time is commonly mentioned in terms of the time-span of the PDI or, as Desimone (2009) called it, the duration of the PDI. It is well established that short and single time interventions are less effective than long-term and frequent ones. Another benefit of having more time is when it is allocated to engage in the PDI activities (De Geest et al., 2009). Along with long-term and the allocated time, I also include the need of time to respect teachers' pace to engage in change as part of this component.

Support is mentioned in many studies investigating teacher change and effectiveness of PDI. It is among the characteristics in studies that summarize effective features of PDI, such as in Clarke (1994), Borko (2004) and Joubert and Sutherland (2008).

Weissglass (1994, 1990) suggests a model for teacher change where one of the five pillars is "obtaining emotional support". Weissglass claims that "obtaining emotional support can help us deal with new situations constructively and creatively" (p. 70). The support I offered to teachers allowed me to provide such emotional support, in order for them

to be in a better position to deal with the novelty suggested in the project lessons.

Support is the component related to emotions. Many studies show the importance of emotions in diverse situations, for instance negative feelings students have about mathematics (Nardi and Steward, 2003); primary teachers' emotional relationship with mathematics (Hodgen and Askew, 2007); emotional reactions to reform (Reio, 2005); teacher stress or burnout (Nolder, 1992; Perryman et al., 2011), etc. But the topic is still often left out of the structure of PDI (Weissglass, 1994).

Although this component is common in the literature, explanations of how support can be implemented and sustained are very broad and superficial. In Section 8.1.3.d I present a list of actions I took in order to provide support for teachers in my project. It can be summarized as being available and prepared to talk, listen and encourage teachers through their daily issues in the classroom.

Another well-established component that fosters teacher change is **discussion**. Frequently related to collaboration with peers (Goldsmith et al., 2014), discussion includes moments when teachers can talk to each other and also with a facilitator. It constitutes opportunities for teachers' collective participation (Desimone, 2009), networking (De Geest et al., 2009) or the creation of a professional community (Borko, 2004). It is difficult to distinguish between these terms, but in these three examples, the researchers associate the discussion between teachers with teachers' learning.

As facilitator, I had the role to maintain the intentionality of the meetings and conversations with teachers, which is a crucial role that can lead to teacher change, and largely reported in research on the professional development of mathematics (Borko, 2004; Clarke, 1994; Crespo, 2006; Desimone, 2009).

The last component in this group is **reflection**. In my study, it was manifested especially through comparison, when teachers were able to compare the project lesson plans and their regular lessons.

Many studies confirm that "reflection" promotes teacher learning (Reinholz, 2016), change in practice (Clarke and Hollingsworth, 2002), and teachers' capacity of evaluating the benefits of changing (Clarke, 1994; Smith et al., 2005).

Now I move to three components of the PDI that are not vastly reported in the literature about teacher change and PDI effective features.

The first one is **trust** between the teacher and the researcher. In my study it was essential in enabling teachers to become confident in discussing mathematical topics with me, being open about their apprehensions towards the project lessons and comfortable in giving me their honest opinion about the project lessons.

I achieved that with all three participants, as they constantly asked my opinion after a lesson; we frequently engaged in open professional discussions and we we talked about different mathematical topics and the atmosphere of the meetings was light and relaxed. We respected each other opinions and views.

The closest to trust that studies have considered is the role of the facilitator as being someone that teachers need to trust (Borko, 2004). This aspect has been brought up a lot in research on PDI that focuses on video, with examples being the studies from Coles (2014, 2013), where noticing and discussions are crucial elements, and the use of non-judgmental comments is identified by Coles as key for the effective development of the meetings with the teachers. However, what my analysis highlights, in consonance with the importance given to trust by the studies mentioned before, is that building trust between the person promoting a PDI and the participants should be seen as one of the features of the PDI.

The second component in this group is **congruence**. In a study from the 1970s, Doyle and Ponder (1977) defined congruence as: "the extent to which a proposed procedure is congruent with perceptions of their [teachers'] own situations" (Doyle and Ponder, 1977, p.7). After that, to the best of my knowledge, no other study considers congruence other than alignment (or coherence) with teachers' beliefs and knowledge (Desimone, 2009; Garet et al., 2001). In my study, maintaining some congruence between the teachers' regular lessons and the new project lessons was important in fostering teachers to try the innovations and take risks.

By maintaining some level of congruence, the project was respecting teachers and the school culture. As Mason (2003) argues, people promoting professional development "need to stimulate them [teachers] to question their habits, but also, importantly, to respect teachers' conclusions" (p. 290). This is also aligned with the suggestions from Weissglass (1994) when he points out that:

> change occurs as the result of complicated interactions among people […] with their own beliefs and values. At the heart of the process are classroom teachers – recognized and respected as complex human beings, who – along with knowledge – have feelings, beliefs, and values that must be addressed if change is to occur (Weissglass, 1994, p. 67)

Congruence to some of the teachers' routines helped to show respect to teachers' work, experience, and tacit knowledge. Keeping some level of congruence between the project lessons and teachers' regular lessons helped in two different ways. Firstly, it facilitated students' engagement during the lessons since they followed a similar structure as during their regular lessons. When teachers' practices change, social norms in the classroom have to be renegotiated with students, which is not always smooth (Lubienki, 2002b; Wood et al., 1991).

Secondly, it allowed teachers to focus their awareness on the new elements. As highlighted by Mason (2002), awareness is intrinsically related to the possibility of change:

> real change is based on becoming aware of possibilities which were not previously available. Sometimes people are attracted to new ways of describing practice, and over time begin to change the practice itself as well; sometimes people adopt and adapt new practices and only later begin to describe it in new ways. But at the heart of change is the recognition of new possibilities for acting. That is why the very heart and essence of noticing is being awake in the moment to possibilities (Mason, 2002, p. 144)

Congruence helped to create a context in which teachers had more opportunities to notice new possibilities by maintaining other elements the same as usual, allowing teachers to focus their awareness.

The third component is **consistency**. The three teachers in my study commented that the layout of the worksheets of the project lesson plans had high consistency throughout the academic year, which made it easier to teach the lessons and also facilitated students' engagement during the lessons. Beyond that, the lesson plans also maintained consistency in terms of the overall structure of the lessons, style of the questions, representations and type of engagement expected from the students (Barichello, 2019).

The studies from Venkat and Adler (2012), and Adler and Ronda (2015) include the importance of consistency among problems, teachers' explanations and the representations used. These elements have to be aligned in order to consider what was made available to the student's learning. Although these authors were focused on evaluating lessons and not on PDI, their proposal is aligned with my conclusion that the consistency of the lesson plans facilitated its use.

In his model regarding levels of teacher change (see, Section 3.3), Korthagen (2004) argues that "through behavior that is repeated often enough, one develops the competency to also use it in other circumstances" (Korthagen, 2004, p. 80). The teachers in my study had

the opportunity to experience the approach of the project lessons many times since they were consistent throughout all the lesson plans. Therefore, they had the opportunity to become competent in that approach and, following Korthagen's (2004) argument, incorporate it to their repertoire of teaching strategies. The consistency of the project lessons fostered teachers to become competent with the novelties suggested, which facilitate change in their lessons about fractions.

As most PDI structured around lesson plans or teaching approaches are developed at the university and then delivered to teachers, consistency is taken for granted. However, in a close to practice approach as mine, due to practical issues that inevitably occur in school, it is easy to lose consistency from one lesson to another or from one teacher to another. My findings highlight the importance of paying attention specifically to this issue as a way to enhance the positive cycle of experimentation for teachers.

Lastly, the following two components are not reported in previous studies as features of PDI. The first is **familiarity** with participants, their groups and their lessons in general. I knew particularities about each group, which created a shared knowledge with the teachers about what was happening in each class. Therefore, I was in a privileged position to suggest practices the teachers found acceptable for their specific context. The adequacy of my suggestions was only possible due to the prolonged time I spent with each teacher in my study. While this may had been possible due to my professional situation (full time researcher) at the moment, my analysis suggests that some level of familiarity will enhance the interactions between teachers and the people responsible for the PDI.

It could be said that familiarity is not a component as the others, but actually, a baseline or foundation from which other components could grow. Familiarity enabled a better rapport between the teachers and me, and from that rapport, we developed trust. It also enabled me to provide more adequate support and engage in more relevant discussions due to

our shared knowledge. Finally, familiarity was necessary for the researchers to develop lesson plans congruent to teachers' practice.

Therefore, in my study, familiarity can be seen more as a means to develop other components than as an end in itself. It also highlights the respect to teachers as professional, with experience and valuable tacit knowledge.

The second is **agency**, which is largely reported in general but not as a characteristic that needs to be considered in the design of the PDI. In my study, agency refers to teachers having the final decision on their lessons, even if they were project lessons, and to my attitude to guarantee teachers' autonomy and ownership of their lessons.

Although the 14 components I suggested above need to be considered together, because they affect each other, I perceive agency as the overarching component. Although this component was only included after I considered David's data (Section 8.2.4), it was already part of the design of the PDI (see Section 4.2.1) as teacher autonomy.

As I reported in different sections of this thesis, respecting the teachers' decisions and choices, giving them agency, admitted the fact that each participant was different and enabled them to progress at their own pace. For instance, each participant chose when to use the project lesson plans as they were, and each participant asked for tweaks they considered adequate to their groups.

This finding is aligned with other studies, such as Vähäsantanen (2015) who identified that "the manifestations of professional agency (involving decisions and actions related to the reform) are significant at the individual and social levels" (p. 31). Their findings:

> underline the significance of agency for teachers' work behavior, organizational commitment, satisfaction, and well-being at work. Furthermore, professional agency emerges as a fundamental element for the development of educational and workplace practices – at least at micro-level – and for the (re-)negotiation of professional identity. (Vähäsantanen, 2015, p. 31)

As I also found, Vähäsantanen's suggests that agency will influence teacher's commitment and practice. This author had a focus on implementing reform, which can be seen as a mandatory change, but Castle and Aichele (1994) also pointed out that imposing change is not effective and promoting change that lasts in teacher's practices during a PDI has to be something teachers chose to do, it is "an autonomous activity chosen by a teacher in search for better ways of knowing and teaching mathematics" (p. 3).

This need for some level of autonomy is also highlighted as a feature of effective PDI by Leahy and Wiliam (2012). The authors state that:

> when teachers themselves make the decision about what it is that they wish to prioritize for their own professional development, they are more likely to 'make it work'. […] when the choice about the aspects of practice to develop is made by the teacher, then the responsibility for ensuring effective implementation is shared (Leahy and Wiliam, 2012, p.6)

Returning to Castle and Aichele (1994), they advocate that:

> professional knowledge cannot be transferred. Rather, it is constructed by each individual teacher bringing his or her "lived experiences" as a learner and teacher to an educational setting and interacting with the environment in a way that relates new knowledge to previously constructed knowledge in an attempt to make the best sense of the new knowledge (Castle and Aichele, 1994, p.4)

This individualized issue was not the focus of my study, and when I began to consider aspects that could be generalized in my findings, I reached a possible contradiction. But looking at my components, it is evident the personalized aspect of them: the professional characteristics is calling the attention that we need to observe each teacher before they engage in a PDI, the cycle of experimentation can be different for each participant teachers, and features such as agency, familiarity and congruence are focused on individual features of teachers. There is no "one size that fits all" model for the process of teacher change. Individual

teachers will benefit from working together, with each other and with researchers, but the mechanism for change is personal. Therefore, I suggest that we need to look at the specificity of the context if we want a PDI to work in your context.

9.1.3. Expanding on previous research

For this study, I considered several studies related to the professional development of teachers. There were two related, but different, focus areas in the literature: one considered features of effective PDI, e.g., Desimone (2009) and De Geest et al. (2009), and the other consider the process of teacher change, e.g., Clarke and Hollingsworth (2002). My study combined these two areas, investigating features of the PDI that were influencing teacher change in practice.

Desimone (2009), sought characteristics to be considered of a PDI to make it possible to compare initiatives. Her review of the literature leads her to five features of effective PDI that would allow the comparison, but the study does not consider teachers' characteristics and the context. As my study showed with the two dropouts (Section 8.1.2.c) and with the differences between the participants (Table 5.1 and Section 8.3), the PDI may work very differently depending on the teachers' condition at the time. Therefore, a PDI designed with all the five features from Desimone's study might still not be effective due to particular issues of each teacher, such as not having control of the classroom or not being interested enough, as were the case for the two dropouts in my study. Additionally, issues of the context, such as teachers being under pressure to adopt curricular changes, can hinder the results, as it has been reported for a long time now (e.g. Nolder, 1992; Perryman et al., 2011).

Studies that considered the change process, usually include teacher's personal aspects and the context. However, they often neglect the PDI features and only see PDI as an external factor that can influence the change process. Clarke and Hollingsworth (2002), one of the main references for my study, developed a model of teacher professional

growth, which provide analytical domain to understand how teacher change. But the model does not help to understand the reasons and the influences behind the changes it describes. Additionally, a PDI, in their model, would be one of the possible external influences, as much as a facilitator or a book read by a teacher. These are all placed in the general "External Domain" in the model, which does not facilitate the specific understanding of what and how to do something so recurring in educational environment as a PDI.

My findings confirm the importance of this domain and that it can affect, through reflection, the "Personal Domain", or through enactment, the "Domain of Practice", in Clarke and Hollingsworth's (2002) terminology. It also confirmed the variety of paths that a teacher could follow while changing. My contributions to their ideas are the influences I identified affecting this process and how they might act together. The components in my model specify and characterize what are possible influences in each domain from Clarke and Hollingsworth's model.

My study looked at the process of change considering how the teachers were before the PDI, looked at the influences from and during the PDI and the influences that foster the change to happen in their classroom. Merged, Desimone's, Clarke and Hollingsworth's and mine results shed some light on how to plan, what to expect and how to analyse teacher change during their participation in a PDI.

9.2. Practical implications

Reio (2005), in an introductory article from a special issue of *Teaching and Teacher Education*, summarised the issues within the area of teacher development, change and learning, to which we still need answers:

> How much learning activity should a policy maker or principal plan to assure optimal professional development? Would formal (e.g., university classroom instruction) or informal learning activities (e.g.,

> mentoring) or some combination be best? How might we develop and promote an organizational climate that reduces the teacher uncertainty and stress that undermine learning and identity development? What might we do to remove the environmental barriers to learning (e.g., availability of time, policies, and procedures) that lead to the understanding and implementation of educational change? (Reio, 2005, p.990)

Based on my findings, the suggestions I describe here go some way towards answering these questions. Extrapolating from my conclusions in the sections above, and considering the literature in the field, I will introduce and discuss the idea of a school-based designer.

9.2.1. Teachers as learners in collaboration

Teachers are constantly dealing with change and novelty in their working lives. Some of these changes are part of every teacher's routine, such as getting to know new students and colleagues. Other changes can bring pressure and high levels of stress if conditions are not favourable for the teachers, such as using new equipment in the classroom and implementing a new curriculum. About 25 years ago, Hargreaves (1994) had already pointed out the intensification of teachers' workload. The high demands of teachers are causing a destructive imbalance, as the situation seems not to have improved, but intensified further (Fullan, 2016, p.130). Ideally, the school context should create an environment in which teachers are always willing and ready to engage in activities aimed at improving their teaching in general, and particularly in trying new elements in their classroom practice. In other words, teachers should be in a context where they can operate within their Innovation Zone. In my study, the three teachers in Purple Valley were able to act within their Innovation Zones while teaching the project lessons. The balance achieved between the risk of trying something new in their practice with low-set groups, the characteristics of the PDI, and the teachers' readiness to experiment in their lessons enabled teachers to change their practice.

As discussed in Chapter 3, teachers changing their practices can be seen as learning about teaching. It is also known that successful schools have teachers who are constantly learning. For instance, Little (1982) investigated teachers learning in the work place and found that successful schools, selected based on achievement scores over a 3-year period in three disciplines, promote an environment that encourages teachers to work together on activities related to their practices, such as collaborative planning, experimenting and evaluating teaching practices. Little (1982) showed that in these successful schools, teachers constantly worked together, which promoted teachers' learning about teaching, raised job satisfaction and ultimately raised students' attainment.

A more recent example of teachers learning and changing, while working together as a group, was shown by Watson and De Geest (2014). In Watson and De Geest's study, three mathematics departments decided to take action to improve their low-set groups' attainment. The researchers followed the departments for three years and concluded that eventually the departments moved the focus from gathering resources, to talking about "students' learning and the concern about the pedagogy of the tools and also using hybrid methods to focus on appropriate knowledge and fluency" (p.364). These discussions fostered change in teachers' practices, which according to the authors, is associated with improvement in students' learning.

Besides studies that investigate teachers' learning without external interference, there are plenty of studies of interventions that foster teachers' collaboration while in contact with an external source (a PDI, a researcher or a mentor), promoting teacher change in practice. The collaboration fostered teachers' learning (or growth) by providing participants a space to reflect (Day, 1999) engage in conversation (Britt et al., 2001), share practices (Nisbet et al., 2003) and, to some extent work together (Ponte, 2012).

Another set of theories about how teacher learning can happen in school is developed from the idea of "Community of Practice" (Wenger,

1998). Viewing teachers in a school as a Community of Practice means that teachers are engaged in similar activities, including the development and use of specific vocabulary, behaviour and values, and are part of a joint enterprise, and shared repertoire (Vangrieken et al., 2017; Wenger, 1998; Winbourne and Watson, 1998).

The focus on teacher practice as the means to improve education is a natural choice, since any change will only "reach students through the way teachers interact with students about the content" (Hiebert, 2013, p.46). Also, the classroom is largely agreed to be the primary learning location for teachers (Lampert, 2010). For all the studies on professional development and collaboration mentioned so far, teacher practice is incorporated (at some level) as a topic in their agenda.

However, not all studies specify how teacher practice is captured and shared. Exceptions are researchers that use video recordings from lessons to stimulate conversation (Borko et al., 2008; Coles, 2014; Santagata, 2009), and research that considers teachers' reports from their own lessons (Ponte, 2012; Smith et al., 2005). To the best of my knowlwdge, few studies with collaboration report that teachers are frequently observed, or that teachers have support during lessons.

In my study, in order to sustain the components of the PDI, crucial for teacher change, my constant presence as an extra person in the routine of the participant teachers was necessary. My conclusions and the literature discussed, taken all together, suggest that an external person, working as a member of the mathematics department and supporting teachers in their daily routine, can bring many benefits to the PDI. I am calling this person the "school-based designer".

One of the goals of the school-based designer (SBD) is to foster the creation of a community among the mathematics teachers in a school. Together, working in collaboration, the participants can question the normal state, and be encouraged to consider how appropriate their practices are (Jaworski, 2008, 2005). However, based on my data and my

background as a teacher, I perceive that the SBD should focus on inquiry as a teaching strategy, only if this was the route agreed with the teachers. As Mason (2003) argues:

> those who support professional development of others need to trust individuals and their local communities of practice as long as they are evidently working on issues. They need to stimulate them to question their habits, but also, importantly, to respect teachers' conclusions. (p.289-290).

Following Mason's suggestion, the SBD would be the person who supports professional development. Based on the 14 components discussed earlier (see Section 9.1), I can identify four specific characteristics to be sought by the SBD in order to trigger change in teacher practice.

a) Local issues

In my study, many of the components I found fostering teachers' participation were linked to the fact the PDI was designed for the context of Purple Valley, taking into consideration the three participant teachers' existing ways of teaching and their specific teaching groups. Teachers' agency was maintained as the teachers chose the topic on which we were going to focus and the low-set group with which they were going to use the project lessons.

Since I developed familiarity with teachers' regular lessons, the PDI in general, and the project lessons specifically, were designed taking into account each specific teacher and their specific group of students. During the meetings and the interviews, teachers reflected on the experience with those specific lessons, and the learning of those specific students, which we then discussed.

Additionally, the project lessons were designed to guarantee some level of congruence with the teachers' current practices, helping teachers to reach and stay within their Innovation Zones.

b) Valuing teachers' practice

Having teachers' classroom practices as the reference for the whole project, motivated the teachers to engage with it. Additionally, respecting teachers' choices for their classroom practices apparently increased teachers' trust in the researcher, and after a while, actually encouraged the teachers to use the project lessons as they were, with few alterations.

The phase of experimenting in the classroom was central to the project, because it allowed teachers to compare the project lessons with their previous practices. The focus of the discussions were on teachers' practices, but this focus was only possible because of the knowledge that I built by observing teachers' lessons.

c) Time and knowledge (to design)

Time was essential, not only to build trust and familiarity, but also to design the lesson plans and to present and discuss, with the teachers, the rationale behind them. The researcher developed the initial ideas for tasks (that were discussed with the teachers during the meetings), maintaining a consistent approach to the topic in terms of notation, previous knowledge and what students should know by the end of each lesson. The final project lessons plans were developed maintaining a consistent layout in terms of structure, font and spacing.

d) Constant support

There was constant support for teachers, especially during the lessons they were teaching the project lessons. Last minute alterations were possible because I was reachable via email and was at Purple Valley at least three days a week.

9.2.2. The school-based designer

Given the realities of schools, realistically, only a person with a designated role profile would have the time to observe lessons from all the teachers, select tasks, plan the meetings to show the ideas to the teachers, develop the project lessons plans incorporating the agreed specificity for each teacher's groups, and to be flexible enough for possible last minute changes in teachers' plans to teach the lessons.

Although the teachers in Purple Valley are still using the ideas of visual representation from the project lessons (the cut-outs and the diagrams) to teach fractions to Years 7 and 8[23], they no longer meet to develop other lessons and discuss practice. The project fostered change in practice that seems to have remained after the end of the research project, for the lessons about fractions, but the meetings are no longer happening and apparently there is no initiative focused on other topics or groups. The researcher's presence in the school was apparently important to keep the group as actively engaged in changing their practice as before.

Based on that, my suggestion is to create a new position in the school within the mathematics department: the school-based designer (SBD). This new role is inspired by the researcher role in my own study, and the attributions of the SBD can be related to the project activities developed. As mentioned above, the SBD is an extrapolation of the findings of this study, and literature on teachers' professional development.

The SBD role includes observing lessons of all teachers in the mathematics department; planning regular meetings; engaging with teachers; and designing activities (tasks, sequence of lessons, etc.). She/ he would act as I did in this project, but now integrated into the daily life of the department.

23 I visited Purple Valley after 4 months and again after 18 months since the project ended. Julia told me they were using the tasks and the cut-outs with the years 7 and 8.

Initially, the SBD could be responsible for assessing each teacher situation, considering their professional readiness. If the teacher has problems controlling behaviour, commitment to the job or lacks curiosity, the SBD decides on appropriate activities for this teacher. This is the first fundamental difference between my study and the SBD role. As pointed out in Section 8.1.2, teachers have to be prepared for the task of changing their lessons. An external specialist will be in a better position to evaluate whether the teacher is ready to take risks: some basic conditions should be met so the chances of positive experimentation are high.

The lesson observations will help the SBD to evaluate teachers' readiness to engage in the process, and they also help to develop trust and knowledge about the practices in the school. During the observations, the SBD can act as an extra teacher in the room, helping the teacher, looking at students' work, and learning how that teacher teaches. This will enable the SBD, when designing the activities, to keep congruence with teachers' actual practice – suggesting new elements that move teachers into their Innovation Zone, but not into their Risk Zone.

The trust is built over time, as the SBD works on developing a non-threatening atmosphere, where the teachers can refer to the SBD regarding different issues they are having in their classroom. The SBD will, after a while, become familiar with the teachers' groups, allowing the teachers the comfort of talking to someone who knows more about their context.

The meetings will provide moments for teachers to discuss their practices and to learn from each other. However, as this may not emerge naturally, the role of the SBD is to foster positive discussions. My research suggests that this can be achieved by focusing on elements of teachers' practices, such as possible tasks to be used in future lessons, and answers given by students in a recent lesson.

The SBD will plan the meetings, and guarantee that there will be check points to decide if there is a desire to change the focus, always addressing issues raised by the teachers. This is the second difference from my study, as after teachers decided on the topic of fractions we did not plan to move beyond this topic. Julia, Alice and David mentioned that they were curious to move forward on the topic of fractions, and Julia planned lessons of fraction multiplication, as described in Section 6.2.3.b, but PhD commitments did not allow me to continue visiting the school on such a regular basis.

After deciding the issues on which the group wants to focus, the SBD should have time to research and gather suggestions about how to tackle the problem. Since the SBD knows all the teachers and has observed many lessons, they can suggest that one of the teachers present their strategy to colleagues and build on that. The SBD can bring new teaching approaches, and suggest the use of different materials or new tools. The role requires someone who is constantly looking for suggestions; the SBD might be the person in the department who attends events, such as seminars and conferences, or the department's contact with higher education institutions, thus attracting newly qualified teachers, or to get specific training, and to engage with new results from research.

As the name suggests, a key component of the SBD's attributions is to design a task, a lesson plan or a sequence of lesson plans, according to regular practices in the school. My intention here is to highlight that the SBD should go beyond presenting and discussing interesting tasks, but develop something to be used by the teachers in actual lessons, with a clear rationale and purpose. This product, after being tested and refined, together with the teachers in the school, can be used the next year by other teachers or with other groups. Although I have no data from my research to support this claim, this product may help to develop coherence among teachers from one year to the next, fostering students' learning. It can also work as material for new teachers that arrive in the

school and even as a file to register how the topic was taught in previous years.

By following the description given above, the SBD can enhance the opportunities for learning in the school, keeping the group of teachers working towards constant improvement, raising job satisfaction and ultimately raising students' attainment (Little, 1982; Watson and De Geest, 2014).

9.2.3. SDB: further research

Since the SBD is a new role in the school, there is likely to be a significant issue over resources and funding. To overcome this, a transition strategy could be implemented, as a partnership between the school and a higher education institution (HEI). A funded research project would financially maintain the SBD in the school in the first instance. The close contact between the SBD and the HEI would also act as a support for the demands of the job. The HEI might be responsible for providing some initial training, considering the role of the SBD, and provide access to literature and other resources. The initiative could be seen as a longitudinal study aimed at monitoring and evaluating the new position, with data from the teachers and administrative staff from the schools, the SBD and from students.

Another possible strategy would be to hire the SBD as a "researcher/designer in residence" in the school. This type of relationship is common for arts and music and the basic idea is to hire professionals in the field to become part of the school staff for a period of time in order to promote some sort of innovation in the department, or to increase engagement. This strategy could be combined with a research project or be an independent action from the school.

9.3. Limitations of the study

The first limitation to this study refers to the number of participants. This study investigated only three teachers, although the reduced number allowed me to gain in depth data, since I could spend more time with each participant, but it weakened any generalization of my findings. The decision regarding the number of participants is a trade-off, as Hammersley (1992) explains, between generalisability of the information obtained and the detail of the data collected (p.188). Considering my aims of investigating teacher change in practice and the resources available, I decided that the detail of data for a limited number of participants would provide more interesting findings. Nevertheless, my participants were different in some respects (see Tables 5.1 and 5.10). For instance, by having one novice teacher (Alice) and another teacher very experienced (Julia), I was compelled to investigate what Julia's years of experience had provided her with, instead of just labelling "experience" as a major factor affecting her changes. This way similarities and differences between them naturally emerged and were considered in my analysis. At the same time, they were also teaching in the same school, so the environment was the same for all of them, reducing the possibility of exploring contextual factors in more depth.

The second limitation comes from the fact that my project focused on a specific mathematical topic, addition and subtraction of fractions, resulting in two possible limitations to my findings. Firstly, fractions is a recurrent topic (Zhang et al., 2015), with plenty of scientific and professional papers, books and PDI providing many sources for teachers to learn from. My participants might have had more familiarity with fractions than with other topics, and that could have facilitated their use of the project lesson plans. A reason they might have agreed on fractions, and which would have been kept from me, is that they were all comfortable with it. It could be possible that the teachers would have issues related to their content knowledge if I had chosen a different topic.

Secondly, the focus on visual representations might have enhanced the interest of the participants and influenced the development of the lessons regardless of the features of the PDI. Although I do recognise the consistency of the lessons and the tasks as one of the components affecting the change process, it might be possible that the specific instructional approach has contributed to my results. Nevertheless, even though I recognize this as a possibility, there was no evidence that that is what occurred.

A third issue that could be considered to be a limitation, refers to my focus on low-achieving students. It may have been exacerbated by the nature of the school where this study took place. Purple Valley is located in an economic disadvantaged area, with students achieving below the national average (Section 2.1). Nevertheless, this profile fitted my personal interest in investigating teachers teaching low achieving students.

I also want to highlight an issue that is not a limitation of the study, but a criticism regarding the SBD, related to the long period of time spent on it. This study lasted for almost 18 months, including the Reconnaissance Period (RP), during which we developed and enacted around 18 lesson plans, but this could be considered not to be efficient enough to be adopted by a school, as I suggest when discussing the SBD proposal. However, it is important to remember that this was a research study that considered the possibilities of a project within the school before actually starting it. The SBD, on the other hand, would have a designated role in the school, and once established, I expect it would become embedded in the school culture and function at an appropriate pace, considering the local and collective demands and expectations.

Lastly, considering the exploratory nature of my study, I was open to acknowledge different influences on teachers' change. These influences could come from different sources, and were limited only by my methods of data collection. The components elicited from the data could be grouped into three different areas (see Table 8.2) and the discussions

presented in Chapters 6, 7 and 8 illustrate some relationships between these components. The implication of this exploratory stance is that I was able to demonstrate the importance of the components and suggest relationships between them. However, I could not focus on them individually, either from a theoretical perspective or during my data collection. The next stage could be to design a study in which specific components from my findings could be refined and investigated further.

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Appendices

Appendix 1. Observation Schedule

University of Nottingham

Lesson Observation Record

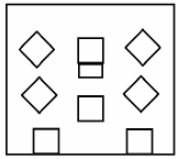
Teacher:
Observer: Rita
Date:_____
Time:_____
Year: ____ Set: ___ No. of pupils: ___

Title/Topics or Learning objectives as declared by the teacher:

Remembering notes:

Overall observation:

The classroom:



Page 1

Starter – from __:__ to __:__

Photo/copy: YES ☐ NO ☐

Page 2

Teacher:_____Date:_____ Year:____ Set:____

Task__– from___:___to___:___	Description/Thoughts/Discourse
Introduction	
The task	
Development	
Closure	

After the lesson:
Questions:

Comments:

Page __

Appendix 2. An example of a project lesson plan

Nome: _____ **Year:** _____ **Date:** _____

Starter: Fill in the table with the fractions.

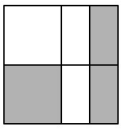
 =			
 =			Create your own here
 =			
 =	$\frac{3}{4}$		
 =			

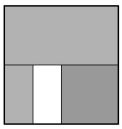
$\frac{2}{10}$ $\frac{3}{15}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{2}{12}$ $\frac{4}{8}$ $\frac{9}{12}$ $\frac{1}{5}$ $\frac{2}{4}$ $\frac{2}{6}$ $\frac{1}{6}$ $\frac{6}{8}$

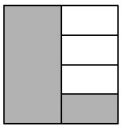
Name: _____ **Year:** ____ **Date:**_____

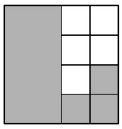
Task 1

Add the fractions in the diagrams.





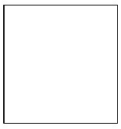




Task 2

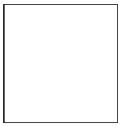
Represent in the diagram the sum and solve it.

a) $\frac{1}{2}+\frac{1}{4}$



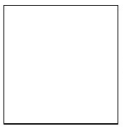
$\frac{1}{2}+\frac{1}{4} = \frac{\quad}{\quad} + \frac{\quad}{\quad} = \frac{\quad}{\quad}$

b) $\frac{3}{4}+\frac{1}{8}$



$\frac{3}{4}+\frac{1}{8} = \frac{\quad}{\quad} + \frac{\quad}{\quad} = \frac{\quad}{\quad}$

c) $\frac{1}{4}+\frac{3}{16}$



$\frac{1}{4}+\frac{3}{16} = \frac{\quad}{\quad} + \frac{\quad}{\quad} = \frac{\quad}{\quad}$

Task 3

How much is $\frac{1}{2}-\frac{1}{8}$? Use the space below to explain your answer.

Appendix 3. Consent form from Dr. Gates' project

Signature: _____ **Date:** _____

From: Peter Gates
Direct Line: 0115 951 4432
Email: peter.gates@nottingham.ac.uk

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

School of Education
The Dearing Building
Jubilee Campus
Wollaton Road
Nottingham
NG8 1BB

Project Title: ***Supporting Low Achieving and Disadvantaged Learners of Mathematics Through Visual and Spatial Imagery.***

Investigators: ***Dr Peter Gates***

Teacher Consent Form

- I confirm that I have been given a full explanation of the above research study that will take place in Bigwood School and that I have read and understood the information letter which has been given to me.
- I agree for this study to take place in my classroom, subject to all the conditions outlined in the **Research Project Information**
- I have been given the opportunity to ask questions and discuss the study with the researchers on all aspects of the study and have understood the advice and information given as a result.
- I authorise the researchers to disclose the results of the study but not the name of the school or any participants.
- I understand that I can ask for further explanations at any time.
- I understand that I am free to withdraw from the study at any time, without having to give a reason.
- I understand that information collected during the study will be kept in a secure database. If data is transferred to others it will be made anonymous. Data will be kept for 7 years after the results of this study have been published.
- I give permission for recordings to be made of conversations with pupils in my lessons as long as pupils give their permission at the time.
- I give permission for photographs to be taken in my lessons as long as pupils give their permission at the time. No photograph will be subsequently used or published without my approval, the Head teachers' approval and the approval of any pupil involved.

(Please cross out any of the above points as appropriate)

Name: _____ **Position:** _____

Signature: _____ **Date:** _____

Appendix 4. Consent form from my research project

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

TEACHER CONSENT FORM

Project title: *A collaborative teacher learning initiative to discuss lessons for low achieving students*

Researcher's name: *Rita Santos Guimaraes*

Supervisor's name: *Dr. Peter Gates*

- I have read the Project Information and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand that I will be audio taped/ videotaped during the interview and meetings.
- I understand that information collected during the study will be kept in a secure database. If data is transferred to others it will be made anonymous. Data will be kept for 7 years after the results of this study have been published.
- I give permission for recordings to be made in my lessons as long as pupils give their permission at the time.
- I give permission for photographs to be taken in my lessons as long as they do not show pupils faces. No photograph will be subsequently used or published without my approval, the Head teachers' approval and the approval of any pupil involved.
- I understand that I may contact Rita Santos Guimaraes or Peter Gates if I require further information about the research, and that I may contact the Research Ethics Coordinator of the School of Education, University of Nottingham, if I wish to make a complaint relating to my involvement in the research.

Signed .....

Print name ..... **Date** .....

Contact details

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School of Education Research Ethics Coordinator:
educationresearchethics@nottingham.ac.uk

Centre for Research in Mathematics Education, School of Education
University of Nottingham
Jubilee Campus, Wollaton Rd
Nottingham - NG8 1BB

Appendix 5. Interview schedules

a) First Interview Schedule

Opening – All teachers

1.1 – Just to have more context. Your degree is in XXXXX, right? And when do you start to teach? For how long?

1.2 – Why teaching and why mathematics?

About the lessons – Alice

2.1 – Can you talk about the titles and the learning outcomes that you have every lesson? Where do they come from? How do you decide them? What does happen if you do not have time to cover all the learning outcomes during one lesson?

2.2 – Can you talk about how you chose examples? What about the items for a task?

2.3 – I noticed that you sometimes have a some sort of introductory task before beginning a topic, like when you asked them to measure the angles of regular polygons before you tell them the property (Year 8 set 5). Or asks if they know the meaning of some words (faces, edges and vertex 03/11/15, Year 7 set 5/6). Why do you do that?

2.4 – I noticed that the students are taking their books home. Is it going okay? Are they bringing it back? Because I remember that you told me once that they were not trustful.

About the lessons – David

2.1 – Can you talk about the titles and the learning outcomes that you have every lesson? Where do they come from? How do you decide them? What does happen if you do not have time to cover all the learning outcomes during one lesson?

a) Can you spot any difference between this two examples?

b) The lesson is different depending on the type of learning objective you have?

2.2 – Can you talk about how you chose the items for a task?

2.3 – I noticed that sometimes you put students together to work on an extra tasks when they have finish the main one or to check each

other answers. Why do you do that? There is any other practice you do with the same purpose?

About the lessons – Julia

2.1 – Can you talk about the titles and the learning outcomes that you have every lesson? Where do they come from? How do you decide them? What does happen if you do not have time to cover all the learning outcomes during one lesson?

a) They have words like "explain" and "demonstrate" what are you looking for in each?

b) The lesson is different depending on the type of learning objective you have?

2.2 – Can you talk about how you chose the items for a task or examples?

General – All teachers

3.1 – After the students leave your classroom we sometimes talk about how was the lesson. I notice that with the lower sets it is more common to see you with some sort of disappointment or frustration. What do you think are the major challenges when you are teaching the low sets?

3.2 – Do you plan the lessons differently for your bottom sets?

Can you give me an example? Why do you do that?

3.3 – Is there anything else that you want to tell me? Anything that you think is important considering that I am trying to understand your practice.

b) Second Interview Schedule

1 – About the second set of lessons:

a) What did you think about it considering: the way the lessons were happening – video followed by tasks that could be solved in group, with drawings?

b) For you, as the teacher, how much in control did you feel? Was it a problem?

c) Do you think students needed more help than usual? More help than during other lessons?

d) Finally, in terms of students learning? Was it worth? What were the advantages and disadvantages of the method?

e) Can you recall anything that was totally unexpected?

2 – You commented with us that these lessons were fostering students resilience. What were the episodes that made you realise that? And which characteristics of the lessons do you think have that power?

a) Overall, how would you characterise the lessons?

b) Do you think the lessons like these are more aligned with the new curriculum?

3 – Do you think you are free to try new practices in the classroom considering the school culture? What would be the main constraints?

4 – Would you like to have more time to prepare lessons? Would you consider yourself overloaded with work?

5 – To what extent the behaviour of the students has an impact in the way you teach?

6 – What do you take into account when you say "this was a good lesson"? What are the criteria for you to consider that a lesson was good?

c) Third Interview Schedule

1 – Why did you choose this school? And why did you stay here?

2 – When you look back over your teaching career, what are some of the moments that stand out for you? Why?

3 – Why did you start participating in this project? And why did you stay?

4 – I want to talk about the experience we had this year with the lessons about fractions.

5 – I would like you to think back about the meetings that we had when we talked about the lessons before you taught them. What was useful and what was less useful in those meetings for you? Why?

6 – Can you talk about your plans for the next academic year regarding lessons about fractions?

7 – Now I want to talk about what you perceive as the role of the shapes and the diagrams in the lessons.

Extra question for Julia – You went further on the topic. You planned and taught the lesson about multiplication of fractions. How was it?

Extra question for David and Alice - You had the chance to use the lessons twice. How was it? What were the differences/similarities in the two experiences?

8 – We already talked about the time you have to prepare lessons and how you could always have more in order to develop resources and different strategies. But now, considering a regular week, how do you go about preparing for a lesson?

9 – Can you describe what you think is going on here (example of a frustrating episode in one of his/her lesson)? Why do you think I picked this episode?

10 – Can you describe what you think is going on here (example of an apparently drastic change in one of his/her lesson)? Why do you think I picked this episode?

11 – Can you tell me how you think these (four students' names chosen to cover range of behaviours, profiles and engagement) students are doing with maths at the moment?

12 – Thinking about your lessons in general for the lower sets and the top sets you have this year. Write percentages for each section adding up to 100% answering each question below. You can add another answer if none of these feels right.

a) How do you see learning in your classroom?

	For your **lower** sets	For your **top** sets	For our lessons about **fractions**
an individual activity based on watching, listening and imitating until fluency is attained.			
an interpersonal activity in which learners are challenged and arrive at understanding through			

discussion.			
an individual activity based on practical exploration and reflection.			

b) How do you see your teaching in your classroom...

	For your **lower** sets	For your **top** sets	For our lessons about **fractions**
a non-linear dialogue between teacher and learners in which meanings and connections are explored verbally. Misunderstandings are made explicit and worked on.			
assessing when a learner is ready to learn; providing a stimulating environment to facilitate exploration; and avoiding misunderstandings by the careful sequencing of experiences.			
structuring a linear curriculum for the learners; giving verbal explanations and checking that these have been understood through practice questions; correcting misunderstandings when learners fail to 'grasp' what is taught.			

c) What is your current view on Mathematics?

an interconnected body of ideas which the teacher and the learner create together through discussion.	
a creative subject in which the teacher should take a	

facilitating role, allowing learners to create their own concepts and methods.	
a given body of knowledge and standard procedures, a set of universal truths and rules which need to be conveyed to learners.	

13 – Do you want to ask me something about this project?

Appendix 6. Observation schedule of a lesson by Julia

University of Nottingham

Lesson Observation Record

[redacted]

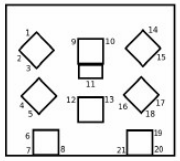
Teacher: [redacted]
Observer: Rita
Date: 02/02/2016 – Tuesday
Time: 11h 20min
Year: 8 Set: 4 No. of pupils: 21

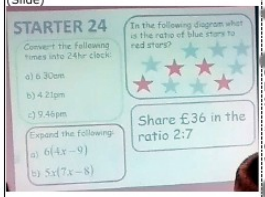
Title/Topics or Learning objectives as declared by the teacher:
(Board) Metric conversion
- demonstrate understanding of how to use the flow diagrams;
- convert between different units

Remembering notes:

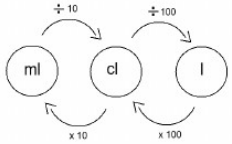
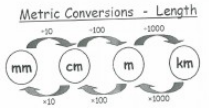
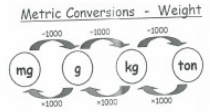
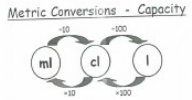
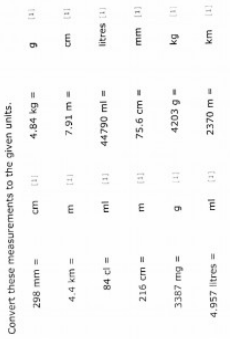
Overall observation:
1 – S3 was sent out of the classroom for bad behaviour.

The classroom:



Starter – from 11:20 to 11:38	
Photo/copy: YES [X] NO [ ]	
(Slide)  	11:26 [redacted] prepared the board. 11:28 [redacted] asked for feedback. Green: talked about the rule for covert the hours (**they were just accepting, as Something they should know/memorize?) ** S8 asks me about the red item – expanding brackets. She did not know what to do at all. [redacted] wrote all the answers on the board, asking questions to students and going over the way to solve each item more than once.

Task 1– from 11:38 to 12:20	Thoughts/Discourse

Introduction [redacted] talked about the topic: length / weight / capacity. (Slide) [redacted] was asking students to complete it, saying by how much they would need to times or divide to convert to the units shown. One slide for each – capacity, weight and length.	
The task 11:48 [redacted] talked about the sheet, the calculator and the conversion sheet. 11:50 [redacted] solved an example.    	

Development [redacted] was helping around.	** 4 students did the same mistake when trying to calculate x 100 and after that x 10. Because they had the calculators, they were doing this in one go, as if it was the same as x 110. This happened in only one item, and [redacted] did not asked any of these students to say the final answer, so I am pretty much sure she does not know about this problem.
Closure 12:00 (Visualiser – sheet) [redacted] was asking students, writing the answer and the 'multiplier' or the 'divisor'. 12:03 [redacted] talked about what would be the same as ÷10 and then ÷100 in only one step. (solving 44790ml to litres)	12:05 [redacted] asked them to self mark their work. 12:05 [redacted] talked about their last exam. Gave their percentage and talked about how it was different from other exams. Saying that they will get used to it, it has more functional questions, it is difficult to spot the topic, there are hidden questions. It is a new style. MAX. 28% MIN. 11% – 13%

After the lesson:

Appendix 7. Observation schedule of a lesson by Alice

University of Nottingham

Lesson Observation Record

[redacted]

Teacher: [redacted]
Observer: Rita
Date: 23/02/2016 - Tuesday
Time:11h 19min
Year: 8 Set: 5 No. of pupils:16

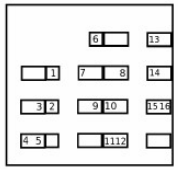
Title/Topics or Learning objectives as declared by the teacher:
(Board)
Solving linear equations

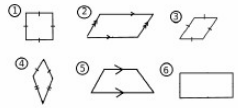
(No learning outcomes)

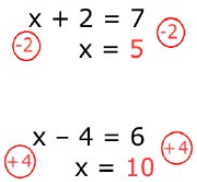
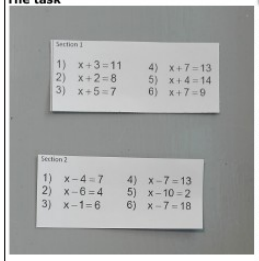
Remembering notes:
1 – The TA is not here and [redacted] does not have any idea why not!

Overall observation:

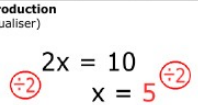
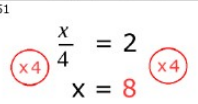
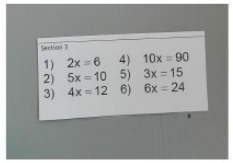
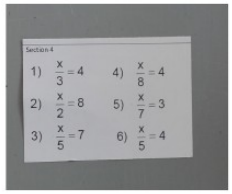
Classroom position:



Starter – from 11:20 to 11:29	
Photo/copy: YES ☐ NO ☒	
(Visualiser) STARTER Name the quadrilateral 	11:28 [redacted] asked for answers, not choosing students, but accepting anyone. She then repeated the right answer and went to the next one. She did not write or show the words on the board.

Task 1– from 11:29 to 12:14	Thoughts/Discourse
Introduction [redacted] talked about equation, showing on the visualiser x + 2 = 7. [redacted] 'Some you can just see the answer', and asked students how much added 2 make 7. [redacted] solved 2 example on the board, asking students to give the number to make the sum right and then using the 'balance method' to get the same answer. [redacted] talked about balance; opposite operations; same sum on both sides to keep the balance. (**I just think she did not emphasise that they are getting the value of the letter, they are getting a missing value. So the students were not associating their answer with x on their notebooks.)	(Visualiser)  11:35 [redacted] asked them to copy and hand out a small piece of paper with six equations.
The task  	[redacted] also hand out clue. She only gave the second Section for students that have finished the first, getting all items corrected.
Development [redacted] was walking around, helping students. She told me that she was always explaining the balance method.	The idea was that they will use because it always works and they will need it for the items with more than one sum.

Closure 11:47 [redacted] asked for pens down and did the register (not calling them, only filling the table on the computer).	**Most student have finished sections 1 and 2. I saw 4 that did not.

Task 2 – from 11:49 to 12:13	Thoughts/Discourse
Introduction (Visualiser)  	11:51  [redacted] was asking students to help, asking what was the opposite and checking the initial answer with the method.
The task 11:53 New small sheet  	And, for students that had finished and had all the right answers [redacted] gave the last sheet. 
Development [redacted] was walking around, helping students.	
Closure None	

Task 3 – from 12:13 to 12:19	Thoughts/Discourse
Introduction [redacted] said that they should finish the item they were solving and do, at least, the 3 first items of the exit ticket.	
The task (Slide) EXIT TICKET 1. 3x = 9 x = ? 2. x + 7 = 12 x = ?	3. x – 2 = 10 x = ? 4. $\frac{10x}{5} = 4$ x = ?
Development None	[redacted] did not check any book.
Closure None	

After the lesson:

I asked about the TA and [redacted] said she did not know where was she. And also commented that this was annoying because she was not prepared to have the students that are usually outside with her.

We also talked about the two boys that are usually out.

[redacted] There is no point just giving them a lot of adding and subtracting to do.

[redacted] They kind of...They understood something at least.

I said I liked the way she did the explanation, getting their answers intuitively and them showing that the method would lead to the same answer.

[redacted] I couldn't work out how to do it, really. It is quite a fundamental, isn't it, that balance? … But some were too lazy to want even see my method once they knew the answer. (lazy is normal) but they got to know because as soon as they got to the 2-step problems they will have no idea.

[redacted] Talked that she did the balance method all the time when she was walking around.

[redacted] Talked that she did it with her year 10 this morning, they needed that… they needed the method for simple equations.

I talked about reading the problem. She agreed with me.

**In the end of the lesson she left the students waiting a little after the bell and said that it was not good enough. But it was not so clear what wasn't good enough – they

were quite naughty today. And also, they did not realise when it was okay to go, everybody went out together, not the well behavioured first.

Appendix 8. Observation schedule of a lesson by David

University of Nottingham

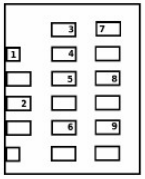
Lesson Observation Record

[redacted]

Teacher: [redacted]
Observer: Rita
Date: 11/02/2016 - Thursday
Time: 8h 43min
Year: 9 Set: 6 No. of pupils: 9

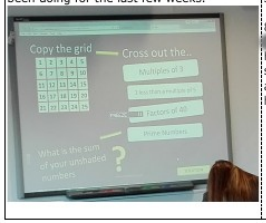
Title/Topics or Learning objectives as declared by the teacher:
(board)
Compound shapes
- Find missing sides using a consistent method;
- Use all sides of a shape to find the perimeter.

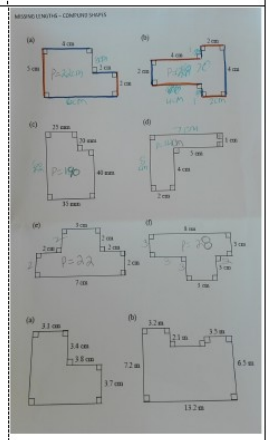
Remembering notes:
- I audio recorded the lesson from the back of the room.



Overall observation:
1 – [redacted] used colours to highlight the sides in each direction on the shapes. During the lesson, we talked about it (audio record)

The classroom:

Starter – from 8:43 to 8:55	
Photo/copy: YES [x] NO [ ]	
(Slide) **This is the same starter [redacted] has been doing for the last few weeks.  	8:50 [redacted] hand out coloured pens for all students. 8:53 [redacted] showed the answers on the slide. He only asked about the final sum, students did not help or gave any answer, and [redacted] did not talk too much about how to get the right numbers.

Task 1– from 8:55 to 9:34	Thoughts/Discourse
Introduction [redacted] asked the students how to get the perimeter of a shape. S6: Add all the sides.	[redacted] solved the first item of the sheet asking students to help, using colours to highlight the horizontal and the vertical sides.
The task (Sheet) With 8 shapes – all rectangular format.	
Development I was helping students.	[redacted] was in his desk, checking something on his computer.
Closure 9:25 (visualiser) [redacted] solved all the items, but the last, asking students for help. Using the colours to show the related sides.	

Task 2 – from 9:34 to 9:45	Thoughts/Discourse
Introduction (Visualiser) "Area" [redacted] talked about area. Asking students 5cm 3cm Area = 5x3 = 15cm^2	About meaning and how to calculate it. Area – space inside a 2D shape. This will be the next topic.
The task None	
Development None	
Closure None	

After the lesson:
I praised the lesson.
[redacted] said that this group needs repetition and repetion works with them.