

BRIATHAR DÉ MO LÓCHRANN



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Exploring the Impact of Lesson Study on the Theory-Practice Gap in Pre-service Teacher Education

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Abstract

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Studies of initial teacher education have repeatedly revealed a disparity between the theory taught in teacher education programmes and the subsequent practice of these teachers in the classroom (Allen, Butler-Mader & Smith, 2010; Cheng, Cheng & Tang, 2010; Korthagen, 2010). Defined by Cheng et al (2010) as the “inconsistencies between the selection of the best teaching strategies and the most commonly employed teaching strategies” (p. 94), this concept of the theory-practice gap is not new. However, despite vigorous attempts of researchers to address this problem it remains a central issue in teacher education today. This study seeks to examine if a curriculum specialisation in mathematics education, based on the principles of Japanese lesson study, can support pre-service teachers in bridging the theory-practice gap. Qualitative data was collected from a variety of data sources including; pre-service teachers’ lesson plans, reflections and presentations, observation of lessons taught by the pre-service teachers and interviews with the pre-service teachers. Analysis of the data revealed that lesson study is indeed an effective approach in assisting the pre-service teachers to bridge the theory-practice gap. Through this classroom-based inquiry approach and with continuous guidance from the mentors (teacher educators teaching the course) the pre-service teachers began to judge the success of their lesson based on student learning. This new focus on student learning enabled them to make vast improvement in both their lesson planning and implementation. In their lesson planning they demonstrated a greater understanding of important components of the lesson, they began to critically examine the representations they chose to teach the mathematical content and they displayed a more knowledge-based anticipation of students’ responses. In practice they developed a confidence in their use of constructivist teaching approaches, they improved their questioning and collaboration skills and they began to reflect more openly and honestly on their lessons.

Declaration

I hereby declare that this project is entirely my own work other than the counsel of my supervisor and that it has not been submitted for any academic award, or part thereof, at this or any other educational establishment.

Signed: _____

Author

Date: _____

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Chapter 1: Introduction

1.1 Introduction

“Mathematics is of central importance to modern society. It provides the language and analytical tools underpinning much of our scientific and industrial research and development. Mathematical concepts, models and techniques are also key to many vital areas of the knowledge economy, including the finance and ICT industries. Mathematics is crucially important, too, for the employment opportunities and achievements of individual citizens”.

(Smith, 2004 p. v)

In recent times the importance of mathematics in our society has increasingly been recognised. This increasing recognition coupled with the current economic climate, has led to a more intense scrutiny of our mathematics education system. Closer examination of our education system has highlighted Ireland’s declining performance in international mathematics assessments such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment). For example, in 2009, Irish performance in PISA was below the OECD (Organisation for Economic Co-operation and Development) average whereas in the preceding years Irish students had been performing at the OECD average (Eivers and Clerkin, 2012). Repeatedly, Irish students have been scoring below countries in the Asia-Pacific region such as Singapore, Hong Kong and Japan (Eivers and Clerkin, 2012). Given the importance of mathematics in almost every sector of society it is imperative that steps be taken to improve standards of mathematics in this country. Like many of our international counterparts, Ireland has begun to look at practices in countries whose students are constantly outperforming others in international studies on mathematics (Richardson, 2012; Corcoran, 2005; Ma, 1999). One example of such a practice is the Japanese approach of lesson study, a model which has been gaining increasing recognition over the last number of years. This is an education model which treats the theory and practice of teaching as inseparable entities, the antithesis of current practices in Irish education (Long et al, 2012).

The gap between the theory and practice of teaching is an issue of great concern for teacher educators. As early as 1904, John Dewey identified the gap between theory and practice in teacher education and made attempts to amend it. However the sheer complexity of the problem means that it has remained a perennial problem in teacher education. Indeed one of the main criticisms of teacher education programmes today, is their failure to enable students to bridge this gap (Allen, 2009). Several reasons have been proposed as to why this theory-practice gap is so manifest in teacher education. One of these is the lack of ‘connection’ between the teacher education programmes and school-based teaching

experiences (Cheng et al, 2010). This seeming disconnect has resulted in the theory and practice of teaching being treated as separate entities (Bartholomew, 1976).

Hiebert et al (2002) examined how theory and practice can be integrated within teacher education. They suggest that, if theory and practice were integrated successfully, teachers would be able to use researcher knowledge to help them understand the issues they were experiencing in the classroom and therefore improve their practice. They imagined this sort of practice would take the form of teachers searching “the research archives to help them interpret their students’ conceptions and misconceptions, plot their students’ learning trajectories, or devise more alternative teaching practices” (p.3) which in turn would lead to an improvement in their students’ learning. Lesson study, the Japanese approach to the improvement of classroom teaching, is driven by precisely those motivations.

In recent years in Mary Immaculate College, the response to the theory practice gap in pre-service teacher education has been to incorporate lesson study into the pre-service teacher education programme. Lesson study is an approach initially developed and utilised by the Japanese to reform Japanese teaching. It is based around the idea that teaching is a multifaceted cultural activity and cannot be improved by simply introducing top down reforms but “through the gradual improvement of individual lessons, and through the knowledge developed and shared during this process” (Stigler and Hiebert 1999, p. 127). Lesson study has proven to be very successful in helping mathematics teachers in Japan to improve their teaching (Stigler and Hiebert, 1999). In this investigation the author investigates if lesson study supports pre-service teachers in Mary Immaculate College in bridging the gap between theory and practice in their teaching of mathematics.

1.2 Originality and Purpose of the Study

Several attempts have been made to bridge the gap between theory and practice. These have included both changes to pre-service teacher education and the introduction of school based staff development models. Donald Schon, an author in the field of reflective practice, has caused people to look at school-based training in English teacher education in an attempt to bridge the theory-practice gap (Newman, 1996). In the Netherlands, teacher education has already shown a trend toward this type of school-based model of teacher training (Buitink, 2009). The idea of school-based teacher training has received much support based on the reasoning that teaching is such a complex activity that the best way to learn it is in an authentic context (Howey and Zimpler, 1994; Johnson et al., 1993). However the

negative aspects of using such a model in teacher education have also been highlighted. In particular it has been shown that teachers learning in such a way learn through imitation without understanding the underlying principles which make one instructional strategy more favourable than another.

School-based staff development models have also been introduced in an effort to bridge the theory-practice gap. In the United States a research lead teacher (RLT) model was implemented in an attempt “to bridge the gap from research to practice in implementing effective instructional strategies” (Spencer and Logan 2003, p.52). This investigation included the use of strategies such as in-service, teacher study groups and coaching. It aimed to provide teachers with research-based rationales for using particular instructional strategies to improve student performance. The findings of this investigation showed that teachers need on-going support in implementing research based procedures. These were similar findings to those of Schumm and Vaughns (1995b) and Showers (1990). However this sort of top-down planning can often cause misinterpretation and create a divide between classroom teachers and educational policy makers (Stigler and Hiebert, 1999).

The Japanese approach of lesson study has been gaining increasing support in the reform of teaching (Cohan and Honigsfeld, 2007; Hiebert et al, 2002; Lewis, Perry and Murata, 2006; Sims and Walsh, 2009). Lesson Study is an approach to teacher education that incorporates many of the same ideas of the RLT model. Similar to practices in the RLT model, teachers planning research lessons in lesson study are expected to read “about what other teachers have done, what ideas are recommended by researchers and reformers, and what has been reported on students’ learning of this topic” (Hiebert et al. 2002, p.9). However in contrast to the RLT model, lesson study incorporates a combination of top-down and bottom-up planning which creates a strong link between the classroom teacher and the educational policy makers (Stigler and Hiebert, 1999).

More recently researchers have begun to examine how the lesson study approach can be adopted in pre-service teacher education (Cohan and Honigsfeld, 2007; Burroughs & Luebeck, 2010; Sims and Walsh, 2009). Indeed, lesson study has now been included in several pre-service teacher education programmes in Ireland and researchers, including those at Mary Immaculate College, are examining how lesson study benefits pre-service teachers (Corcoran & Pepperell, 2011; Cohan & Honigsfeld, 2007; Leavy, 2010). Cohan and Honigsfeld (2007) found that “the lesson study approach is an effective tool for lesson planning, lesson presentation, and lesson evaluations” (p.81). Corcoran and Pepperell (2011) found that “lesson study fosters the collective development of mathematical knowledge”

(p.229). This echoed the findings of Leavy (2010) who had previously found lesson study supported pre-service teachers' development of statistical knowledge. However these studies have focused on changes in pre-service teachers' pedagogical and content knowledge and have not looked specifically at how lesson study can be used to bridge the theory-practice gap.

Looking more closely at lesson study research in Mary Immaculate College research efforts have primarily focused on the improvement of teaching the individual mathematical content rather than on how lesson study can help students to bridge the gap between theory and practice. In the time since lesson study was first included as a component of the pre-service teacher programme in Mary Immaculate College the research lessons taught have included topics such as Inferential Reasoning, Algebra and Data Analysis and Statistics. Within each of the cycles of lesson study data were collected and analysed. These data were used to provide information on the teaching of these subjects and feedback into the preparation of pre-service teachers to teach primary level mathematics. For example Leavy (2010) found that "much of the discussion in the classroom was too general and did not focus adequately on statistical reasoning" (p.57).

The author believes that several aspects of lesson study lend itself to supporting pre-service teachers in adopting new knowledge and beliefs they are being taught in their initial teacher education programme into their practice, hence assisting them in bridging the theory-practice gap. Lesson study directly connects "to the work of teachers and their students", it is "participant driven and grounded in enquiry", it promotes "reflection and experimentation and collaborative and involve the sharing of knowledge", all features considered by Darling-Hammond & McLaughlin (1995) to be extremely important in enabling teachers to "adapt new knowledge and beliefs to their own teaching contexts" (p.2). In this study the author hopes to determine if the use of lesson study within the pre-service teacher education programme allows students to bridge the gap between theory and practice and, if so, how it could further be improved to help them to do so.

1.3 Research Questions

The principal research question that focused this study was:
In what ways does participation in the lesson study process support pre-service teachers in incorporating research knowledge and theories acquired in previous teacher education

modules into their teaching of mathematics, hence facilitate them in bridging the theory-practice gap?

A secondary question was:

What improvements, if any, can be made to the lesson study model in order to better facilitate pre-service teachers in bridging the theory-practice gap?

Through the exploration of these questions, this study has provided significant evidence that the lesson study model is an effective approach in facilitating pre-service teachers in bridging this theory-practice gap. The evidence of this will be outlined and discussed in the following chapters. Several limitations of this model will be identified. However this study also reveals particular aspects of the lesson study model, which the pre-service teachers found to be particularly effective and which could be adapted to fit other teacher education models.

1.4 Structure

This study will be illustrated using the following headings; literature review, methodology, results, discussion and conclusions and recommendations. A brief synopsis of each chapter has been included to give the reader an overview of the study.

Chapter 2: Literature Review

In this chapter the author provides the reader with insights into previous research undertaken in this field. It provides a background to the theory-practice gap and outlines some of the contributory factors commonly identified in the literature as being responsible for this problem. It subsequently examines the measures which have been adopted by some teacher educators in response to the theory-practice gap. Finally it describes the lesson study model and examines the recent support for it in teacher education, both internationally and nationally.

Chapter 3: Methodology

This chapter outlines the various methodologies undertaken by the author in conducting this research. It provides an overview of the curriculum specialisation course through which lesson study was delivered. It presents the background of the participants, describes the tools and processes used in analysis of the results and describes the steps taken to improve the reliability and validity of the study. Finally, the limitations of the study are brought to the attention of the reader.

Chapter 4: Results

The results obtained from the various data sources are described in this chapter. The majority of the data collected in this study was qualitative, therefore the statistical package Nvivo was the main analysis tool used in the study. The common themes which were identified using Nvivo are presented. The findings of the study are then examined under these themes. Samples of the data collected are used to corroborate the results.

Chapter 5: Discussion

In this chapter the author discusses the results obtained in the study. This discussion provides a context for the results by comparing and contrasting them with the findings of previous research. This allows the reader to see the similarities and differences between the findings of this investigation and those of previous research. It also explains why lesson study proved to be successful where other models have failed.

Chapter 6: Conclusion and Recommendations

In this chapter the author summarises the main findings of the study and outlines the conclusions that can be drawn from these findings. Aspects of lesson study that were highly successful in assisting the pre-service teachers to bridge the theory-practice gap are highlighted and some limitations of the lesson study process undertaken are also acknowledged. Finally the author makes some recommendations for future research.

1.5 Conclusion

The author undertook this study in order to examine the effectiveness of the lesson study model in supporting pre-service teachers to bridge the theory-practice gap. The knowledge gained in this study showed the benefit of the lesson study cycle to the pre-service teachers' knowledge and practice which has implications for the delivery of course work and school placements in the future. In the next chapter the author will examine the work of other researchers in the field to provide a context for the study.

Chapter 2: Literature
Review

2.1 Introduction

In the previous chapter, the author introduced the reader to the research field within which this study lies. In this chapter the author will build on this further by reporting the findings of research previously carried out in this domain. Initially the author will examine the theory-practice gap as it occurs in the field of education. Next the author will provide an insight into the factors contributing to the theory-practice gap and outline several solutions which have been trialled in an attempt to bridge the gap. This is followed by a description of the lesson study approach; the approach the author hypothesises might help pre-service teachers to bridge the practice-theory gap. Finally the author will examine models of teacher knowledge which will be used in the analysis and discussion of results.

2.2 The Theory-Practice Gap

The objective of teacher education programmes is to provide pre-service teachers with a set of skills which enable them to cope with the complex situations they find themselves faced with in their everyday teaching (Cheng et al, 2010). However it seems the challenge of teacher education is to help these pre-service teachers put what they have learned in the teacher education programme into practice (Cheng et al, 2010). Indeed Allen (2009) has identified being able to “strike a balance between theory and practice” (p. 647) as one of the greatest challenges for all pre-service teacher education programmes since the professionalization of teaching. Studies of teacher education have repeatedly revealed a disparity between the theory learned by student teachers in their teacher education programmes and the subsequent classroom practice of these teachers (Allen et al, 2010; Cheng et al, 2010). This gap between the knowledge teachers have and what they can do has been labelled as a ‘performance paradox’ (Pfeffer and Sutton 2000, p. 243). Cheng et al (2010) further defined this ‘performance paradox’ in the teaching profession as, the “inconsistencies between the selection of the best teaching strategies and the most commonly employed teaching strategies” (p. 94).

2.3 History of the Theory-Practice Gap

Researching the theory-practice gap is not new. As early as 1904, John Dewey observed the gap between theory and practice in teacher education and proposed possible ways to bridge this gap (Korthagen, 2010). Despite vigorous efforts being made to address

the problem throughout the twentieth century, the issue of theory and practice remains a central problem in mathematics education and has become increasingly urgent (Wittmann, 2001). During the twentieth century, efforts to bridge this gap focused on how teacher education faculties could better respond to reforms based on academic research (Korthagen, 2007). Abstract knowledge was viewed to be of more significance than concrete skills (Kessels and Korthagen, 1996). In more recent times researchers have acknowledged that their universal theories lack concreteness, flexibility, subtlety and congruency and because of the situated nature of teachers' practice, translating research knowledge into forms useful for teaching can be problematic (Kessels and Korthagen, 1996). This has led to a shift in focus on how the theory-practice gap should be approached. Efforts are now being focused on developing "more reflective, more culture-sensitive, and more practice-orientated research" (Clements and Ellerton 1996).

2.4 Contributory Factors to the Theory-Practice Gap

Given that as early as 1904, Dewey had perceived the gap between theory and practice and had proposed possible ways to bridge this gap, it is remarkable that it remains such a central issue in teacher education today. However closer examination of the contributory factors to the theory-practice gap reveals the sheer complexity of the problem. Korthagen (2007) believes that it is this complexity that makes the theory-practice gap more manifest in education than in other disciplines, such as medicine and engineering. In particular Korthagen (2007) highlights "the complex psychological and sociological phenomena influencing educational processes" as posing particular difficulty for those searching for solutions to the problems causing the theory-practice gap (p. 306). Robinson (1998) also recognised the complexity of the issue emphasising that "narrowing the research-practice gap is not just a matter of disseminating research more effectively or of using more powerful influence strategies" (p. 17). This viewpoint acknowledged that the cause of the theory-practice gap was not simply the disconnect between university researchers and classroom practitioners but that the root of the problem lay much deeper. In the following sections several issues identified in the literature as being contributory factors to the theory-practice gap are examined.

2.4.1 The Complexity of Teaching

Hoban (2000) insists that the role of a teacher is much more than delivering the prescribed content using a variety of teaching strategies. He acknowledges that the actions of

a teacher in their classroom are influenced by the interaction of many components. This is a view of teaching shared by numerous researchers exploring the theory-practice gap (Allen et al 2010; Korthagen 2010; Leikin and Levav-Waynberg 2007). Leikin and Levav-Waynberg (2007) in their examination of teachers' practice describe it as a practice "embedded in a complex cultural enterprise that includes many interrelated factors" (p. 366). Such factors include those directly related to the teaching context such as educational policies, curricular requirements, individual school environment, assessments and student responses (Leikin and Levav-Waynberg 2007; Korthagen 2007). However Hiebert et al (2005) also recognise that factors which shape teaching "extend far beyond the classroom door" and that "just as with other institutions, schools and classrooms and the practices they sustain reflect the wider society" (p.113). Korthagen (2007) believes that teacher practices are also affected by the 'human factor'. This 'human factor' includes both feelings and emotions and teacher identity. According to Hargreaves (1998a), feelings and emotions play an essential role in teaching. And Korthagen (2010) warns that this must be acknowledged by those trying to instigate change in practices as emotional reactions to losing stability, certainty and predictability can prove problematic. Both Korthagen (2007) and Frick et al (2010) also recognise the impact of teacher identity on how teachers perceive and approach the teaching and learning relationship. Given the broad range of factors which can influence the decision making and actions of teachers at any particular time, it is clear that teaching is indeed a complex activity. According to Hoban (2000) it is this complex nature of teaching that requires teachers to use 'holistic judgement' (Day 1999) in their everyday practice, something for which Korthagen (2010) says it is hard to prepare teachers. Similarly, Kellaghan (2004) believes that "when one considers the complexity of teaching, the need to be flexible, adaptable, and able to deal with change that will occur during their lifetimes, it becomes clear that an approach that simply "trains" students to act in prescribed ways is bound to be inadequate" (p. 22).

2.4.2 Prospective Teachers' Preconceptions

Another aspect of teacher education which is difficult for educators to address is the powerful role that preconceptions play in pre-service teachers' learning. Joram and Gabriele (1998) state that these preconceptions are "constructed on the basis of personal experience and cultural beliefs" (p.175). Lortie's (1975) concept of 'apprenticeship of observation' illustrates how teacher socialisation occurs through the observation of the practice of teachers during the thousands of hours prospective teachers spend in classrooms as students. According to Cheng et al (2010) this 'apprenticeship of observation' continues during their

teacher education programme as the prospective teachers observe their lecturers and use their practices as a source of models for teaching. Cheng et al (2010) suggests that this modelling behaviour can be used as an opportunity to allow prospective students to experience likely outcomes of various teaching approaches rather than just teaching them theoretically.

Kellaghan (2004) appreciates the provision of opportunities such as this claiming that

“students need assistance in interpreting and integrating their experiences in the various elements of their preservice programme, as well as those acquired prior to entering the programme, and in constructing new understandings to guide them in making the practical day-to-day decisions of teaching.”

(p 22)

Many researchers have emphasised the influence that preconceptions can have on what pre-service teachers learn during their teacher education programmes (Cheng et al 2010; Hiebert et al 2007; Joram and Gabriele 1998; Korthagen 2010; Lortie 1975). Cheng et al (2010) and Hiebert et al (2007) discuss how teachers’ prior experiences and beliefs can act as a filter through which they interpret what they are being taught and what they learn. Cheng et al (2010) and Joram and Gabriele (1998) believe that prior experiences can limit prospective teachers’ receptivity to certain aspects of their teacher education programmes. Therefore it is clear that it is important for teacher educators to take student preconceptions into consideration when developing teacher education programmes. Joram and Gabriele (1998) and Korthagen (2010) stress that because these preconceptions are often long-standing they are remarkably stable and resistant to change which adds to the difficulty teacher educators face in addressing the problem.

2.4.3 Socialisation towards Patterns Existing in Schools

The complexity of teaching is probably one of the reasons why students often feel ill-equipped to deal with the challenges that lie ahead in their new profession (Frick et al 2010). Perhaps then this feeling of inadequacy explains why so many teachers experience a phenomenon known as ‘the transition shock’ (Veenman 1984) once they leave their teacher education programme and begin working in the field. ‘The transition shock’ is a term coined to describe the change in attitudes of fledgling teachers as they seemingly abandon university theory and begin to emulate the practice of the teachers around them (Korthagen 2010). Similar socialisation towards patterns existing in the school has also been associated with the practice of pre-service teachers during their field experiences (Cohn 1981; Zeichner and Tabachnick 1981). Zeichner and Tabachnick (1981) suggest that many of the conceptions

regarding teaching practices developed during university teacher education are ‘washed out’ during school experiences. There have been various suggestions as to why this might happen. Frick et al (2010) propose that:

“students’ ability to instigate change and/or explore new pedagogies may be inhibited as a result of power imbalances in the professional relationships between pre-service and in-service teachers.”

(p.424)

Zeichner and Gore (1990) and Klein (1992) both allude to the relative inflexibility of school culture and how difficult it is for an individual to change the established patterns of schools.

However Zeichner and Tabachnick (1981) offer an alternative theory to the idea that the effects of university teacher education are ‘washed out’ by school experience. They consider the possibility that perhaps university teacher education never really impacted on the prospective teachers in the first place. Studies conducted by Finlayson and Cohen (1967) and Gibson (1972) provide evidence to support this view. Similarly, Leikin and Levav-Waynberg (2007) in their study of the theory-practice gap found that “educational programs often do not provide sufficient opportunities for adequate conviction to form”. Perhaps it is the short amount of time spent in preparation programs, coupled with the fact that the theory learned there is not being reinforced by the approaches to teaching and learning the students encounter during their field experiences (Morrison and Marshall 2003), which contributes to the theory-practice gap.

2.4.4 The Relationship between Researchers and Practitioners

The notion that the theories being presented in universities is not being reinforced during their field experiences highlights the disconnect between university instruction and the classroom model (Morrison and Marshall 2003). Indeed the relationship between the researcher and the practitioner is one which has received much attention in the literature and has been identified as being another contributory factor to the theory-practice gap (Klein 1992; Korthagen 2007; Leikin and Levav-Waynberg 2007; Wittmann 1984). Several reasons have been suggested for the existence of such a divide between the two professional cultures.

One reason put forward is that both researchers and practitioners want to maintain their comfortable status quo in education (Klein 1992). Changes to their role is sometimes seen as threatening by both researchers and practitioners (Klein 1992; Korthagen 2010) especially when there are few rewards for them to improve their practice (Klein 1992). A second reason for the gap between the cultures is the accessibility of the work done by

researchers. Spencer and Logan (2003) suggest that many teachers are not aware of the effective research-based strategies that educational researchers are developing. Klein (1992) explains that this is due to a combination of both the language used by the researchers and where they publish their work. Klein (1992) further clarifies this, explaining that because researchers publish their research in academic journals, their audience is primarily other researchers.

A third reason is the lack of ownership the practitioners have over the theory. The importance of ownership of ideas has been strongly expressed by Goodson (2001) in his work on educational reform. Goodson (2001) found that reform in educational practice can only be successful if the teachers feel they have ownership of the ideas. Spencer and Logan (2003) found that teachers often dismiss research “as having no connection to their classroom” (p. 51). Klein (1992) states that until teachers accept researchers’ ideas as being relevant and meaningful to them it will continue to have little impact on practice.

However Wittmann (1984) says that often researchers develop theories without thinking about the practical implications. This helps to explain the fourth reason for the practitioner-researchers divide; both researchers and practitioners value different things (Klein 1992; Wittmann 2001). It is this idea of different values that has caused several researchers to examine the type of theory being developed by their fellow researchers.

2.4.5 Inadequacy of the Theory

The inadequacy of the theory that prospective teachers are being provided with has received much attention in the literature (Cheng et al 2010; Korthagen 2010; Hiebert et al 2002; Hiebert et al 2007). The criticisms mainly focus on two aspects of the theory: the type of knowledge being imparted and how the knowledge is being imparted. Korthagen (2010) makes the distinction between the type of knowledge that is being provided and the type of knowledge that is needed. Korthagen (2010) describes the knowledge that is needed as “prompt and concrete answers to situations” and the type of knowledge being provided as “abstract, systemised and general expert-knowledge” (p.409). Klein (1992) makes a similar distinction between the abstract principles taught to pre-service teachers and the knowledge required in the specific context of their classrooms. Indeed many researchers in this field have referred to this tension between ‘formal knowledge’ and ‘practical knowledge’ (Hiebert et al 2002; Kessels and Korthagen 1996; Korthagen 2010).

This longstanding controversy dates back to the Greek philosophers, Plato and Aristotle. Aristotle placed more importance on knowledge as *pronesis* or practical wisdom

whereas Plato considered that knowledge as episteme, or knowledge connected to a scientific understanding of the problem, to be most important (Kessels and Korthagen 1996). If we examine the most dominant models in education today, it is clear that current teacher education favours Plato's knowledge as episteme. According to Korthagen (2010) the most dominant models in teacher education since the late nineteenth century have been the theory-to-practice model and more recently the technical-rationality model. Both of these models are grounded in the use of 'formal' knowledge. The theory-to-practice model in teacher education led to programmes where "experts in certain domains taught their 'important knowledge' to prospective teachers" (Korthagen 2010, p. 408). The technical-rationality model in teacher education is founded on the view that providing prospective teachers with theories based on scientific research will make them better teachers (Korthagen 2010). Researchers have criticised this use of the natural sciences as a model for developing theory, condemning its emphasis on control and predictability, and deeming it unsuitable for the field of education (Kessels and Korthagen 1996; Klein 1992). It is apparent on this evidence that there is significant criticism for the type of theory prospective teachers are being taught and for the manner in which the theory is being imparted to prospective teachers.

Bartholomew (1976) suggests that theory and practice are treated as separate entities within colleges of education. Korthagen (2010) describes current practice in teacher education programmes as educators teaching theories to prospective teachers which they then must try to apply during their teaching practice experiences. However Bartholomew (1976) believes that students "never experience in practice the ideas they are allowed to express in theory" (p. 123). Wittmann (1984) states that theory and practice cannot be treated as separate entities, proposing that, theories which are developed independently of practice cannot be applied afterwards. Kessels and Korthagen (1996) maintain that certain aspects of teaching such as choosing a behaviour appropriate for a particular situation cannot be transferred "through the use of purely conceptual knowledge" (p.20).

These feelings of discontent with the current approach to theory provision in teacher preparation have led to various suggestions on how the situation can be improved. Cochran-Smith (1992) suggests the goal of teacher education has to change from "teaching students how to teach" to "teaching them how to continue learning in diverse school contexts" (p. 109). This idea is shared by Hiebert et al (2007) who propose that teacher education should provide prospective students with a set of skills to prepare them to continue learning from their practice once they begin teaching. Kellaghan (2004) also advocates developing this type of professional reasoning that will enable them to deal with the complexities they will face in

the teaching profession. Robinson (1998) suggested that the value of theory lies in its use in perceiving practice rather than providing teachers with concrete solutions. There has been considerable support for this notion of developing prospective teachers' perceptual awareness (Edwards and Hammer 2006; Korthagen 2007; Kessels and Korthagen, 1996). Both Kessels and Korthagen (1996) and Korthagen (2007) identify the importance of helping students to become aware of the important aspects of their teaching experiences. Korthagen (2007) suggests that there has been too much emphasis on formal knowledge and that the development of perceptual awareness has been overlooked.

2.5 Solutions to the Theory-Practice Gap

It is clear that there are problems associated with current practices, however, given the complexity of the problem it is also clear that finding an appropriate solution is not easy. Several different approaches to solving the problem have been proposed in the literature. In general they can be categorised under the following headings:

- School-University Partnerships
- Alternative Forms of Knowledge Provision
- Alternative Teaching Strategies

In the following section approaches from each of these categories will be examined in greater detail.

2.5.1 School-University Partnerships

Allen et al (2010) acknowledge that teacher education programmes can no longer assume that the theory they teach within the university “will be automatically translated by pre- and beginning in-service teachers into meaningful pedagogical discourse in the classroom” (p.618). Allen (2011) suggests that the theory and practice components of teacher education will remain disjointed while they are being taught and supervised by people who are not communicating with each other. Therefore it would seem that the obvious solution to this problem is to bring practitioners and researchers together and have them communicate and collaborate (Klein 1992; Korthagen 2007).

In recent decades this kind of reasoning has led many researchers to believe that the professional development of pre-service teachers needs to be strongly intertwined with both professional cultures (Korthagen 2007). Korthagen (2007) explains that this means that both universities and schools must share the responsibility for the professional development of

pre-service teachers. Similarly, Smedley (2001) suggests that developing good teachers can be greatly facilitated by a three way relationship between a pre-service teacher and two subject experts, the higher education tutor and the practicing teacher. The benefit of this type of triadic partnership is that it recognises the skills and expertise that each group can offer. Ruddock (1992) identifies the different but complementary contributions that higher education tutors and practicing teachers can bring to such a partnership:

“What teachers as partners in the enterprise of training can offer is practice-based knowledge rooted in sustained experience of a particular setting. What higher education tutors can offer is an analytic perspective that is fed by observation in a range of classrooms and sharpened by the evidence of research”.

(p.160)

Many recent approaches to teacher education are founded on the belief that strong relationships between school and university staff can enhance the education of pre-service teachers. Allen et al (2010) and Smedley (2001) outlined several strategies that have been adopted since the development of school-university partnerships. These included: higher education tutors and practicing teachers are taking joint responsibility for the development of policies and ideas, development of communities of learning to include both practicing teachers and higher education tutors, organising seminars for higher education tutors and practicing teachers as opportunities for developing social relationships, for goal setting and for sharing information, establishment of teaching or professional development schools [these are schools in which the school and university partners work together to improve teaching (Castle et al 2006)] and secondment of practicing teachers to the universities to work as part-time lecturers.

The benefit of such school-university partnerships have been recognised by both teachers and researchers (Day 1998; Korthagen 2007; Smedley 2001). Korthagen (2007) suggests that school-university partnerships offer a chance for a real integration of theory and practice. Smedley (2001) agrees, highlighting the increased opportunity for pre-service teachers to experience methodology that is currently successful in schools as critical to this integration. Allen et al (2010) evaluated a teacher education programme in Queensland with a particularly strong school-university partnership. They reported that graduates of that programme “rated significantly higher than graduates from other Queensland pre-service teacher education programmes in making clear links between the theoretical and practical aspects of teaching” (p.619). Castle et al (2006) found that professional development schools (PDS) were producing teachers who were “more integrated and student-centered in their

thinking about planning, assessment, instruction, management, and reflection” (p.78) than their non-PDS counterparts.

However this approach to bridging the theory-practice gap has also faced several challenges. One such issue is that school-university partnerships are based on relationships between individuals and Korthagen (2007) warns that these relationships can break down if a leading person leaves their job or if personal conflicts arise. Indeed Allen (2011) maintains that conflict and/or misunderstandings are the norm for these partnerships due to conflicting beliefs and values of partners. Smedley (2001) reports that there are a limited number of teachers suited to becoming involved in school-university partnerships due to various other commitments within the school. Other factors which threaten the success of partnerships are lack of communication between partners, time constraints, maintaining initial enthusiasm and expanding workloads of teachers and lecturers (Allen et al 2010; Smedley 2001). Smedley (2001) concludes that the attitudes and dispositions of the individuals involved will ultimately determine the success of school-university partnerships.

2.5.2 Alternative Forms of Knowledge Provision

Another of the factors identified as contributing to the theory-practice gap was the inadequacy of the theory being provided by researchers. Several approaches to bridging the theory-practice gap have focused specifically on alleviating this problem. As was previously discussed, one of the reasons why the theory was deemed inadequate was that the theory being developed made little sense in the context of the classroom. Consequently Hargreaves (1999) called for knowledge to be created that “evolves within the context of its application” (p. 136). Several other researchers have supported this notion, recognising the value of the development of a practice-based knowledge (Hiebert et al 2002; Klein 1992; Korthagen 2007).

This type of knowledge offers several advantages over knowledge being developed independently of practice. According to Hiebert et al (2002) these advantages include:

- It is useful for practice because it develops in response to specific needs for action of teachers in their classrooms.
- It is grounded in the particular setting in which teachers work.
- It provides prompt, detailed and concrete answers to situations.
- Within this type of knowledge all of the types of knowledge (content, pedagogical and content pedagogical) are intertwined, “organized not according to type but according to the problem the knowledge is intended to address” (Hiebert et al 2002, p. 6).

However this new approach of developing practice-based knowledge also brings new challenges. Hiebert et al (2002) states that this type of practitioner knowledge can still be viewed sceptically because it has not been verified by researcher knowledge. They suggest several steps that would need to be taken before practitioner knowledge could become a knowledge base for the teaching profession. These are:

- Professional knowledge must be public.
- Professional knowledge must be storable and sharable.
- Professional knowledge requires a mechanism for verification and improvement

(Hiebert et al 2002, p 7-8)

Another issue that arises from this approach is that higher education tutors would have to alter their research habits. This may mean having to change from following their own research and knowledge interests to adhering to an externally mandated, needs-based agenda (Day 1998). Day (1998) proposes that such changes would be hard to legislate.

Kelly and Sloane (2003) reported on an emerging research method called design research which has taken this issue into consideration. The design research process, within the context of education, begins with the development of hypotheses and principles by researchers which are then applied and tested within actual classrooms (Kelly and Sloane 2003). Hence in this approach, researchers retain their licence to follow their own research interests and because it is carried out in actual classrooms it has many of the same advantages as the practitioner knowledge approach. However Kelly and Sloane (2003) warn that this approach has several shortcomings of its own in relation to model estimation and model validation.

2.5.3 Alternative Teaching Strategies

Kellaghan (2004) states that pre-service teachers frequently have difficulty in recognising how their coursework is relevant to their practice and insists that these pre-service teachers need assistance in identifying its relevance in practice. Many researchers have attempted to bridge the theory-practice gap by changing the teaching strategies being employed in teacher education. Similarly to the approaches mentioned in the previous section These approaches signify an acknowledgement by researchers of “the disconnect between acquiring knowledge in university coursework and applying that knowledge in the classroom” (Sims and Walsh 2009, p. 725). These approaches represent deliberate attempts to encourage pre-service teachers to “draw on the conceptual to inform their subjective responses to the particular” (Edwards and Hammer 2006, p. 467). Such approaches have

included: allowing students to experience the effects of various teaching strategies for themselves, developing specific reflective frameworks to teach pre-service teachers how to reflect on teaching and learning, and teaching students how to perceive practice and adopt suitable teaching strategies based on their analysis.

Several researchers have recommended providing opportunities for pre-service teachers to experience the teaching strategies, teaching behaviours and classroom environments they learn about in theory in order to facilitate their translation into their own practice (Corcoran, 2005; Schifter and Bastable, 1995). Cheng et al (2010) emphasise role modelling by teacher educators as one such opportunity. They recognise higher education as a source of influence on students' conceptions of teaching and suggest that it can be used as a model through which pre-service teachers can experience outcomes of various teaching approaches. Coppens (2002) puts forward a similar argument for the inclusion of drama courses in teacher education. Coppens (2002) bases her argument on a number of theoretical principles:

- Aspects of teacher behaviour...can be trained with the use of drama.
- Placing pupils in a research situation that is convincing heightens their ability to learn the subject matter.
- To learn to display teacher behaviour you first have to learn to 'see' the effects of your expressive performance

(p. 199-201)

She concludes that consequently drama classes can help to bridge the gap between theory and practice. Wittmann (2001) proposes that allowing pre-service teachers to experience the learning environments that they will subsequently be using in their classrooms gives them an intimate knowledge and understanding of them.

Hoban (2000) shared this view and used the pre-service teachers' own classroom environment as the unit of study in his investigation. Various teaching strategies were employed by the teacher educator during the course. The pre-service teachers had to reflect on how the teaching and other aspects of the context affected their learning. Their reflections were guided by a specially designed framework which aimed to teach prospective teachers how to reflect on teaching and learning as a system. Hoban (2000) reported that the pre-service teachers "gained insights into how they learned which had implications for how they planned to teach" (p. 165). However Hoban (2000) warned that it is unknown if teaching prospective teachers to reflect on classrooms as dynamic systems is transferable to later teaching practices.

Hiebert et al (2007) suggest that an alternative approach to current teacher education is to design programmes that will prepare pre-service teachers to continue learning from their teaching after they enter the teaching profession. Hiebert et al (2007) proposed that in order for pre-service teachers to be able to do this they must have developed certain competencies.

These include:

- Understanding students' thinking about the subject
- Simplifying the complex concepts of the subject
- Representing the concepts in accessible ways for the students
- Posing meaningful questions
- Setting relevant learning goals
- Assessing whether the goals are being accomplished
- Hypothesising why the lesson did/did not work
- Using these hypotheses to revise the lesson

(Hiebert et al, 2007)

According to Eilam and Poyas (2009) these competencies are not being developed by the traditional approach to teacher education. They found that pre-service teachers who were taught in the traditional manner tended to perceive their teaching experiences through the lens of their preconceptions about teaching and learning. They further reported that this led to the pre-service teachers often neglecting the cognitive aspects of the lesson and relying mostly on affective components of teaching. Kessels and Korthagen (1996) have stated that it is the role of teacher educators to develop the perceptual knowledge that these pre-service teachers are lacking. They propose that in order for pre-service teachers to develop this “perception-based type of knowledge” (p.21) they need to be given experience of concrete situations.

Eilam and Poyas (2009) advocate the use of a case-oriented approach, deeming it to be a suitable method for dealing with difficulties related to pre-service teachers' beliefs and preconceptions of teaching. Indeed many researchers have based their interventions on this approach and have experienced considerable success. Edwards and Hammer (2006) report on a pedagogical approach called Problem-Based Learning employed in a university in Australia. In this study pre-service teachers were confronted with problematic scenarios teachers had previously faced in a real teaching context. Edwards and Hammer (2006) reported this to be an effective approach to bridging the gap between theory and practice because it afforded the pre-service teachers with an opportunity to participate in a scenario which required them to draw on the relevant theory to make informed decisions.

Analysis of video-cases has become a popular intervention in teacher education in various parts of the world. Korthagen (2010) reported on an approach called the ‘realistic approach’ which was developed in a university in the Netherlands. This approach used the problems experienced by the pre-service teachers during their teaching practice as units of study. Their teaching experiences were video-taped and the pre-service teachers interacted with both their peers and the teacher educator to reflect on various aspects of the experience. In the final stage of the process the experience was connected with the relevant theory. The realistic approach has been praised by participating students as providing a “seamless connection between theory and practice” (Korthagen 2010, p416). Eilam and Poyas (2009) also used video-recorded authentic classroom situations in their intervention in Israel. They reported that this approach was successful in improving pre-service teachers’ “ability to apply academic theories when interpreting teaching-learning situations” (p. 103).

Both Hiebert et al (2007) and Sims and Walsh (2009) have acknowledged the important role that videos of teaching episodes can play in the development of students’ analytical expertise. Hiebert et al (2007) suggests that it allows for a deliberate and systematic analysis of teaching. Sims and Walsh (2009) propose that it permits a critical analysis of the teaching process

“enabling pre-service teachers to examine preconceived notions, refine conceptual and practical tools, develop a reflective disposition, and appreciate the importance of a professional community in learning to teach.”

(p.725)

2.6 Lesson Study

A relatively new approach adopted by some teacher educators in order to improve teaching is lesson study, a popular professional development approach initiated in Japan (Fernandez and Yoshida, 2004). Lesson study is an approach which permits a critical analysis of the teaching process. Stigler and Hiebert (1999) describe lesson study as an opportunity for teachers to examine their practice “with new eyes”.

“This professional development model is used systematically to deepen content knowledge, increase understanding of pedagogy, and develop one’s ability to observe and understand student learning.”

(Burroughs and Luebeck 2010, p391)

The term lesson study is a translation of the two Japanese words: *jugyo* and *kenkyu*, which mean lesson and study, respectively (Fernandez and Yoshida, 2004). As suggested by the term, lesson study is a process, Japanese teachers regularly engage in, to examine their teaching practice through the careful planning and observation of lessons (Cohan and Honigsfeld, 2007). Lesson study represents a shift from “teaching as telling” to “teaching for understanding” in Japanese education (Lewis, 2002; Lewis and Tsuchida 1998). Figure 2.1 graphically represents the lesson study cycle. As can be seen from Figure 2.1 lesson study consists of three critical phases: the planning phase, the implementation phase and the post-lesson phase.

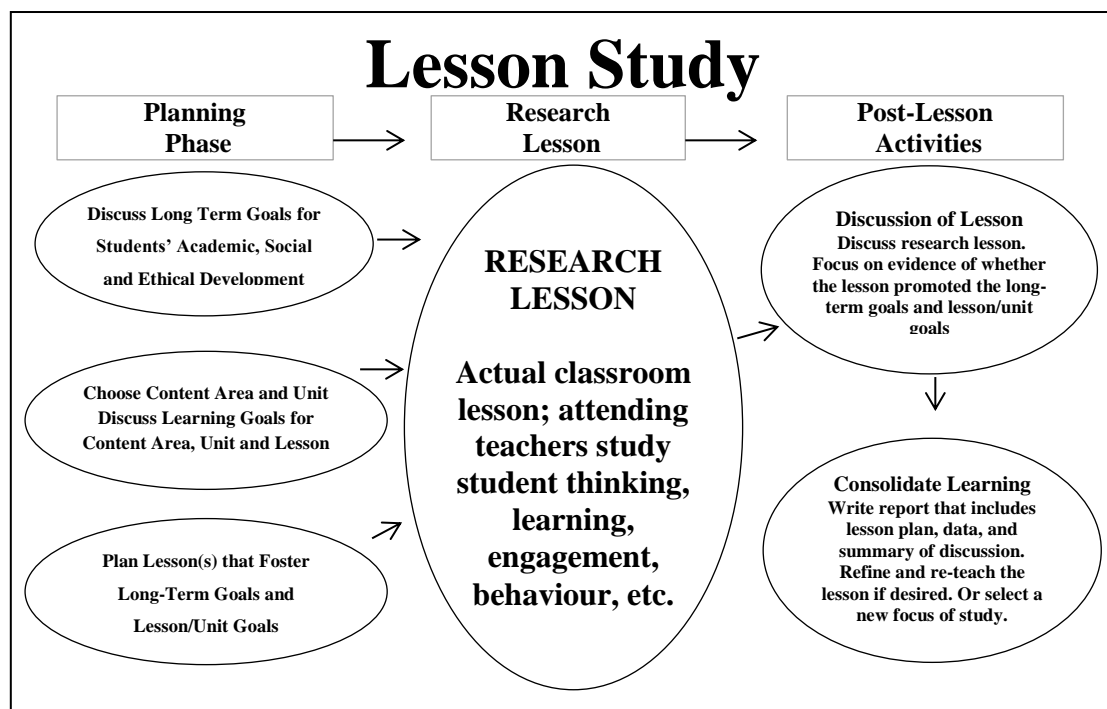


Figure 2.1: Lesson Study Cycle (Lewis, Perry, Friedkin, Roth, Baker & McGrew, 2012)

In the first phase of lesson study the teachers involved work together to formulate goals. These goals can be related to either developing a successful approach to a specific teaching topic for example “to help children grasp the connection between sound and vibration” (Lewis and Tsuchida 1998, p13) or they can relate to broader educational goals for example students will become “active problem solvers” or “take initiative as learners” (Lewis and Tsuchida 1998, p13). Once the goal for the lesson study has been chosen the teachers work together in meticulously planning the lesson. Teachers share ideas for how best to design a lesson to achieve these learning goals. They draw on “past experiences, observations of their current students, their teacher’s guide, their textbooks, and other research books” (Fernandez and Yoshida 2004, p. 7). The next phase is the implementation of the lesson,

where one of the teachers teaches the lesson to the students. The other teachers come to the lesson as observers. They gather evidence of student learning throughout the lesson. Once the lesson has been taught the final phase is reflecting and revising the lesson. The teachers discuss the success of the lesson focusing on determining if the learning goals for the lesson were achieved. They use the evidence gathered during the teaching of the lesson to improve the lesson for future teaching or to improve their knowledge of instruction in general (Lewis, 2002).

The focus of the lesson study cycle is the research lesson. Although these research lessons are taught in the teachers' actual classrooms they differ from everyday lessons in that they comprise of a number of special features. Lewis and Tsuchida (1998) identify the following special features of research lessons:

- They are carefully planned, sometimes over several months, typically in collaboration with at least one colleague.
- They are focused. They focus either on a specific goal, such as helping students become active problem-solvers, or developing a successful approach to a specific topic, for example subtraction with regrouping.
- They are observed by other teachers. Sometimes the observers are limited to the other teachers involved in the lesson study process whereas sometimes they can be open to observers from the whole of Japan.
- They are recorded. This can be done in a number of ways: videotaped, audiotaped, narratives or copies of students' work.
- They are discussed. Subsequent to the teaching of the lesson, the strengths and weaknesses of the lesson are discussed. Particular emphasis is placed on the effectiveness of the lesson on achieving the learning goals.

This focus on the lesson as the unit of analysis and improvement means that lesson study can still preserve the complexity that characterises classroom life. This is because “even a single lesson retains the key complexities – curriculum, student characteristics, materials, and physical environment, among other things – that must be taken into account as we try to improve classroom learning” (Stigler and Hiebert 1999 p. 122). In order for it to be a successful lesson the teachers developing it must attend to all of these aspects, which together create significant learning opportunities for the students (Hiebert et al, 2002). Hence

the research lesson provides a unit of analysis which provides the teachers with knowledge which can be generalised to real classroom situations.

The Japanese approach of lesson study, which treats theory and practice as inseparable entities, has been gaining increasing support in the reform of teaching (Cohan and Honigsfeld, 2007; Hiebert et al, 2002; Lewis, Perry and Murata, 2006; Sims and Walsh, 2009) and more recently researchers have examined how the lesson study approach can be adopted in pre-service teacher education (Cohan and Honigsfeld, 2007; Burroughs & Luebeck, 2010; Sims and Walsh, 2009). Other researchers, such as Corcoran & Pepperell (2011), Corcoran (2007) and Cohan & Honigsfeld (2007) examined how lesson study benefits pre-service teachers. Cohan and Honigsfeld (2007) found that “the lesson study approach is an effective tool for lesson planning, lesson presentation, and lesson evaluations” (p.81). Corcoran (2007) believe that “a more collaborative approach to preparation of and reflection on lessons [such as the approach of lesson study] would be valuable” (p. 275). Corcoran and Pepperell (2011) found that “lesson study fosters the collective development of mathematical knowledge” (p.229). This echoed the findings of Leavy (2010) who had previously found lesson study supported pre-service teachers’ development of statistical knowledge. Importantly, lesson study has not only become popular among researchers. Since its introduction in 1999 lesson study has become very popular among teachers in the United States. By 2004 at least: 32 states, 150 lesson study clusters/ groups, 335 schools, 125 school districts, and 2300 teachers were involved in lesson study (Chokshi, 2002). In England, the British shadow education secretary, Stephen Twigg said that they “must learn from high-performing nations like Japan to radically transform education in England” (Richardson, 2012). He spoke of how Labour planned to “bring reform into the classroom by learning from the Japanese system of lesson planning, known as *jugyou kenkyuu*” (Richardson, 2012).

2.7 Lesson Study in Irish Initial Teacher Education

In recent years lesson study has also been adapted and developed in Irish colleges of education as teacher educators recognise its potential to improve pre-service teacher practice. For example, Corcoran (2007) acknowledges that lesson study offers an opportunity for pre-service teachers to develop a

“meaningful understanding of the primary mathematics curriculum...by studying children during mathematics lessons, by optimising the use of the available supporting documents and organising classrooms to maximise the development of mathematics process skills.” (p286)

Several studies of lesson study have been undertaken in colleges of education in Ireland and the findings of these studies show that lesson study has the potential to greatly influence initial teacher education. Corcoran (2007) found that through the lesson study inquiry cycle pre-service teachers can build their mathematical subject knowledge. Similarly Leavy (2010) found that lesson study provided her pre-service students with an avenue for deepening their understanding of statistics. Corcoran and Pepperell (2009) found that lesson study allowed pre-service teachers to expand both their mathematical and pedagogical skills. The pre-service teachers, in their study, showed significant knowledge growth particularly in relation to their foundation knowledge as categorised by Rowland (2005). Leavy, Hourigan and McMahon (2010) found that pre-service teachers' attitudes towards algebra were improved through their participation in lesson study. Leavy and Sloane (2008) found that the

“experiences in observing the impact of teaching design lessons on student learning served as the springboard for the development of understandings than could not have been facilitated within college-based clinical contexts.”

(p.168)

These researchers highlighted several aspects of lesson study that made this learning possible. These included: collaborative planning (Leavy and Sloane, 2008), observing and reflecting on the practice of teaching (Leavy and Sloane, 2008), attending to what and how students learn mathematics (Corcoran and Pepperell, 2009) and learning about the effects of diverse methods of teaching on students' learning (Corcoran, 2007).

2.8 Issues with Subject Knowledge

One particular aspect of teacher education which has received frequent criticism over the past number of years is teacher subject knowledge, particularly since the TIMMS and PISA studies have revealed serious gaps in student learning (Ma, 1999). Although it is recognised that teachers do not necessarily need to study mathematics to degree level it is widely accepted that teachers require an extensive knowledge base to achieve optimum student learning. In particular teachers should

“be familiar with the content of the curriculum and to know how to represent and formulate it in a way that makes it comprehensible to pupils.”

(Kellaghan 2004, p.22)

Indeed Ma (1999) has suggested that in order to improve students' mathematical education, the mathematical knowledge of their teachers must be improved. Internationally both

qualified and pre-service primary teachers have been found to be lacking in mathematics subject matter knowledge (Ma, 1999). Indeed Ma (1999) found that “not one of a group of above average U.S. teachers displayed a profound understanding of elementary mathematics” (p.144). Similar issues with teacher content knowledge have been revealed within the Irish context (Hourigan & O’Donoghue, 2007; Corcoran, 2005; Kellaghan, 2004). In 2002, a Working Group on primary pre-service education identified mathematics content knowledge as an aspect of teacher knowledge which many teachers entering the profession were lacking (Kellaghan, 2004). However given the broad range of subjects primary teachers are expected to develop competence in, it is impossible for them to have expert knowledge of each subject (Hourigan, 2010; Kellaghan, 2004).

Throughout the literature, a number of researchers have cited particular types of knowledge as being critical for optimum student learning. Table 2.1 outlines the main categories of teacher knowledge cited in the literature.

Table 2.1: Types of Teacher Knowledge (O’Meara 2010, p1)

Type	Description
Content Knowledge	The common knowledge of mathematics that the majority of adults have access to, as well as specialised knowledge for the purpose of teaching.
Pedagogical Knowledge	This is the practical knowledge that teachers require in order to teach. It refers to the transfer of a teacher’s content knowledge into representations, analogies, explanations and examples comprehensible for students.
Knowledge of Students	This requires teachers to have an in-depth knowledge of the thought processes of students as well as the way in which they acquire knowledge and develop positive attitudes, both towards the subject and about themselves.
Curricular Knowledge	An understanding of the curricular alternatives available for instruction.
Knowledge of Other Subjects	Knowledge of other subjects to which students are exposed and the links between these subjects and mathematics.

Over the past number of years various researchers have developed models for representing the different types of teacher knowledge. These include; Shulman (1986), Ball, Hill & Bass

(2005), Hill, Ball & Schilling (2008) and Rowland, Huckstep and Thwaites (2005). They believed that becoming an effective teacher required the development of each of the specific categories of knowledge.

2.8.1 Shulman's categorisation of subject knowledge

Shulman (1986) was one of the first researchers to categorise the different types of knowledge required by teachers. He identified seven categories of teacher knowledge, three of which focused explicitly on the subject knowledge of teachers. He proposed that teacher subject knowledge should be classified under three distinct categories; subject matter content knowledge (common knowledge of mathematics), pedagogical knowledge (knowledge of how to teach mathematics) and curricular knowledge (primary school mathematics curriculum) (Shulman 1986). He believed that particular emphasis should be placed on subject matter content knowledge as he considered this to be the most important category of the three. Shulman's definition of content knowledge goes beyond a simple "knowledge of the facts or concepts" (p.9) to a deep understanding of the structures of the subject. This type of knowledge encompasses both the substantive and syntactic structures of the subject.

The substantive structures are the ways in which the fundamental ideas within a subject are organised. Substantive knowledge within mathematics has strong implications for the curricular decisions teachers make in their classrooms. Teachers with strong substantive knowledge make connections between topics which promote their students' conceptual understanding (Ball, 1991; Ma, 1999; Stigler & Hiebert, 1999; Davis, 2004; Simon Tzur, Heinz & Kinzel, 2000). For example a teacher with good substantive knowledge would teach their students the relationship between multiplication and division to help their students grasp the concept of division.

The syntactic structures of a subject are the rules for determining validity or invalidity within that discipline. Syntactic knowledge is important in teachers' representation of mathematical concepts and a lack of syntactic knowledge can cause teachers to misrepresent mathematical concepts (Davis, 2004).

"For example, the substantive structures of similarity are heavily influenced by the relationship between angle measurement and proportional sides. Teachers with a limited syntactic knowledge of similarity may be unable to sufficiently explain this relationship or engage in discourse to allow their students to explore angle measurement and corresponding side lengths."

(Davis 2004, p. 12)

Corcoran (2005) suggests that pre-service teachers often lack knowledge of the syntactic structures of mathematics. She finds that much of pre-service teachers' mathematics knowledge is procedural and warns that deficiencies in pre-service teachers' knowledge of the syntactic structures can hinder their further development of mathematical knowledge.

The second category of knowledge in Shulman's (1986) model of teacher knowledge was pedagogical content knowledge. Shulman (1986) defined pedagogical content knowledge as knowledge of "the most useful forms of representation of those [mathematical] ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations" (p 9). In other words how best to articulate or represent the mathematical content to make it more comprehensible for their students. Also included in this category was knowledge of how students perceive the topic: what makes the topic difficult or easy for them, misconceptions they might have and strategies for reshaping students' misunderstandings of these mathematical topics.

The final category of teacher subject knowledge outlined by Shulman (1986) was curricular knowledge. He believed that curricular knowledge encompassed three different aspects of curriculum:

- Knowledge of "the full range of programs designed for the teaching of particular subjects and topics at, a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstance" (Shulman 1986, p9).
- Knowledge of other subject curriculums that relate to the teaching of ones subject, particularly any crossover of concepts between subjects.
- Knowledge of topics that are taught in the preceding and subsequent years of their students' schooling.

The three categories of subject knowledge Shulman (1986) proposed were not mathematics specific they were general to all forms of teaching. Later in the years, models of teacher subject knowledge specific to the teaching of mathematics were defined with mathematics specifically in mind.

2.8.2 Ball's categorisation of subject knowledge

Deborah Ball and other educational researchers in Michigan developed their own model of teacher knowledge, an illustration of which can be seen in Figure 2.2. Developing further on a model initially proposed by Ball, Hill and Bass (2005), Ball, Thames and Phelps (2008) reconceptualised Shulman's proposed model. Their model proposed that subject

matter content knowledge contained three components; common content knowledge, specialized content knowledge and knowledge at the mathematical horizon. Common content knowledge is described as knowledge used in the profession of teaching in ways that are similar to how it is used in other occupations or professions that are mathematics related (Hill, Ball and Schilling, 2008). Specialised Content knowledge is described as the mathematical knowledge that enables teachers to effectively engage in teaching tasks such as choosing suitable representations and examples to illustrate mathematical ideas, providing suitable mathematical explanations for common rules and procedures and having proficient mathematical reasoning which allows them to examine and subsequently understand non-standard solutions to mathematical problem (Ball, Hill and Bass, 2005; Hill, Ball and Schilling, 2008). Although common content knowledge is similar to Shulman’s subject matter content knowledge, specialized knowledge is a newer concept.

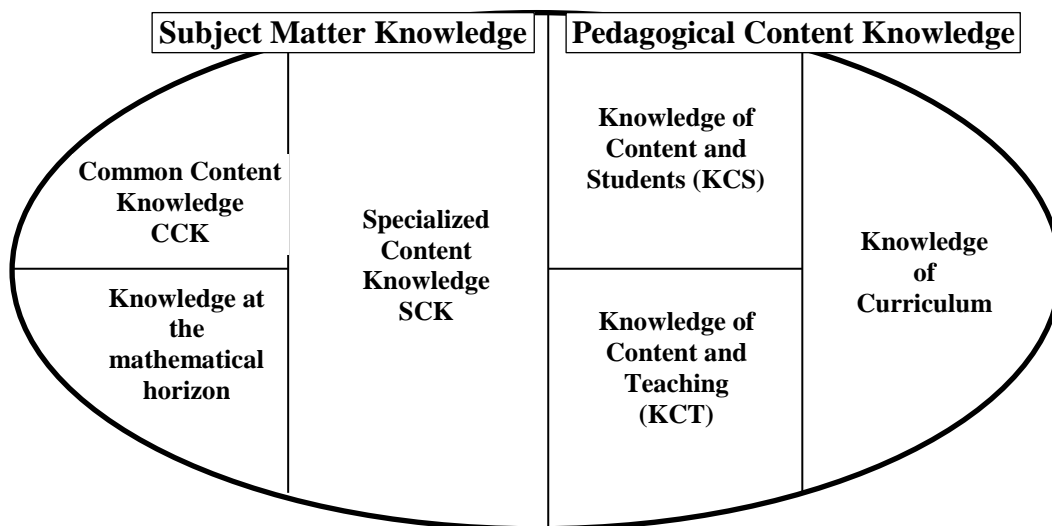


Figure 2.2: Domain map for mathematical knowledge for teaching (Ball, Thames & Phelps 2008, p. 377)

Ball, Thames and Phelps (2008) also subdivided Shulman’s category of pedagogical knowledge. This category was divided into knowledge of content and students and knowledge of content and teaching. Ball et al (2008) defined knowledge of content and students as knowledge “that combines knowing about students and knowing about mathematics” (p.401) and knowledge of content and teaching as knowledge that “combines knowing about teaching and knowing about mathematics” (p401). Hill, Ball and Schilling (2008) felt that knowledge of students as learners was underspecified in previous conceptions of teacher

knowledge. The greater consideration given by this model to the learning of students are supported by the beliefs of Loucks-Horsley, Stiles, Mundry, Love and Hewson (2009) who feel that, in a time when classrooms are becoming ever more diverse, more attention needs to be paid to the promotion of teaching practices based on understanding how children learn. Hall et al (2008) identified examples of teacher activities that best demonstrated this type of knowledge. Figure 2.3 illustrates teacher knowledge which was identified by Hill, Ball and Schilling (2008) as being examples of knowledge of content and students.

- Common student errors: identifying and providing explanations for errors, having a sense for what errors arise with what content, etc.
- Students' understanding of content: interpreting student productions as sufficient to show understanding, deciding which student productions indicating better understanding etc.
- Student developmental sequences: identifying the problem types, topics or mathematical activities that are easier/more difficult at particular ages, knowing what students typically learn 'first', having a sense for what third graders might be able to do, etc.
- Common student computational strategies: being familiar with landmark numbers, fact families, etc.

Figure 2.3: Examples of knowledge of content and students (Hill et al 2008, p. 380)

Similarly Ball, Thames and Phelps (2008) identified aspects of teacher activities that they considered to be examples of knowledge of content and teaching. These can be seen in Figure 2.4 below:

- The particular sequencing of topics or concepts teachers choose for instruction of content.
- The examples teachers choose to start a topic with and which examples they use to develop a deeper understanding of the topic.
- The ways in which teachers evaluate the advantages and disadvantages of the various representations used in the teaching of specific concepts and decide which different approaches and techniques would best facilitate instruction.

Figure 2.4: Examples of knowledge of content and teaching (Ball et al, 2008)

2.8.3 Rowland's categorisation of subject knowledge

In recent years Tim Rowland and a number of researchers developed a framework specifically designed for “the discussion of mathematics content knowledge, between teacher educators, trainees and teacher-mentors, in the context of school-based placements” (Rowland et al 2005, p. 277). It is also a useful framework which researchers can use in the analysis of observed teaching (Rowland, 2005). This model further categorises teacher content knowledge into foundation knowledge, transformation knowledge, connection knowledge and contingency knowledge. These categories were developed through the analysis of video-taped mathematics lessons pre-service teachers taught on their final school placement. From the analysis of these video-taped lessons they identified a number of dimensions relating to the pre-service teachers' mathematical subject matter knowledge and pedagogical content knowledge. Initially this model contained seventeen dimensions but further refinement of Rowland's conceptualisation of teacher knowledge has led to an enhancement of the knowledge quartet and addition of further dimensions. The researchers then identified relationships or connections between these dimensions and the four superordinate categories; foundation, transformation, connection and contingency were developed. The current dimensions (and their respective categories) of the knowledge quartet can be seen in Table 2.2 (next page). As can be seen from the table, each dimension of the respective categories is of a similar nature to the other dimensions in its category.

Foundation knowledge refers to the theoretical beliefs and preconceptions the pre-service teachers hold and which they bring to bear on the decisions they make in the preparation and execution of their lessons. The Foundation category is considered by Rowland and Turner (2007) to be the basis for the development of the other categories of knowledge. It includes both the knowledge that pre-service teachers acquired in their own personal education and in their initial teacher training (Rowland, Huckstep and Thwaites, 2005). Rowland et al (2005) hold similar views to Cheng et al (2010) and Hiebert et al (2007) who also believed that “possession of such knowledge [preconceptions and beliefs from pre-service teachers' own education] has the potential to inform pedagogical choices and strategies in a fundamental way” (Rowland et al 2005, p261). Hence the other three categories are related to how this foundation knowledge is used in the preparation and implementation of the pre-service teachers' lessons.

Transformation knowledge also known as “knowledge in action” by Rowland et al (2005) is similar to Shulman's pedagogical knowledge in that it describes how teachers

choose to represent the mathematical concepts to make them more comprehensible for their students (Rowland et al , 2005).

The third category of Rowland’s knowledge quartet, connection knowledge, is a combination of Shulman’s pedagogical knowledge and curricular knowledge. Teachers are required to use their curricular knowledge and their knowledge of the most effective ways to sequence instructional topics in order to make the mathematical concepts more comprehensible and coherent for the students (O’Meara, 2010).

Table 2.2: The Dimensions of the Knowledge Quartet (Rowland, 2012)

Category of Knowledge	Dimension
Foundation Knowledge	<ul style="list-style-type: none"> Theoretical underpinning of pedagogy Awareness of purpose Identifying pupil errors Overt display of subject knowledge Use of mathematical terminology Adherence to textbook Concentration on procedures
Transformation Knowledge	<ul style="list-style-type: none"> Teacher demonstration Use of instructional materials Choice of representations Choice of examples
Connection Knowledge	<ul style="list-style-type: none"> Making connections between procedures Making connections between concepts Anticipation of complexity Decisions about sequencing Recognition of conceptual appropriateness
Contingency Knowledge	<ul style="list-style-type: none"> Responding to students' ideas Deviation from lesson agenda Teacher insight Responding to the (un)availability of tools and resources

The final category of Rowland's knowledge quartet is contingency knowledge. This type of knowledge is the knowledge teachers require to make 'on the spot' judgements to deal with unexpected occurrences in their classroom (O'Meara, 2010). This includes aspects of decision making such as responding to students' ideas, and flexibility and willingness to change tasks originally included in the lesson plan based on incidences that occur in the classroom (Rowland, 2012).

2.9 Conclusion

In conclusion, the literature highlights the need to find an appropriate solution to resolve the theory-practice problem. It emphasises the factors contributing to the theory-practice gap which need to be considered when attempting to find a solution to the problem. It also provides insights into lesson study and its potential to support pre-service teachers in bridging the theory-practice gap. In the following chapter, the author describes the methodologies undertaken in this study used to determine the effectiveness of such an approach.

Chapter 3:
Methodology

3.1 Introduction

In the previous chapter the author provided the reader with an insight into the context of this research study. In this chapter the author outlines the methodologies used in this study, provides a rationale for choosing those particular methodologies and discusses the limitations of those methodologies. This chapter also provides details of data collection methods used, describes how the data from these sources was triangulated and outlines the demographics and background information of the participants who took part in the study. Finally it outlines any ethical considerations which were pertinent to this study.

3.2 Purpose of the Research

The purpose of this study was to examine how a curriculum specialisation course in mathematics education, modelled on the principles of Japanese lesson study, could assist pre-service teachers in Mary Immaculate College in bridging the theory-practice gap. According to Fernandez and Yoshida (2004) lesson study conducted in Japanese schools stimulated the development of both topic specific pedagogical knowledge and pedagogical knowledge for mathematics in general, in the teachers involved which in turn greatly improved their practice and potentially improved student learning. In order to examine if the curriculum specialisation course in Mary Immaculate College, which was modelled on the principles of lesson study could provide similar benefits to pre-service teachers undertaking this course, the principal research question that focused this study was:

In what ways does participation in the lesson study process support pre-service teachers in incorporating research knowledge and the theories acquired in previous teacher education modules into their teaching, hence facilitate them in bridging the theory-practice gap?

As outlined in chapter 2, the definition of the theory-practice gap chosen for the purpose of this study is: “the inconsistencies between the selection of the best teaching strategies and the most common teaching strategies” (Cheng et al. 2010, p. 94). These teaching strategies include both those strategies employed in all facets of teaching and those teaching strategies specific to a particular topic. Examples of general teaching strategies are group work or the 5E learning cycle model (engage, explore, explain, elaborate and evaluate) and an example of a subject specific teaching strategy is the use of tables to represent the data in the teaching of growing patterns. This encourages students to read the table vertically

rather than focusing on the horizontal relationship between the step number and the output, therefore recursive thinking is induced.

3.3 Place Within Recent Research/ Relevance of Research

Other studies have examined curriculum specialisation courses modelled on the principles of lesson study. However the focus of the other studies differed from the focus of this study. Leavy (2010) and Leavy and Sloane (2008) used the lesson study process to examine gaps in specific content knowledge and to identify obstacles pre-service primary teachers faced when designing and teaching lessons in particular mathematics topics. For example, Leavy (2010) used the lesson study process to identify both “the content and pedagogical content knowledge needed for teaching informal inference and to investigate how this knowledge is used by teachers when teaching” (p.49). Similarly Leavy and Sloane (2008) used the lesson study process in their “investigation of the pedagogical knowledge needed for teaching data at the primary level and how this knowledge is used by teachers in teaching” (p.44). Corcoran and Pepperell (2011) also examined the potential benefits of lesson study to Irish pre-service primary teachers. In particular they examined “the ways in which it is claimed to enhance mathematical knowledge for teaching” (p.213). Their findings were primarily associated with this enhancement of mathematical knowledge for teaching but also the enhancement of pre-service teachers’ attitudes towards mathematics, including improving their willingness to learn and an optimism that they can go on learning mathematics in teaching.

3.4 Research Design

Due to the complexities of teaching, which were alluded to in Chapter 2, the research design of this study was multifaceted. Various data collection methods were adopted in order to obtain the most comprehensive picture possible of the phenomena being studied and its underlying relationships. The data from these different sources were then triangulated to generate strongly supported findings. The method of enquiry employed in this study was a collective case study. Yin (2009) identifies that the essence of a case study is that “it tries to illuminate a decision or set of decisions, why they were taken, how they were implemented, and with what result” (p.17). In this particular study this translates to: what teaching

strategies the pre-service teachers chose, why they chose those particular strategies and the consequences of the strategies they chose.

A collective case study was selected as an appropriate research method for several reasons. Firstly this study was carried out in an educational context, which by its very nature is very complex (as is discussed in Chapter 2). According to Adelman et al (1980, cited in Cohen et al. 2007) case studies' particular strength "lies in their attention to the subtlety and complexity of the case" (p. 256). Similarly, Zainal (2007) acknowledges that case studies are a suitable research method for the analysis and interpretation of complex issues.

Secondly, in this study the primary goal was to examine the influence of the lesson study process on how the pre-service teachers taught, in particular the teaching strategies they chose and why. Bassey (1999) highlights the importance of analysing the topic of enquiry "as it is" when examining "its structures or processes or relationships which link with existing theoretical ideas" (p.40). Therefore it was important to observe the subjects in a real life context, such as designing actual lessons to be taught and the teaching of real mathematics lessons, in order to examine the strategies the pre-service teachers choose and why. According to Yin (2009) case studies facilitate such an approach, allowing the analysis of the lesson study process within its real life context.

Third, Yin (2009) identifies that the case study approach has a distinct advantage over other research methods when a 'how' or 'why' question is being asked about a contemporary phenomenon over which the researcher has little or no control, as was the case in this particular study where the researcher was a non-participant researcher.

Case Studies are also considered to provide a suitable method of research when looking to answer research questions which look at social processes such as teaching (Swanborn, 2010). Furthermore Goddard and Melville (2004) recommend the use of case studies in research which looks to determine if a specific situation (in this case participation in the lesson study approach) gives rise to a specific result (in this case helping pre-service teachers to bridge the theory practice gap). Khanzode (2004) also advocates the use of case studies in research which involves careful observation of a unit such as was the case in this investigation.

Finally the case study approach offers the opportunity to collect data from multiple sources and then converge the data in a triangulating fashion (Yin, 2009). Therefore it allowed the researcher to collect data from questionnaires, observations, interviews and participants written responses. Therefore there was strong evidence to support the use of the case study as the research method for this study.

3.5 Participants

The participants in this study were a group of final year pre-service teachers in Mary Immaculate College who had selected the teaching of mathematics as their specialist area of study in the final semester. At this stage in their degree programme the pre-service teachers had completed all the compulsory mathematics education courses and all their required teaching practice placements of their degree. The group consisted of 25 students, 11 of which were male and 14 of which were female. The pre-service teachers' were all aged between 19 and 31. This curriculum specialisation was the first choice of study for 24 out of the 25 pre-service teachers, and was the third choice for the remaining pre-service teacher.

The pre-service teachers had varying mathematical backgrounds on entering this curriculum specialisation. There were 5 mature students in the group, four of whom had completed mathematics related degrees prior to beginning this degree. Of the 25 pre-service teachers who undertook lesson study, 14 studied mathematics at higher level for their leaving certificate and 11 studied mathematics at ordinary level. The following table (Table 3.1) shows the breakdown of grades received by the pre-service teachers at both of these levels. As can be seen from the table there was some variation in grades across the group of pre-service teachers.

Table 3.1: Mathematics Grades of the pre-service teachers by Leaving Certificate Level

Grade	A	B	C	Total
Higher	5	7	2	14
Ordinary	8	3	0	11

As part of their teaching degree each of the pre-service teachers also had to specialise in a Liberal Arts subject of their choice. In this group 6 pre-service teachers had chosen to specialise in mathematics. The topic covered in the mathematics module during this semester was probability, one of the topics assigned for teaching during the lesson study cycle.

In the pre-lesson study questionnaire the pre-service teachers were asked to give the main reasons for choosing the mathematics curriculum specialisation. The reasons the pre-service teachers gave were: because they like doing mathematics, they want to improve their teaching of mathematics, because they enjoy teaching mathematics, they want to learn new strategies or approaches to teaching mathematics and because they enjoyed previous mathematics lectures. Table 3.2 (next page) shows the spread of reasons given.

Table 3.2: Reason for Choosing the Mathematics Curriculum Specialisation

Reason	Number of pre-service teachers
Improving their teaching of mathematics	11
Like doing mathematics	9
Learn new strategies or approaches to teaching mathematics	7
Enjoy teaching mathematics	5
Enjoyed previous mathematics lectures	5

3.6 Overview of the Curriculum Specialisation Course

The lesson study research was carried out over a 12 week spring semester in the context of a curriculum specialisation in mathematics education course offered to third years pre-service teachers in Mary Immaculate College. As part of this course students were required to take part in a lesson study cycle. Permission was sought for access to any data obtained during lesson study and to the participants work developed during lesson study. The course reflected the main components of the Japanese lesson study process as described in Chapter 2: the planning phases, the implementation phases and the post-lesson phases. Each of the participants was involved in every aspect of the process; the planning, teaching, analysing and revising of the mathematics lesson.

In the semester prior to the commencement of lesson study the members of the mathematics education faculty spent several weeks preparing for the lesson study process. First the faculty members had to select the topics that would be taught during lesson study. Growing patterns in algebra and several key topics of probability were chosen. These were: Describing Likelihoods, Comparing & Explaining, Ordering Likelihoods and Sampling. The faculty members then explored research journals to identify the topics in probability that would be taught. Once the ‘big ideas’ in probability had been identified, faculty members trawled through both research and practitioner journals and selected reading materials for the pre-service teachers relevant to the assigned topics (A list of the assigned readings and their references are included in Appendix P).

The initial weeks of the next semester involved introducing students to the lesson study process and preparing for lesson study. The participants were divided into five groups of five people and then each group was assigned a different topic of either algebra or

probability. The research lesson on algebra focused on growing patterns. The remaining four research lessons in probability focused on: describing likelihoods, comparing and explaining likelihoods, ordering likelihoods and sampling. Each group received two readings based on lesson study and a number of readings related to their specific teaching topic. Each group then researched the relevant theory surrounding their topic. Many of the pre-service teachers admitted to having limited knowledge of the topics they had been assigned, therefore many of them sourced further research materials outside of those given to them by faculty members. Sources of further research were the library and the internet.

The members of the group met several times a week to collaboratively work on the lesson preparation. A log was kept by each group to record details of their meetings. Each group met approximately nine times before the first teaching of the lesson. These meetings lasted for between one and two hours. In these meetings the pre-service teachers discussed: ideas acquired from the readings, suitable contexts for their lesson, their lesson objectives, activities and teaching strategies they might use and the roles of each of the group members. At the end of the meetings group members were usually assigned tasks to be completed before the next meeting. For example, creating materials for the lesson or writing up sections of the lesson plan.

Three members of the mathematics education faculty were responsible for instructing and supervising the lesson study process. The groups met with at least one of these faculty members on three or four occasions during this planning phase. Prior to the meetings the pre-service teachers were required to submit a draft lesson plan. The groups were required to design their lesson plan based on the specific lesson study template (Ertle, Chokshi and Fernandez, 2001). Each planning meeting was scheduled at a time to facilitate all group members attending and lasted approximately 30-45 minutes. In the meetings the faculty members provided written and verbal feedback on the lesson plan and answered any questions the pre-service teachers had in relation to their topics. The pre-service teachers were also asked to justify their pedagogical decision making throughout the lesson study process.

The next phase of the lesson study process was the implementation stage. This involved one pre-service teacher from each group teaching their respective lesson to a 5th class in a primary school while the other group members observed the lesson. Their observations involved evaluating student thinking and learning in relation to the concepts being taught, engagement with the content of the lesson and behaviour of the students during the lesson.

Immediately after the teaching of the lesson all group members met with at least one faculty member for a post-lesson collaborative reflection in the college canteen. These meetings lasted approximately an hour and opened with all group members giving their initial thoughts on how they felt the lesson went. As these meetings progressed the analysis became more focused. The group members and faculty members shared their observations on the first lesson and suggestions were proposed on how the lesson should be modified. In general, feedback and observations focused on pedagogical aspects of the lesson, but two of the groups revised the content of their lessons to incorporate greater challenge.

The group members then met and modified the lesson accordingly, in preparation for the re-teaching of the lesson. Following these meetings changes to the lessons incorporated attention to whether the learning goals of the lesson were achieved, ensuring that the lessons were pitched at the right level, modifications to ensure that the tasks/activities were appropriate, and that the children were adequately engaged by the lesson etc. The redrafted lessons were sent to members of faculty who provided feedback on the modified lesson plans. The pre-service teachers had the opportunity to meet with faculty members to discuss this feedback or ask questions if necessary.

The next phase involved the re-teaching of the lesson to a different 5th class of students in a different primary school. In some of the groups, a different teacher taught the second lesson whereas in some groups the same teacher re-taught the lesson. Once again the rest of the group members observed the teaching of the lesson.

After the final teaching of the lesson the groups met to reflect on the revised lesson. These meetings included one meeting with the faculty members and three or four meetings in their small groups. The aim of these meetings was to consolidate what they had learned from the lesson study process and to prepare for the presentations..

Finally the groups had to report on their lesson study experience. This included a group presentation to their peers, submitting an individual reflective journal and some of the group members participated in an interview. The group presentations were a graded assignment carried out in the final weeks of the semester. Each group were required to give a twenty five minute presentation reporting on their lesson study experience. The groups all used a powerpoint presentation to illustrate their lesson study journey. During the presentations the pre-service teachers provided examples of the materials they used in their lessons, engaged their peers in some of the activities they used in their lessons, presented samples of their students' work and used video to select key teaching moments or to model aspects of their lesson. In all of the presentations the pre-service teachers demonstrated high

levels of both content and pedagogical knowledge. They identified student misconceptions they experienced in their lessons, they discussed students' learning pathways, they highlighted aspects of their lessons that were successful and others that were limiting and they outlined the advantages and disadvantages of the representations they had chosen for their lessons.

3.7 Data Collection Procedure

As was discussed earlier (3.4 Research Design) throughout the study a variety of data collection techniques were used. The primary data collection technique adopted was participant observation which included in-class observation of teacher practice and observations of lesson study group meetings (which were also recorded and transcribed). Other data collection methods included pre-service teacher questionnaires, examples of pre-service teachers work, pre-service teacher interviews (recorded and transcribed), pre-service teacher presentations and pre-service teacher reflective journals.

Modelled on the procedure used by Leavy (2010) and by Leavy, Murphy & Farnan (2009) data collection methods adopted were closely synchronised with the stages of the lesson study process. Table 3.3 (adapted from Leavy, 2010) illustrates the relationship between the data collection procedure and the lesson study cycle.

Data Collection during Step 1 consisted of the questionnaires being administered and collected. The researcher attended all (16) of the group meetings that were held with faculty members before the lessons were taught. Discussions during group meetings were observed and recorded. The pre-service teachers also began the written logs of all group discussions. The researcher also attended and made observations of each of the tutorial sessions scheduled as part of the curriculum specialisation. The initial sessions provided important insights into the attitudes of the pre-service teachers to the topics they were assigned to teach.

At Step 2 the researcher observed the teaching of each of the five 'research' lessons. Each lesson lasted approximately 45 minutes. During all observations the researcher acted in the role of non-participant observer (Bassey 1999). The researcher observed the lesson from the periphery of the room during teacher led activities but circulated the room during student activities to examine student work. During the lessons the researcher, the faculty members and the group members (not teaching the lesson) all had a copy of the lesson plan to hand to guide and record their observations. Observation notes were collected from each of the lesson study group members and faculty members. These observations focused particularly on

student thinking and learning, engagement and behaviour of the students and suitability of the lesson in achieving the learning goals.

Table 3.3: Synchronisation of the data collection methods with the lesson study process

STEPS OF THE LESSON STUDY CYCLE	DATA COLLECTION STRUCTURE AND METHOD
STEP 1: Collaboratively Planning the Research Lesson	<p>➔ Audio taped meetings with faculty members</p> <p>➔ Written logs of group discussions</p> <p>➔ Record of resources used to research and design lesson</p>
STEP 2: Seeing the Research Lesson in Action	<p>➔ Observation of lesson by researcher</p> <p>➔ Observation notes of lesson study group members</p>
STEP 3: Discussing the Research Lesson	<p>➔ Audio taped group meetings of researcher, faculty member and lesson study participants following the lesson</p>
STEP 4: Revising the Lesson	<p>➔ Written logs of group discussion</p> <p>➔ Record of changes made to revised lesson and justification of those changes</p>
STEP 5: Teaching the New Version of the Lesson	<p>➔ Videotaped lesson</p> <p>➔ Observation of lesson by researcher</p> <p>➔ Observation notes of lesson study group members</p>
STEP 6: Sharing Reflections about the New Version of the Lesson	<p>➔ Written logs of group discussion</p> <p>➔ Record of changes made to revised lesson and justification of those changes</p> <p>➔ Videotaped group presentation of their work</p> <p>➔ Group interview with researcher</p>

During Step 3, the reflection on the lesson stage, the meetings of the group and the faculty members were observed and recorded. The researcher attended all (5) of the group meetings that were held with faculty members after the lessons were taught. Proposed changes to the lesson were recorded by the researcher.

In Step 4 the pre-service teachers continued the written logs of group discussions. The changes that they initiated to the initial lesson plan and the justifications for these changes were recorded by the researcher.

Step five was the teaching of the revised lesson and again the principle method of data collection was observation. The researcher observed the lesson and collected observation notes from the lesson study group members and faculty members. The lessons taught in this phase were also video-recorded.

In the final step of this lesson study cycle the pre-service teachers completed and handed up their written logs of the group meetings, the pre-service teachers produced a reflective journal outlining their journey of understanding during the lesson study process, the

groups made a presentation to their peers, reflecting on their experience of lesson study and the researcher conducted interviews with several of the pre-service teachers. In their reflective journal and presentations the pre-service teachers were expected to outline their understanding of the subject taught, how they developed that understanding, where they got the information which helped to develop their understanding as well as insights they gained into the learning trajectories of their students within their particular topic.

3.8 Data Collection Methods

As was described in the previous section, data were collected from a variety of sources. The intention of using a variety of sources was to capture the most comprehensive insights possible into whether the lesson study process could help pre-service teachers integrate theory into their practice. Each method of data collection offered a unique opportunity to gain these insights. The principles behind selecting each data collection method will be discussed in the following sections.

3.8.1 Observations

Observation was the principal method of data collection used in this study. According to Bailey (1994), researchers who use this method of data collection can “discern ongoing behaviour as it occurs” and “make field notes that record the salient features of the behaviour” (pp.244-245) which made it a useful technique when examining what teaching strategies the pre-service teacher used and to what effect. Kothari (2004) highlights that one benefit to using observation is that it “relates to what is currently happening; it is not complicated by either the past behaviour or future intentions or attitudes” (p96). Therefore subjective or social desirability bias and memory problems are eliminated. Hall (2008) supports this viewpoint particularly in relation to non-participant observation. Furthermore, Cohen et al (2000) suggest that participant observation allow for “the generation of ‘thick descriptions’” (p.311) which can provide a clearer understanding and interpretation of the event rather than the researcher having to draw their own inferences.

3.8.2 Questionnaires

The questionnaires were administered at two different stages of the lesson study cycle. The content knowledge questionnaire (see Appendix M) and the preservice teacher data questionnaire (see Appendix N) were both administered on the first day of the curriculum specialisation course. The content knowledge questionnaire was administered

again on the last day of the curriculum specialisation course. The content knowledge questionnaire was designed to assess the pre-service teachers' content knowledge before and after the lesson study cycle. The pre-service teacher data questionnaire was designed to obtain information regarding the pre-service teachers' mathematical background and their attitudes towards the topics they were assigned and towards the teaching of these topics. Twenty two out of the twenty five pre-service teachers responded to the questionnaires pre and post lesson study. Three pre-service teachers were absent on the day the pre-lesson study questionnaires were administered. The pre-service teachers were given approximately twenty five minutes to answer all the questions on both occasions.

The questions pertaining to the pre-service teachers' attitudes towards the mathematical topics and mathematics in general were composed by the researcher. However the questions for the content knowledge questionnaire were sourced or adapted from a variety of research and practitioner books and journals. Questions 1, 2, 3 and 6 of this questionnaire were based on some of the prominent concepts of probability identified in Jones, Langral and Mooney (2007). Questions 2 and 3 were specifically designed to assess probability concepts which Jones et al (2007) identified as concepts frequently misunderstood by pre-service teachers. Question 4 was sourced from Shaughnessy (2003). Question 5 was adapted from activities described in Nicolson (2005). Question 7 was a spinner task from the 1996 National Assessment of Educational Progress (NAEP) sourced from Shaughnessy and Ciancetta (2003). Question 8 was adapted from an algebra problem described in Blanton and Kaput (2003). Finally question 9 was sourced from Herbert and Brown (1997).

The questionnaires were used to obtain the attitudes of the pre-service teachers towards the topics they were assigned, their attitudes towards the teaching of these topics and their content knowledge prior to participating in the lesson study process. The questionnaire has several advantages over other data collection methods when trying to determine participants' attitudes or beliefs. Cohen et al (2000) believes that the information obtained from questionnaires tends to be more reliable because the anonymity encourages participants to be more honest. Kothari (2004) holds a similar viewpoint suggesting that the anonymity helps to eliminate the bias of the interviewer. Other advantages of questionnaires include; they are easy to administer and easy to analyse (Cohen et al 2000; Hall 2008) and respondents can give well thought out answers because they have adequate time (Kothari, 2004).

3.8.3 Interviews

The researcher conducted interviews with six pre-service teachers who volunteered to be interviewed. Of these six there were two male interviewees and four female interviewees. The interviews were conducted after the lesson study cycle and the group presentations had been completed. The questions for the interviews were designed by the researcher to probe deeper into issues raised in other data sources and as a means of verification for codes previously generated by other data sources.

The interview was used for two purposes in this study. Firstly it was used “as an explanatory device to help identify variables and relationships” (Cohen et al 2000, p.268). This was a suitable technique in this case for several reasons. It allowed discussions to develop which generated a wide range of responses (Lewis 1992 cited in Cohen et al 2000; Watts and Ebbutts (1987). This is particularly true in this case where the participants had been working together on a common purpose (Watts and Ebbutts 1987). The interview also provided greater opportunity for probing deeper into participants’ answers (Cohen et al. 2000). The second purpose of the interview was to validate information received from other data collection methods, a practice that is recommended by Hall (2008).

3.9 Data Analysis

The majority of the data collected in this study was qualitative. Nvivo 9 was used to analyse the qualitative data. Throughout the lesson study process dominant themes were identified from the data collected and these themes were then further classified into categories. These categories were then validated across the various data sources. These in turn provided rich insights into the growth of knowledge of these pre-service teachers during the lesson study process.

Data from the lesson study cycle was analysed using the grounded theory approach advocated by Glaser and Strauss (1967). The author commenced data collection without creating any hypotheses or without any pre-established theories regarding the results. Data collection and analysis were done simultaneously. Previous field notes and data were coded before the next set of data were collected. This allowed for a constant reshaping of the researcher’s perspective throughout the analysis process and helped to ensure the list of codes was exhaustive. It also guided future data collection particularly future field notes and the interviews, which were used as a means of verification for previous codes.

Initial data were collected from the group meetings, field notes from the first teaching of the lessons and first reflections. These were transcribed and the raw data was uploaded onto the Nvivo 9 database. The raw data was then broken down into small monothematic ‘chunks’ of paragraphs for ease of coding. These ‘chunks’ of data were then reviewed in minute detail, line by line. Initial codes were generated by interpreting and assigning meaning to the ‘chunks’ of data and separating them into suitably labelled categories. This system of coding is used “so the researcher can quickly find, pull out, and cluster the segments relating to a particular research question, hypothesis, construct or theme” (Miles & Huberman 1994, p57). Multiple coding was used as several ‘chunks’ were candidates for more than one category.

Nodes were created in Nvivo 9 for each code that was generated. Any data which supported this code was then organised under its appropriate code within the Nvivo 9 programme. Some ‘chunks’ were attached to more than one node. As every new node was created in Nvivo 9, a label and a rule for inclusion within the category was created. For example for the code ‘choice of representation’, the rule for inclusion was ‘incidences where the pre-service teacher discussed making choices about representation of a mathematical concept’.

At this stage of the analysis irrelevant data were discarded but stored for further analysis later in the analysis process. Memos were kept throughout the coding process. These memos consisted of ideas the author had regarding particular codes and sometimes notes which provided context to the data. For example, notes were made outlining details of an incident which occurred in the classroom which subsequently led to a particular teacher action which the researcher had highlighted in the field notes. The researcher also made notes of insights which the coding process provided.

After several transcripts had been coded it became evident that certain codes, which the researcher was not cognisant of whilst coding the first transcripts, were appearing more and more frequently in later transcripts. This suggested to the researcher that in the coding of the initial transcripts some emergent categories might have been missed. To alleviate this issue the researcher revisited those particular transcripts to search for instances where this category might have been missed.

Once all the raw data had been coded the researcher retrospectively went through all the ‘chunks’ of data. In this second phase of coding the researcher specifically searched for frequently occurring words or phrases within the data. Some further codes were also generated at this phase of coding. Verification for these new codes was then sought elsewhere

in the data or in future fieldwork. The researcher also looked for ‘chunks’ of data relating to the generated codes which might have been missed in the initial coding phase.

These two phases of coding provided new perspectives to the researcher and guidance for the next phase of data collection. To ensure validity of the codes generated, evidence from at least three different data sources were triangulated to confirm presence of each category. Once these two phases of coding were completed the researcher became more analytical and looked for patterns emerging from the codes. All generated codes were reviewed and similar codes were grouped together under common themes to make the codes more manageable.

Questions from Jones and Gratton (2010) were used to as guidance in this analysis process:

“Can I relate certain codes together under a more general code?

Can I organise codes sequentially (for example does code A happen before code B)?

Can I identify any causal relationships (does code A cause code B)?”

(p.242)

This process organised the data but also provided the author with insights into the data which were not apparent in the initial coding phases. For example it was discovered that the provision of readings played a major role in both the pedagogical and content knowledge development of the pre-service teachers and their decisions regarding choice of representations. Similarly it was discovered that the mentors played a significant role in the pre-service teachers’ understanding of different aspects of the lesson. Finally once all the coding was completed the researcher chose incidences from within the data that illustrated or explained the identified themes. To avoid researcher bias both contradictory data as well as confirmatory data was searched for during this phase.

An example of the coding system described is provided using an excerpt from an interview with one of the pre-service teachers:

“On teaching practice do you know your inspector reads your reflections and they tick something about them and if they didn’t come to see the lesson I don’t see why anyone would write down that it went terrible and that it was awful. Do you know if your inspector wasn’t there...you might as well say that it went great...you know? So in that sense like, reflections...other reflections, on teaching practice, they’re kind of, unless the supervisor saw you teach it you say it in the best possible light and you kind of tend to overlook things that actually went wrong but that’s, do you know, it’s not to say that you haven’t learned from them but you’re thinking about your grades at the same time. At least, in this sense, it’s...what was good about this was we actually felt that we could be honest, like it wasn’t...they made it clear from the start that the grading kind of wasn’t on how well the

lesson went and do you know, it wasn't: we're going to grade you on this teaching and how well you did it and stuff and they kind of made it clear that: Oh, do you know, If it doesn't go well the fault isn't on anyone in particular. We all need to work together to make it better and stuff so we felt then in reflecting that we could actually say, 'Oh, we didn't do this well at all, do you know, we can change that', so it was actually, it was nice to be honest."

(Helen, Group 1, Interview)

The qualitative data in this excerpt verified the code 'honest reflection', which had previously been generated from the data obtained from transcripts of the group presentations. It also generated the codes 'relationship with mentors' and 'prior teaching experiences'. The previously coded data was then revisited to search for other occurrences of these new codes. The relationship with the mentors was subsequently deemed to be a causal factor for the honest reflection code. The memo attached to this 'chunk' of raw data reflected the guidance the faculty members gave the pre-service teachers regarding what they should write about in their reflections:

"The mentors suggested that these reflections were an opportunity for the pre-service teachers to examine how the lesson went. Were the learning goals achieved? What worked well? What didn't work well? They also suggested that such reflections would inform the changes they would plan for the next lesson"

In the final stage of analysis this memo provided an insight into why the pre-service teachers felt honest reflection was so important compared with prior teaching experiences.

3.10 Validity/ Ethical Issues

3.10.1 Validity

Cohen et al (2000) says that in qualitative data, "validity might be addressed through the honesty, depth, richness and scope of the data achieved". Several efforts were made by the researcher to maximise validity. One such effort was methodological triangulation. Stake (1995) highlights that by using "multiple approaches within a single study, we are likely to illuminate or nullify some extraneous influences" (p.114). Furthermore Cohen et al (2000) suggests that the more the methods differ from each other the more confident the researcher can be about the findings. An example from this particular study would be if the findings of the observations supported the outcomes of the questionnaire. Investigator triangulation (Stake 1995) gave further validation of the observation data as data was collected by the researcher, the group members and members of faculty. Finally the interview offered further

opportunity to improve the validity of the study in the form of member checking (Cohen et al 2000; Stake 1995). The interview was an opportunity to check with the participants of the study the adequacy/accuracy of the analysis and interpretations the researcher had made from the data collected earlier.

3.10.2 Ethical Issues

Before beginning the investigation the author sought and was granted ethical approval by the Mary Immaculate Research Ethics Committee (MIREC). Ethical approval was granted based on the author conforming to particular conditions relating to data protection. Firstly and most importantly the case study involved the participation of pre-service teachers and students from two local primary schools. In order to ensure their protection it was necessary to take the following steps:

- Permission was sought from the respective board of managements of the two local schools to have access to a 5th class group of students in their school (these documents can be found in Appendix G and H).
- Information regarding the purpose of the study, the nature of their participation and the freedom they have to choose either to participate or not or to withdraw at any time during the study was provided to all the pre-service teachers, the participating students and the parents of the participating students (these documents can be found in Appendix A, C, D, I and J).
- All participants (pre-service teachers and students) and the parents of the students signed consent forms to confirm their agreement to participate in the study (these documents can be found in Appendix B, E, F, K, and L).
- Names of the participants will not be stored with the data. Pseudonyms were used to protect the identity of the pre-service teachers throughout the study.
- The data will be stored in the supervisor's office and only the supervisor and the investigator will have access to this data. The data will be stored for 7-10 years after publication.

3.11 Limitations

Several of the methods of data collection used in the study relied on self-report methods which are susceptible to social desirability bias. Therefore it is important that respondents "must tell what is rather than what they think ought to be or what they think the

researcher would like to hear” (Tuckman 1999, p.237). However methodology triangulation helps to alleviate this problem.

Observation was also an important method of data collection in this study. This brings in issues of researcher bias and selectivity as

“the researcher is constantly making choices about what to register and what to leave out, without necessarily realizing that – or why – one exchange or incident is being noted but another is not.”

(Miles and Huberman 1994, p.56)

Once again this issue is alleviated by the methodology and investigator triangulation applied in this study.

The reflective activities were assigned as part of the course work for the curriculum specialisation module. This meant they were written for the educators teaching the module. This may have led to the reflections being more favourable towards the lesson study process. However once again methodology triangulation helped to alleviate this issue as the interview data was only accessible to the researcher (who was acting in the role of non-participant observer).

The sample size used in this study was small because it was limited to the pre-service teachers who selected the curriculum specialisation course. Therefore it would be inappropriate to make generalisations based on the findings of the study.

3.12 Conclusion

In conclusion, the research method chosen for this study was the use of a case study and this proved to be an effective methodology. It provided in-depth insights into the effectiveness of the lesson study approach in assisting pre-service teachers to bridge the theory-practice gap. Every effort was made to ensure the validity of the data collected particularly through triangulation of data sources and investigator triangulation in the collection of observation data. Data collection and analysis were done simultaneously in an attempt to find an exhaustive list of themes. In the next chapter the author will examine the results obtained by this data collection process.

Chapter 4: Results

4.1 Introduction

In this chapter the results of the investigation are outlined. The results from the various data sources and from each of the lesson study groups are outlined together under the common themes identified using Nvivo. The data sources that contributed to the results were the author's observations from the university classroom and the primary school classrooms, logs and observations of group meetings, logs of changes made to the lesson plans between drafts, the pre-service teachers' reflections, the pre-service teachers' presentations and the pre-service teachers' interviews. The main findings of this investigation are that lesson study supported the pre-service teachers in adopting best practices during their lesson planning and implementation through careful mentoring during the lesson study process. Lesson study also helped to reaffirm and reinforce the pre-existing beliefs the pre-service teachers had in relation to the best teaching strategies they were already adopting in their teaching. These results were brought about through both the careful mentoring by the faculty members teaching the course (mentors) and the experiences of the pre-service teachers in the classrooms, where they witnessed first-hand the effectiveness of these strategies. In the following sections the results will be examined under the headings of the themes which were identified in Nvivo. The themes were:

- Engaging in the Lesson Study Process Reiterated the Purpose and Importance of Different Components of 'The Lesson'
- Tweaking Lesson Management to Improve the Flow of the Lesson
- Providing Suitable Challenge for Students
- Refining Important Teacher Skills
- Improving Pedagogical and Content Knowledge
- Collaboration and Sharing of Ideas
- Important Role of the Mentor in the Lesson Study Process

4.2 Engaging in the Lesson Study Process Reiterated the Purpose and Importance of Different Components of 'The Lesson'

Throughout their undergraduate education courses, pre-service teachers were exposed to theory regarding the purpose and the importance of the various lesson components e.g. the objectives, the introduction and the conclusion. However from the initial drafts of their lesson plans it was clear that they weren't putting this knowledge into practice. This can, perhaps, be explained by the theory-practice gap literature explicated in the previous chapters. The pre-

service teachers' initial lesson plans reveal that the pre-service teachers did not appreciate the function and importance of several structural components of the lesson. This was reflected in the feedback the pre-service teachers received from the mentors. Specifically, these components were; the objectives of the lesson, the introduction to the lesson and the conclusion of the lesson.

4.2.1 Objectives

The importance of having clear and concise learning goals/objectives is frequently alluded to in the literature (Stigler and Hiebert, 1999). Identifying precise learning goals is also one of the key concepts of lesson study, which was acknowledged by the pre-service teachers.

“I think just when you are going through your schemes of work you have a tendency to...you know what you want to teach and you'll write down an objective to do with that...but for this lesson we kind of pinpointed exactly like, really specifically what it was we wanted to teach.”

(Sophie, Group 5, Reflection)

However the first draft of three (out of the five) groups' lesson plans either included no learning objectives or vague learning objectives. One such example was:

“[The objective for this lesson is] for the pupils to get an understanding and think for themselves some basic rules of algebra”

(Group 1, Lesson Plan)

This had several repercussions for the planned lessons. These repercussions were outlined in their reflections and in the meetings with the mentors.

“Our lesson study was not satisfactory... We felt that this related to the difficulty we encountered with... what our focus actually was in our lesson”

(Group 4, Group Assignment)

“You cannot simply go into a lesson and get the pupils to participate in many different random activities in the hope that the pupils will fully understand what is occurring... Instead, you must ensure that there is a firm base to the lesson with clear and specific objectives in relation to what you want the pupils to learn.”

(Evan, Group 4, Reflection)

At the group meetings the mentors explained that some of the activities the pre-service teachers included in the lesson plan served no purpose in addressing the lesson objectives. In other cases the activities planned for the lesson were not sequential, students were expected to complete harder tasks before they had built up the requisite understanding. This latter shortcoming relates again to the pre-service teachers failure to identify clear objectives that

increase in complexity as the lesson progresses. Furthermore, because it was not clear in initial lesson drafts, what the students were supposed to be learning, it was impossible to determine if it was accomplished at the end of the lesson (Hunt, Wiseman & Touzel, 2009). Following feedback sessions with the mentors, the pre-service teachers developed much clearer, precise objectives and changed the activities accordingly.

Having clear objectives benefitted the pre-service teachers later in the process as it allowed them to analyse their teaching and see how they could improve it. In the presentations, members of group three said that they felt they lost the mathematical focus during some of the activities in their first lesson and that “the kids started looking at them as games” (Group 3, Presentations). However because they had clear objectives they were able to go back to them and think “What are we trying to do in this part?” (Group 3, Presentations). Then they were able to come back “with a clear focus and in turn that meant that the kids were focused” (Group3, Presentations).

Critically, this focus on learning goals and objectives led to the pre-service teachers using them as assessment criteria to judge the success of their lessons. Towards the end of the lesson study process, they had begun to assess the success of their lessons by referring to how well they felt the learning goals were achieved in the lesson.

“I think the lesson study went well, was structured appropriately and it covered the aims of the lesson plan.” (Ryan, Group 4, Reflection)

“the introduction achieved its goal to explain the continuum and link it with fractions.” (Nadia, Group 4, Reflection)

“Any changes that have to be made relate to... the outcomes. I think the latter will be important so that we can evaluate whether or not our objectives for the activity have been achieved.” (Marian, Group 3, Reflection)

4.2.2 Purpose of the Activities

The feedback the pre-service teachers got from the mentors and the work they did on improving their lesson objectives prompted them to critically examine the purpose of the lesson activities. They began to look critically at each activity and ask themselves what learning goals were to be achieved through engaging in the activity. On prior teaching practices the pre-service teachers described feeling the need to “put activities into their lessons to kind of be the singing and dancing element in case the supervisor comes into the room” (Sophie,

Group 5, Interview). In contrast, during their lesson study experience they were able to examine activities in their lesson plan and come to the realisation that

“while you may have a plethora of activities, discussions, illustrations and assessments in your arsenal, it is more important to ensure the lesson has a flow and that each element serves an important and real purpose.”

(Sophie, Group 1, Reflection)

Groups also said that even though they liked particular activities they eventually decided not to include them in the lesson design if they did not support the lesson objectives. It was interesting to note that pre-service teachers began to compare activities based on how they would aid the teacher in achieving the objectives. One group discussed how they chose a dice activity using two die rather than one dice because the one dice activity would limit the questions the teacher could ask and the concepts the students could learn.

4.2.3 Introduction to the Lesson

The introduction is also a very important component of the lesson which was overlooked by many of the groups. Four of the five groups received feedback from the mentors questioning the suitability of the introductory activity they had selected in the first draft of their lesson plan. In general the introduction was not adequately challenging or was irrelevant and uninteresting for the intended class group. Faculty feedback on the lesson introduction included:

“good opening problem but can you make the context more interesting and relevant to fifth class?”

(Mentor, Group Meeting)

“too basic, they[children] would be able to do this already.”

(Mentor, Group Meeting)

Advice about what makes a good introduction accompanied this feedback from the mentors. The pre-service teachers took on board the feedback and changed their introductory activities accordingly. These changes had a major impact on the success of the lessons and this was noted both by the researcher in the field notes and by the pre-service teachers in their reflections. From their reflections it was clear that the pre-service teachers’ first-hand experience of the value of a good introduction made a lasting impression on them.

“The introduction definitely set the tone and also the level of students’ engagement with the lesson.”

(Claire, Group 2, Reflection)

“The introduction to the lesson succeeded in grabbing their attention...and as a result they were stimulated and engaged from the beginning, which made them eager to investigate the topic further.”
(Grainne, Group 2, Reflection)

“It (the introduction) meant they became invested in the lesson and were enthusiastic about the lesson.”
(Bernadette, Group 3, Reflection)

“I felt that the introduction of the lesson was good for building context for the activities that were to follow.”
(Marian, Group 3, Reflection)

4.2.4 Lesson Conclusion

The conclusion of the lesson was another component of the lesson that many of the pre-service teachers neglected in their planning. Four out of the five groups received feedback encouraging them to create a better lesson conclusion. Many of the initial conclusions were of low cognitive demand or unrelated to the tasks which the students had previously carried out. The feedback from the mentors mainly focused on reminding the pre-service teachers of the purpose of a lesson conclusion. In the early feedback meetings the mentors stressed the importance of the conclusion in consolidating, reinforcing and reviewing what had been covered in the lesson. They highlighted the diagnostic assistance the conclusion offers teachers in preparing to teach future lessons.

“[The conclusion] seems just ‘added on’ to the lesson and does not add much in terms of review, consolidation or extension.”
(Mentor, Group Meeting)

“Very lower order, basic conclusion in comparison to what the students have already done [in the lesson].”
(Mentor, Group Meeting)

“This conclusion seems redundant...It doesn’t seem to progress the lesson sufficiently.”
(Mentor, Group Meeting)

“Conclusion shouldn’t be less challenging than the activities it follows.”
(Mentor, Group Meeting)

Faculty members also gave examples of some concluding activities that the pre-service teachers could use for any of the purposes mentioned. Following this feedback the pre-service teachers adapted their concluding activities. Some groups used activities that were recommended to them and then praised their effectiveness in the feedback meetings after the first lesson. They also remarked that they liked how concluding activities incorporated

informal assessment strategies such as ‘thumbs up, thumbs down’ and the use of mini-whiteboards which provided instant feedback on the achievement of learning goals. Other groups changed their concluding activity to extend or consolidate the activities they had worked on during the class.

“This [concluding activity] worked very well at consolidating the children’s understanding”

(Nadia, Group 4, Reflection)

One group in particular remarked on how in the beginning they felt they “were just putting in the conclusion just because it was there and just because it looked good” (Anne, Group 1, Interview) but then they realised the conclusion could be used as an extension task:

“In the main part of it [the development of the lesson] we guided them to see the steps we need to come up with a general rule and then we let them be more independent in the conclusion”

(Anne, Group 1, Interview)

4.3 Tweaking Lesson Management to Improve the Flow of the Lesson

In initial meetings, much of the mentor feedback focused on the suitability of certain lesson activities. Sometimes this was with regard to the level of challenge of the activity, however other times it focused on how the specific activity fitted in with the lesson as a whole. For example they gave feedback such as “even though the activities on their own were nice, they were disjointed” (Mentor, LP feedback) and “it was like three random activities...” (Mentor, LP feedback) or “it was kind of just an activity for the sake of an activity rather than it linking back [with the previous activity] or linking forward with the concluding activity” (Mentor, LP feedback). They also asked the pre-service teachers questions such as “Are the activities sequentially developmental?” and “Is this activity less challenging than the activity it follows?” (Mentor, LP feedback)

The mentors wanted the pre-service teachers to consider how the lesson would flow given the activities they had chosen and to consider whether there were other activities which would be more suitable for their lesson. Maintaining the flow of the lesson was something which many of the pre-service teachers commented on in their reflections and an aspect of their teaching which they endeavoured to improve in their second implementation of the lesson. Their reflections looked at several aspects of their teaching which they could develop to improve the pacing of the lesson. These reflections mirrored closely the feedback they received from the mentors. This study highlighted several aspects of lesson planning and

implementation that can hinder or assist in maintaining the flow of a lesson. These are: organisation, task pacing and decisions about sequencing.

4.3.1 Organisation

Classroom organisation was a focus of many of the pre-service teachers' reflections following the first teaching of the lesson. It was also something which the mentors made reference to in the follow-up meeting. In particular they focused on the amount of class time that was squandered while materials were being distributed or collected. Their comments included advice for the pre-service teachers such as; they must know when they need to give materials out, how they plan to give them out and "when they're [the students] not using them [the materials] where to put them". The pre-service teachers recognised the need for greater organisation and they acknowledged that their lack of organisation disrupted the flow of their lesson and caused the students to lose focus.

"The flow of the lesson was a bit more stunted mainly due to our group's classroom organisation; this hindered the potential of the lesson at times".

(Claire, Group 2, Reflections)

"We were not organised enough and from this we lost both time and focus."

(Tracy, Group2, Reflections)

Following the second teaching of the lesson the pre-service teachers once again reflected on the importance of classroom organisation in maintaining the flow of their lesson. In particular, they referred to having materials 'ready to go' and 'near to hand'.

"Making sure all the materials we were using were ready to go...so that the flow of the lesson was not disturbed and the children were not losing focus..."

(Grainne, Group 2, Reflections)

"I think the fact that our packs were organised and everything needed by the children in them were ready to go, this helped the lesson flow more easily"

(Bernadette, Group 3, Reflections)

4.3.2 Pacing of Activities

In the group meetings leading up to the first teaching of the lesson, the mentors stressed the importance of keeping up the pace of the lesson and watching the timing of the activities, encouraging the pre-service teachers to "keep them snappy" and not to "let them drag on". However despite receiving this advice it was not until the pre-service teachers experienced the lesson that they were able to understand the importance of the mentors'

advice. Following the first teaching of the lesson the mentors gave the pre-service teachers specific advice on how they might improve the pacing of their activities. These suggestions included using powerpoint as a support in the background for students who miss instructions and as a change of stimulus for the students and giving the students a particular time frame within which to complete the task. Following this meeting the pre-service teachers incorporated these strategies into their lessons and following their second teaching of the lesson they reflected on the success of these strategies.

“The adjustments we made to the lesson, for example the powerpoint, pausing the clip at different stages for questioning and using the same strips of words throughout the lesson improved the flow of the lesson greatly and therefore enhanced and focused on the children’s learning.” (Grainne, Group2, Reflections)

“A practical solution which arose from this was limiting time and providing the class with a five second countdown.” (Keira, Group2, Reflections)

4.3.3 Decisions about Sequencing

In the initial planning phase the pre-service teachers demonstrated poor decision making regarding the sequencing of activities. In some cases there was too much repetition - they had planned numerous activities which had the same learning outcome and demonstrated no progression from activity to activity. In other cases the students were expected to engage in more difficult activities before they had built up the prerequisite knowledge, knowledge which they would then gain in a later activity. The root of this difficulty stemmed from the lack of attention the pre-service teachers paid to the learning objectives and to the purpose of activities.

“This sounds like it might be a nice activity however I don’t get a sense of exactly what the purpose of the activity is and what learning objective it addresses”.

(Mentor, LP feedback)

The pre-service teachers picked activities which were compatible with the identified mathematical concepts, without thinking about the specific learning outcomes arising from student engagement with the activities. This resulted in lesson plans which had numerous activities which sought to achieve very similar learning goals rather than a plan which presented a continual progression for the students as they moved through the lesson. This was frequently alluded to by the mentors in the early group meetings.

“What is the purpose of this activity? Which of the objectives does it address? How does it differ from the spinner activity i.e. what will children learn here that is qualitatively different from the previous steps?” (Mentor, LP feedback)

“There now seems to be a lot of repetition and not enough development.” (Mentor, LP feedback)

“Are the activities getting slightly more difficult as the students move through the lesson” (Mentor, LP feedback)

As was indicated earlier this was particularly evident in the concluding activities which were often of a lower order and more basic than the subsequent activities.

“I like the idea of body percussion but it seems just ‘added on’ to the lesson and does not add much in terms of review, consolidation or extension. If you want to keep it, it might fit better in the introduction”.

(Mentor, LP feedback Group 1)

Following feedback from the mentors, the pre-service teachers made various changes to the sequencing and progression of activities in their lesson plans. For example, group four initially planned to include an activity with one dice, where the children would assign a numerical value to the probability of various scenarios. However following feedback from the mentors they realised that this activity posed no additional complexity compared to the previous activity and therefore served no purpose. Consequently they changed the activity to incorporate two die. Their reasoning behind changing the activity, explicated in the group presentation, demonstrated an understanding of the motives behind modifying the activity:

“There was much more questions that could be asked about two die. The pupils were more challenged in this activity. There were much more different fraction families involved in this activity”

(Group 4, Presentation).

4.4 Providing Suitable Challenge for Students

Pitching the lessons at a suitable level for the students in the class caused difficulty for two of the groups. This could have been due to the pre-service teachers relatively limited experience of teaching this age group and because they had never taught this particular class before. However, it proved a valuable learning experience in that it demonstrated to the pre-service teachers the importance of being prepared to adapt activities for students who need greater challenge or more support.

4.4.1 Underestimating Student Ability

In their first lesson, groups one and two significantly underestimated the ability of their class. The pre-service teachers recognised this during their first teaching and reflected on it in their subsequent assignments.

“For this particular class the challenge just wasn’t high enough...I feel that if we had prepared the lesson to be adaptable to a higher challenge it would have proved more beneficial for the children.”
(Tracy, Group 2, Reflections)

“I think we were prone to underestimating the ability of children...this extension was not in our lesson plan because we had decided that it would pose too much of a challenge for the class.”
(Helen, Group 1, Reflections)

“Overall the level of challenge needed to be greatly increased.”
(Group 2, Assignment)

One of the pre-service teachers who taught a lesson during the study offered an interesting rationale for why this might be the case.

“What this moment taught me is that children are often capable of far more than we consider them capable of. In teaching mathematics, I think that some of us fall victim to this irrational fear that if we ask too difficult a question, all of our good teaching will be undone and any progress will be erased”.

(Helen, Group 1, Reflections)

During the lesson study cycle it became clear that the students’ level of thinking was surprising for the pre-service teachers and some interesting insights into pre-service teachers’ views on student ability were uncovered.

“What actually surprised me at the introduction was their level of understanding and reflection...So I suppose my own learning is I should not underestimate their level of responses or even the level of thinking that goes into their responses”.

(Claire, Group 2, Reflections)

“Firstly I was amazed at how the concepts we were teaching unfolded in the child’s heads. At first I had my doubts about whether the children were able to understand how to make a formula”.

(Andy, Group 1, Reflection)

The emergence of these issues regarding student ability presented an ideal opportunity for the mentors to highlight the importance of challenging all students. They suggested the pre-service teachers should have prepared ways of making the activities more challenging or

more accessible depending on their students' abilities. They recommended using open-ended activities and providing more or fewer manipulatives depending on the needs of the students. The second teaching of the lesson showed evidence of the pre-service teachers applying these practices. Group two provided the students in their lesson with blank strips of paper which allowed them to generate responses according to their ability. The pre-service teachers reflected on how this enabled them "to stretch the children as well as providing them with the opportunity for more autonomy over their learning" (Claire, Group 2, Reflection). Group one provided their students with manipulatives for their final activity, whereas in the initial teaching of the lesson they had not because they had felt the students would be adequately prepared to solve the problem abstractly. Following the second teaching of the lesson the pre-service teachers reflected on the importance of having supportive materials available for those who might struggle with the activities.

"The availability of more manipulatives for the second teaching of the lesson demonstrated to me, how they can be an invaluable resource in teaching algebra...for pupils who are struggling to visualise..."

(Helen, Group 1, Interview)

4.5 Refining Important Teacher Skills

Many of the pre-service teachers felt that the lesson study process supported them in honing their teacher skills. In their reflections and in the interviews many of them took the opportunity to compare their lesson study experience with their prior teaching experiences when explaining the reasons they felt lesson study facilitated this improvement. They felt lesson study offered them an opportunity "to have feedback from the lecturers under a not stressful T.P. setting" (Orla, Group 3, Interview). The less pressurised environment gave them greater opportunity to truly focus on the practices of teaching and learning. They felt they were "thinking more about the actual...how the children are learning rather than teaching to the lesson, teaching to the lesson, teaching to the lesson" (Mark, Group 1, Presentation) which was what they felt they were doing on previous teaching practice experiences. Sophie liked that the focus was on the actual lesson being taught rather than on the individual doing the teaching. She felt that in teaching practice "the focus is really on people...it's about the three hours when someone is sitting at the back of a classroom and what they saw for those three hours, in like a really artificial environment." Whereas in lesson study "it kind of takes the focus away from that [the individual teaching] and just on what's the best way to teach this lesson" (Sophie, Group 5, Interview). The skills which the pre-service teachers demonstrated the greatest improvement in were

skills which pre-service teachers have previously been found to be lacking. These included: questioning, responding to students' ideas and reflection. These will be examined in greater detail in the following paragraphs.

4.5.1 Questioning

Questioning is a key instructional strategy in student-centred approaches to teaching. However despite its importance Lin (2005) and Cohan and Honigsfeld (2006) found that it is a skill which many pre-service teachers are lacking. The lesson study approach places great emphasis on questioning during the lesson. Questions which have the potential to guide pupils towards key learning moments are planned in advance. This approach was also adopted by all the groups in this lesson study cycle.

Insights from this study showed that lesson study helped the pre-service teachers, in various different ways, to refine their questioning skills. Group three struggled with timing and maintaining mathematical focus during activities in their first lesson.

“Following the first teaching of our lesson we realised we need to focus the children more. We took a series of different questions to focus the children on the main concept of each part of our lesson.”

(Group 3, Presentation)

In their final presentation, they observed how their improved questioning in the second lesson benefitted their students' learning and they acknowledged that pre-emption of questions was one of the main benefits they would take from lesson study. Pre-service teachers in other groups also recognised the value of the experience in developing their questioning skills. The experience gave them a greater understanding of the role of questioning in teaching.

“Previous to completing the lesson study, I would ask the students ineffective questions so as to assess the students' understanding of activities which facilitated limited one word answers.”

(Pia, Group 4, Reflection)

Ben remarked how before this experience he felt questioning was; “more about working towards objectives, less about the misunderstandings that could arise. Let's say if someone didn't grasp a certain section of it, what question could I ask to tease it out of them. I wouldn't have thought about that as much.” (Ben, Group 5, Interview)

Darina, made similar realisations; “the importance of probing questions in Maths lessons was really highlighted to me over the lesson study experience. The teacher often might need to help the children along to draw conclusions and come to realisations. That is why probing questions are so important as they get the children to quantify and clarify their thinking and their understanding which leads them to a greater understanding.” (Darina, Group 3, Reflection)

Lorcan found that “simple questioning techniques that I had never even thought of came up just from the other four people” (Lorcan, Group 5, Presentation).

These comments demonstrate the pre-service teachers’ increased understanding of the role of questioning in guiding their students to a greater understanding.

4.5.2 Responding to Students’ Ideas

Anticipating student responses is also a major aspect of lesson study. Sims and Walsh (2009) found that many pre-service teachers find anticipating student responses to be a difficult aspect of the lesson study process given their limited access to students in the planning phase. The mentors overcame this problem by providing suitable readings to the groups and also sharing their wealth of experience in this area. Thus anticipating student responses played a key role in the lesson study cycle.

However, it is impossible to predict all student responses and during the first teaching of the lesson it was the unpredicted responses that caused the pre-service teachers the most difficulty particularly if the responses were incorrect. One pre-service teacher confessed “I saw pupils with incorrect answers on their whiteboards and I did not explain why it was incorrect to them.” (Claire, Group 2, Reflection) Other pre-service teachers remarked how they often accepted answers without discerning from the student if they had grasped the concept or methods behind it.

“Sometimes you just take the answer and you assume.”

(Mark, Group 1, Interview)

“Previously during maths lessons if a student got a correct answer I would never have challenged this answer or asked the student to justify it.”

(Pia, Group 4, Reflection)

The mentors suggested several strategies the pre-service teachers might use to deal with student responses. One of these was getting the students to justify their answers and then if necessary discuss them as a class group. This proved to be an effective strategy for the pre-service teachers. Where in the first lessons many incorrect responses were ignored, in the second teaching of the lesson incorrect responses were explored and corrected. One of the pre-service teachers in the group later reflected that she had come “to understand the importance of the justifications of opinions and answers” (Orla, Group 3, Reflection). Another pre-service teacher explained how she had come to realise that getting students to justify their answers is a useful diagnostic tool for teachers.

“That’s a really big thing [getting students to justify their answers] because they say things and you’re like how did you come up with that but then if you get them to explain...and say what’s that three for...and they say oh yeah...they might see themselves it’s wrong or you’ll see that they’ve a good reason for it or they’re really close”.

(Helen, Group 1, Interview)

Other pre-service teachers found that the students’ justifications helped, both them as teachers and the rest of the class, see the problem from another perspective and perhaps see a different way of solving it.

“This [lesson study] forced me to broaden my mind to see if the other methods the children were using were working.....It is always helpful to have more than one way to solve a problem in maths.”

(Andy, Group 1, Reflection)

“One of the major [insights] I acquired over the course of study, was that while several people may generate the same (correct) formula for a particular pattern, each person may have ‘solved it’ in a different way.”

(Helen, Group 1, Reflection)

In the algebra lesson the teacher faced a similar problem of dealing with student responses. In this lesson the students were working in pairs to identify an expression to represent a new algebraic pattern. The students were calling out the expressions they had come up with in their pairs and the teacher was finding it difficult to recognise ‘on the spot’ if their solutions were correct or incorrect. The mentors suggested getting the students to test their answers themselves or to write their answers. In the following class the teacher successfully implemented these strategies. The students had to solve their expressions, write their answers and then check their answer using cubes. One of the pre-service teachers in the group later reflected that “articulating and writing down a formula in words can often generate insights into the ‘correctness’ of it”. (Helen, Group 1, Reflection)

4.5.3 Reflection

Reflection plays a hugely significant role in good teaching and consequently great emphasis is placed on reflective practice in teacher education programmes. Reflection is also extremely important in lesson study and the pre-service teachers really appreciated how the reflective practice was intertwined within the lesson study process. In fact one pre-service teacher felt “the reflective part of it [lesson study] really is probably the best.” (Ben, Group 5, Interview) Group three felt that one of the main benefits of lesson study for them was “the

engagement with reflection.” (Group 3, Presentation) They felt that genuine reflection was imperative as it formed the basis for improvements for the second teaching of the lesson. They tended to compare this lesson study experience with their negative experiences of reflection in prior teaching experiences. Consequently, this investigation offered insights indicating that the reflective practice that these pre-service teachers engaged in as part of their degree programme prior to this lesson study experience, may not have been as beneficial and realistic as intended.

Firstly the pre-service teachers felt that the pressures present in previous teaching experiences were not present during lesson study. The pre-service teachers felt that on prior teaching practices honest reflection might have effected their grades negatively and so they tended to reflect in a manner they felt would please their supervisors.

“Unless the supervisor saw you teach it you say it in the best possible light and you tend to overlook things that actually went wrong, it’s not to say you haven’t learnt from them but you’re thinking about your grades at the same time.” (Helen, Group 1, Interview)

“Reflection before was, what do they want to hear.” (Ben, Group 5, Interview)

“It’s more about giving the supervisor what they want than actually doing any sort of genuine reflection...I think it’s more like ticking the boxes.” (Sophie, Group 5, Interview)

“When you’re reflecting on T.P....you’re probably just giving a general outline...oh the supervisor will love if I say this...it’s a bit false” (Mark, Group 1, Interview)

“You fill out the T.P. reflections to suit your inspector. I’m not doing my reflection for me, I’m doing my reflection for my grade.” (Orla, Group 2, Interview)

In comparison they felt that, lesson study, without the pressures of other teaching practice experiences allowed them to be open and honest with their reflection.

“It’s a bit more practical than regular T.P. [teaching practice], you’re actually concentrating on the teaching of a topic rather than, you know, two weeks of like a three-ring circus...Even like the people who were teaching themselves, it was teaching practice that wasn’t about them teaching, it was the all about actual lesson.”

(Sophie, Group 5, Interview)

“At least in this sense, what was good about this was that we actually felt that we could be honest...they [the mentors] made it clear from the start that the grading wasn’t how well the lesson went and it wasn’t, you know, we’re going to grade you on teaching.”

(Helen, Group 1, Interview)

“You’re solely doing it for the success of the lesson as opposed to the success of you as a teacher and you’re doing it so the learning of the children is enhanced as opposed to your teaching”

(Orla, Group 3, Interview)

Finally the pre-service teachers felt that the reflection in lesson study was more purposeful and goal-orientated than previous experiences because the reflection informed the planning for the second lesson. This encouraged them to pay more attention to the subtleties of the lesson.

“The fact that you had to teach it again really made you actually reflect more than probably you usually would...we pick out really little things you’re going to change and do you know from doing that you kind of learn that the little things can make a big difference”.

(Helen, Group 1, Interview)

“If something went wrong in the first lesson, you couldn’t write down...oh this went wrong and then not do something about it. Because we’ve said it went wrong, so we had to go off and think about it.”

(Ben, Group 5, Interview)

“It was helpful to have an opportunity to carry out improvements on that exact lesson as opposed to trying to apply them to a different lesson, as was on teaching practice.”

(Orla, Group 3, Reflection)

This differed from their previous teaching practice reflections because although they were asked what they would do differently if they were teaching the lesson again, they felt “that’s all kind of in a vacuum because you’re not actually going to teach that again.” (Sophie, Group 5, Interview)

4.6 Reinforcing & Reaffirming Beliefs about Teaching Methodologies

As the pre-service teachers taking part in this study were in their final year of college and had completed all their required teaching practice placements of their degree many of

their beliefs about teaching methodologies had been established prior to the lesson study experience. However the lesson study experience served to strengthen and reaffirm these beliefs by providing first-hand experience of the benefits of these methodologies.

“You’d know from lectures and writing essays...the importance of all these things [methodologies] so you’re fully aware that... visual aids do help. I understood that...it’s only when you do it ...it worked incredibly well”

(Ben, Group 5, Interview)

“The critical examination [of teaching] for the purpose of lesson study reinforced and highlighted particular approaches.”

(Orla, Group 3, Reflection)

Examples of incidents which reaffirmed their beliefs were mentioned throughout the pre-service teachers’ reflections. They outlined their personal experiences of the benefits of the particular methodologies. Several examples from the reflections are outlined in the following paragraphs:

4.6.1 Group work

All the lesson study groups used some element of group or pair work during their lesson. Even though this was clearly a methodology that the pre-service teachers included in their teaching before lesson study, the pre-service teachers were surprised by the success of this teaching strategy. They also demonstrated a greater understanding of why this strategy was beneficial in their lessons.

“Paired discussion was also helpful in this context as it allowed for the children to bounce notions off one another in a secure setting before presenting their combined efforts to the class...the discussion and justification of children’s responses is key for the teacher’s assessment of the child’s comprehension.”

(Orla, Group 3, Reflection)

“One aspect that we planned for but we didn’t think would work as effectively as it did was the peer teaching element of the groups.”

(Lorcan, Group4, Reflection)

“The group work used...was ideal....In a whole class setting children may be less willing to verbalise their suggestions out of fear of being wrong... I also learned that group work can be very effective...the pupils have a chance to discuss their views with a partner before speaking to

the whole class. They can also compare their thoughts with their partner and see; what's the same and what differs between the views.”

(Andy, Group1, Reflection)

The importance of pair work in providing students with opportunities to justify their responses (alluded to by Orla) is of particular significance in the context of Irish schools, given the relative weaknesses in reasoning displayed by Irish students in recent TIMMS and PISA studies (Eivers and Clerkin, 2012).

4.6.2 Use of Manipulatives

Members of group three demonstrated the greatest development in their understandings regarding the use of manipulatives in teaching. They included manipulatives throughout their first lesson. However their reflections after the first lesson showed that the manner in which the manipulatives are integrated into the lesson became much more important to them. They felt that in the first lesson the students were paying more attention to ‘playing’ with the manipulatives than grasping the concepts. In their reflections and presentation they commented on their more effective use of the manipulatives in their second teaching of the lesson. In the second lesson they saw how effective manipulatives, if used appropriately, can be in demonstrating various concepts.

“The exploration of materials gives them hands on experience of probability and therefore a greater chance of understanding and of retaining what they learn.”

(Darina, Group 3, Reflections)

“Some of the most valuable teaching points I can take from the lesson study on teaching probability are...using as many concrete materials and activities to demonstrate the different concepts as possible.” (Marian, Group3, Reflections)

4.6.3 Real Life Examples

Development in this perspective was particularly apparent in the case of group 1. They had issues choosing a context for their problem initially. They realised that it was important to have some real life examples for students and eventually changed their problem slightly to suit the example they wanted to use. They chose to represent the problem using a local skyscraper planned for the city. The children really ‘bought’ into this idea, providing the pre-service teachers with a perfect demonstration of how effective using real life examples can be.

“In addition to this, presenting the patterns using a real-life context enhances children’s appreciation for the important role mathematics can and does play within daily life”.

(Group 1, Assignment)

“This reinforced to me how essential it is for teachers to connect subject matter with real life.”

(Kevin, Group 1, Reflection)

4.6.4 Class Discussions

Classroom discussions can play a very important role in student learning, yet Chapin, O’Connor & Canavan Anderson (2009) found that few classrooms consistently or even occasionally display student talk. Therefore the demonstration of the benefits of classroom discussion lesson study provided was important in promoting the use of classroom discussion as a teaching tool.

“We saw in the classroom...through the children’s own discussions...it gave other pupils a chance to see their classmate’s perspectives ...which in turn could help them understand something that they might not have originally grasped....It also allowed us to see the children’s understandings and interpretations of concepts”

(Grainne, Group 2, Reflection)

“Over the course of the two lessons, I have learned that the class discussion in which these ideas are shared is an important learning experience within the lesson and leads to peer learning, as it fosters an awareness of alternative strategies that could be employed in dealing with the problem.”

(Helen, Group 1, Reflection)

4.6.5 Discovery Learning

In the group discussions before the first teaching of the lesson several of the pre-service teachers admitted that they often had difficulty letting their students figure out the answer for themselves. They didn’t like to see the students struggling to find an answer. However lesson study showed the pre-service teachers the benefits of letting the students self-discover. As mentioned earlier it also showed the pre-service teachers that persistence and carefully structured questioning are vital in effectively facilitating discovery learning.

“From carrying out this lesson study I have learned that it is very worthwhile to...give them the resources to find the answers for themselves rather than merely telling the class the answers.”

(Valerie, Group 4, Reflection)

“This showed the value of allowing the children to figure it out for themselves. This is an element that should be very prominent in my future teaching as this lesson, in particular, showed its value.”

(Nathan, Group 5, Reflection)

4.6.6 Activity-Based Learning

Similarly, to the case of discovery learning the pre-service teachers' beliefs regarding activity-based learning were also strongly reinforced throughout the lesson study process. The students in both schools were motivated by the activities the pre-service teachers included in their lessons. They were enthusiastic to get involved in activities that didn't involve doing sums from a book.

“This lesson study taught me a lot about teaching in general... I will try and veer away from using the textbook all the time and try and let the class self-discover”. (Anne, Group1, Reflection)

“Throughout this process, I have uncovered the value that practical hands-on activities can have and how they can benefit the students learning.” (Pia, Group 4, Reflection)

4.6.7 Feedback

The importance of providing the students with effective feedback was noted by the pre-service teachers. In particular the pre-service teachers made reference to this when discussing how they could effectively facilitate classroom discussion and pair work.

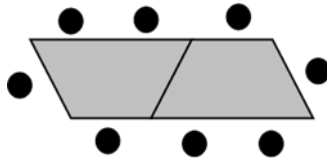
“The lesson study process highlighted for me the effectiveness of feedback”
(Jack, Group 2, Reflection)

4.7 Improving Pedagogical and Content Knowledge

Previous studies have found that lesson study has the potential to support the development of mathematical knowledge (Corcoran and Pepperell 2011; Leavy 2010). These findings were echoed in this investigation. Twenty two (out of the twenty five) pre-service teachers completed pre and post lesson study questionnaires examining their content knowledge of the topics being taught during lesson study. Nineteen out of the twenty two pre-service teachers who completed the questionnaires scored better in the post-lesson study questionnaires than they did in the pre-lesson study questionnaires. Several examples of the questions are included to illustrate the growth in the pre-service teachers' content knowledge.

One group, containing five pre-service teachers taught Algebra during the lesson study cycle. They received six readings from the mentors to help them develop their content and pedagogical knowledge for this topic. Four out of the five algebra group members scored better in the post lesson study questionnaire, on the algebra questions (Figure 4.1 and Figure 4.2), than they did in the pre lesson study questionnaire. The following were the two algebraic questions that appeared in both the pre and post lesson study questionnaires:

ITEM 10 Table and Chairs Problem: Mrs Chen got new trapezoid shaped tables for the canteen. She decided she would place the chairs around each table so that 2 chairs will go on the long side of the trapezoid and one chair on every other side of the table. This way 5 students can sit around 1 table. Then she found that she could



join 2 tables like this:

Now 8 students can sit around 2 tables.

- How many students can sit around 3 tables joined this way?
- How many students can sit around 56 tables?
- What is the rule?

Figure 4.1: Item 10 – Algebra Question from the Content Knowledge Questionnaire

ITEM 11 Crossing the River: A group of 8 adults and 2 children need to cross a river. A small boat is available that can hold 1 adult, or 1 child, or 2 children.

Everyone can row the boat.

- How many one-way trips does it take for them all to cross the river?
- Can you find a rule that will allow you to predict the number of one-way trips for any number of adults and two children?

Figure 4.2: Item 11 – Algebra Question from the Content Knowledge Questionnaire

There were four groups (five pre-service teachers in each group) who were each teaching a particular concept of probability. These groups were given four readings relating to probability and the teaching of probability by the mentors. Out of those 20 pre-service teachers 17 of them completed both the pre and post lesson study questionnaires. Of those 17 who completed both, 11 group members scored better in the post lesson study questionnaire, on the probability questions than they did in the pre lesson study questionnaire. Figure 4.3 and Figure 4.4 are a sample of two of the questions (the rest of which can be found in Appendix M) that appeared in both the pre and post lesson study questionnaires.

ITEM 6 Probability Measurement:

a. Which of the following is the most likely result of five flips of a fair coin?

i.) HHHTT
 ii.) THHTH
 iii.) THTTT
 iv.) HTHTH
 v.) All four Sequences are equally likely

Why? _____

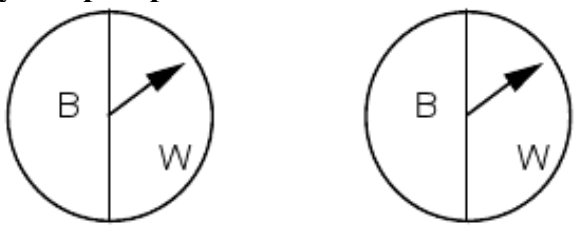
b. Which of the following sequences is the least likely to occur?

i.) HHHTT
 ii.) THHTH
 iii.) THTTT
 iv.) HTHTH
 v.) All four Sequences are equally likely

Why? _____

Figure 4.3: Item 6 – Probability Question from the Content Knowledge Questionnaire

ITEM 9 Probability Sample Space:



The two fair spinners above are part of a carnival game. A player wins a prize only when both arrows land on black after each spinner has been spun once. Jeff thinks he has a 50-50 chance of winning. Do you agree?

Yes No

Why? _____

Figure 4.4: Item 9 –Probability Question from the Content Knowledge Questionnaire

Evidence of improved content knowledge was also demonstrated in the ‘research’ lessons. For example, Ryan described how during lesson study he learned that there were more chances of rolling a seven than a two when rolling two dice. He was subsequently able to use this knowledge to recognise this gap in his students’ understanding.

“They [the students] couldn’t make the connection, as I couldn’t before teaching it, that there are more ways of making seven than two, thus the chances of rolling a seven are greater than the chances of rolling a two.”

(Ryan, Group 4, Reflections)

The pre-service teachers also remarked on the improvements they noticed in their content knowledge in their reflections and presentations. Indeed one of the pre-service teachers who had chosen mathematics as his Arts subject said the lesson study process had helped him become more knowledgeable for his Arts subject.

“Probability is my weakest subject and I have actually learned so much for my academic subject [mathematics] from the probability that we have learned [through lesson study].”

(Lorcan, Group 5, Presentation)

“Prior to this lesson study, I had a false interpretation of the concept of random.”

(Grainne, Group 2, Reflection)

The pre-service teachers demonstrated similar improvements in their pedagogical knowledge regarding the topics they were teaching. For example, members of group two in their first lesson believed that definite and impossible could be placed at either end of a spectrum. However the mentors quickly informed them that it was important that ‘impossible’ was placed to the left and that ‘definite’ should be placed to the right, to make the connection with their representation on a number line. Their second lesson and their reflections revealed the changes in their knowledge.

“If you were to place numerical percentage values on these words impossible would be 0 and definite would be 100 due to this alone it stands to reason that impossible would go at the beginning, as would 0 if it were on a number line and same vice versa.”

(Tracy, Group 2, Reflection)

Evidence of teacher pedagogical knowledge growth such as this was obtained from all the data sources. Lesson study, by its very nature requires intense planning before the lesson is taught and although this level of planning may be excessive in terms of everyday teaching, the experience provided valuable insights for the pre-service teachers into the importance of good planning. In the following paragraphs different aspects of pedagogical planning which were emphasised during the lesson study process will be discussed.

4.7.1 Context

The importance of using a context in the teaching of mathematics is strongly encouraged in the mathematics primary school curriculum. The primary school teaching

guidelines state that “for children to really understand mathematics they must see it in context” (Department of Education and Science, 1999). The need to use a context to explore their mathematical concepts was something which most of the groups recognised at the beginning of the lesson study process and lesson study served to strengthen those beliefs.

“Building a context in which to present the content...became more significant in our theory of teaching and learning as we progressed through the planning and preparation stage of the project.

(Group 3, Assignment)

However the contexts originally chosen by three of the groups were not age appropriate or meaningful for a fifth class group, for example one group had chosen the fairy tale, Goldilocks and the Three Bears, as the context for their lesson. This issue was flagged by the mentors in the initial group meeting and the groups subsequently changed their contexts. These changes were then proven to be very successful in the subsequent teaching of the lessons, in particular for groups two and five. Group two elected to show a video clip of the TV programme, Top Gear rather than the fairy tale context they had originally chosen and it was “through the medium of the clip the students were engaged with the lesson from the onset” (Claire, Group 2, Reflection). Group five felt that their context, Caine’s arcade, “was the ribbon that tied the whole lesson together.” (Group 5, Presentations) In their meeting after the first teaching of the lesson, all of the pre-service teachers remarked how important their context had been in immediately sparking the students’ attention and engaging them in the lesson.

“The children really engaged with the context of the lesson... This helped to grab and sustain their interest through the lesson. It meant they became invested in the lesson and they were enthusiastic about the lesson.”

(Bernadette, Group 3, Reflection)

“I feel that is a very important part about teaching in general, you have to have the appropriate context and relatedness for the class... as you have to get the children interested in Maths as there is that stigma towards it recently.”

(Anne, Group 1, Reflection)

4.7.2 Terminology

Terminology or language was an aspect of their teaching that many of the groups overlooked in their lesson planning. This meant that several difficulties arose with respect to terminology during the first lessons. In the meetings after the first lesson the mentors

discussed the importance of using precise language with the pre-service teachers. The pre-service teachers' reflections following these meetings illustrated the main issues identified:

- Using precise language when introducing or explaining new concepts – “During the lesson study, the emphasis on accurate use of language presented itself as fundamental.” (Orla, Group 1, Reflection)
- Keeping a consistency in the language used throughout the lesson – “Something I learned early on in the first teaching of the lesson, was the importance of continuity and clarity of language” (Helen, Group 1, Reflection)
- Using precise language in student questioning – “Precision of language is also critical, as clarity within the questioning ensures that pupils are aware of what they are being asked.” (Orla, Group 1, Reflection)
- Ensuring fundamental language is understood before continuing – “In terms of teaching maths from lesson study I know the importance of first clarifying the language being used before moving into the mathematical concepts involved.” (Bernadette, Group 3, Reflection)

These issues were dealt with in the subsequent lessons and acknowledged in the presentations and interviews following the lesson study cycle. The pre-service teachers highlighted language as an aspect of their teaching which they would give more attention to in future.

“After the first lesson we noted the importance of using precise language in our future teaching” (Group 4, Group Presentations)

“I suppose one way even, if you're planning on explaining something, just to talk it through. A general thing from that is if you could bounce ideas of someone else or run through a confusing definition” (Helen, Group 1, Interview)

4.7.3 Choice of Representations

The importance of representations became very apparent for several of the groups during the lesson study process. Group one found that their representation of their opening problem caused difficulties in understanding for their students.

“Our representation of the first problem was not very well thought out... This exemplified to me, how representation can sometimes act as an obstacle to children...” (Helen, Group 1, Reflection)

They used the symbol 'x' to represent the variable in their expression. As the expression also included multiplication the two x's caused confusion for the students.

“I felt that if we were teaching it again I would tell the children to come up with a different variable other than x , as this can lead children into confusion between the letter x and the multiplication sign.”

(Kevin, Group 1, Reflections)

However they showed the benefit of good representation with their second problem where their representation of the problem in two stages helped their students’ understanding of what was happening and hence how they could approach it.

“The manner in which we visually represented the rectangular table problem had an influence on the strategies some of the children employed to find the formula”.

(Helen, Group 1, Reflection)

Group five also experienced the successful use of representation in guiding students toward what they described as the ‘Aha moment’ of their lesson. This highlighted for them the importance of representation, something which they had spent time discussing in their group meetings.

“It was only after our meetings and our group discussion that we kind of settled on having them [pie charts] and they were actually one of the best illustrations of the law of large numbers in the end”

(Group 5, Group Presentations)

Group four had similar success when they introduced the fraction wall as a visual aid to help their students in their second lesson.

“We added the use of a fraction wall which highly aided the students’ understanding of where each of the fractions should be placed on the continuum”

(Pia, Group 4, Reflection)

4.7.4 Anticipating Student Responses

In the planning phase of lesson study particular attention is paid to anticipating student responses to enable teachers to be better prepared to deal with issues that might arise during the course of the lesson (Fernandez and Yoshida, 2004). Although many of the Japanese teachers involved in lesson study are able to “draw on their past experiences” and “observations of their current students” (Fernandez and Yoshida 2004, p. 7) to anticipate student responses, the pre-service teachers relied on the experience of the mentors, readings they received from the mentors and research they undertook themselves to help them to anticipate student responses. Anticipating student responses allowed the pre-service teachers deal effectively with misunderstandings which occurred during the lesson. One example of this was in the algebra lesson where a student wrongly identified the algebraic pattern the class were working on. The teacher, whose lesson study group had prepared for this error,

was able to guide the student to finding the correct algebraic pattern using suitable manipulatives. The teacher later commented that knowing this error might arise meant she had a solution ready and this helped maintain the flow of the lesson and gave her confidence. The pre-service teachers also recognised the importance of anticipating student responses or misconceptions so they could have different strategies prepared for students who couldn't grasp a concept.

“First of all it enabled us to identify any misconceptions...How would we rephrase it if pupils still did not grasp what they were being asked?”

(Helen, Group 1, Reflection)

“College level maths is so different. Misconceptions was really where I concentrated on, where people can go wrong, if I wasn't getting that thing wrong myself...I had to stop and say well what if someone does how can I work with that.”

(Ben, Group 5, Interview)

“You do need to think...if there's something really basic or foundational that they need to understand before you move on like...do you have other strategies or other examples or other activities you could do with them. Like other ways of showing them.”

(Sophie, Group 5, Interview)

“From our readings we discovered that it's easier to analyse and generalise patterns that are constructed to look like recognisable figures”

(Group 1, Presentation)

“Pie charts proved to be one of the best illustrations of the law of large numbers in the end”

(Ben, Group 5, Interview)

“Recursive thinking is induced as pupils read the table vertically rather than focusing on the horizontal relationship between the step number and the output”.

(Helen, Group 1, Reflection)

“I know feel that I have learned some key strategies for the teaching of probability, and not only learned them but witnessed firsthand that they are effective for children's learning.”

(Ryan, Group 4, Reflection)

“Adopting the 5E learning cycle model (engage, explore, explain, elaborate and evaluate) could prove to be very beneficial in the teacher instruction of mathematics...I never thought about approaching mathematics in such a manner but I will definitely incorporate this in my future teaching.”

(Claire, Group 2, Reflection)

4.7.5 Research

Research is another important element in the lesson study process and this was reflected in the lesson study cycle carried out in this study. It was particularly important for the pre-service teachers in this lesson study as they did not have “past experiences” or “observations of current students” (Fernandez and Yoshida, 2004) to inform their planning. Although some of the improvements in content and pedagogical knowledge developed through instruction from the mentors, the research materials provided by the mentors and the research the pre-service teachers undertook themselves also played a key role. The pre-service teachers recognised the importance of the research in their reflections.

“Undoubtedly my understanding of the topic...developed immensely throughout the course of the lesson study project...there were a number of reasons for this, the first being that I undertook some reading on the topic from some of the material provided in lectures.”

(Donal, Group 3, Reflections)

“In researching the strategies associated with making and expressing generalisations, I was simultaneously engaging in the processes of learning and learning how to teach.”

(Helen, Group 1, Reflections)

“I felt that the readings we were given at the start of the course were vital in furthering my understanding of algebraic reasoning.”

(Andy, Group 1, Reflections)

4.7.6 Confidence

As a consequence of their research, and subsequently their improved content and pedagogical knowledge the pre-service teachers now feel more confident about teaching the same topics again in the future.

“Now through creating the activities and the lesson with my group it has made me more confident about teaching probability.”

(Darina, Group 3, Reflections)

“Having now completed lesson study I feel this understanding has improved to the point whereby I would now be confident in teaching probability in the primary school classroom.”

(Donal, Group 2, Reflections)

“As more and more research was done in preparation of the lesson during the lesson study process, I felt that I was now more comfortable with the content and concepts of algebra required.”

(Mark, Group 1, Reflections)

This is despite the fact that many of the pre-service teachers had reservations about teaching the topics in the beginning.

“On my teaching practices this was a topic which I refrained from teaching...as I was not sure of what approaches to take whilst teaching this topic.”

(Evan, Group 4, Reflection)

“When we were given the topic...I was a bit apprehensive.”

(Grainne, Group 1, Reflection)

“The idea of probability daunted me. In hindsight, I think that this was because it was a strand unit of which I simply did not have much experience with. Colloquial phrases surrounding chance baffled me. For example, I always wondered why a fat chance was the same thing as a slim chance.”

(Orla, Group 3, Reflection)

4.8 Collaboration and Sharing of Ideas

Collaboration plays a central role in all stages of the lesson study cycle. Cohan and Honigsfeld (2007) have previously found “that collaboration and dialogues about teaching greatly benefit preservice teachers” (p.87). This study echoed these findings even though at times the pre-service teachers found working as a group difficult and there were a few complaints about unequal work distribution. However, overall the pre-service teachers were very positive and enthusiastic about the collaboration and sharing of ideas. In particular they liked the sharing of ideas about teaching, having others to problem solve with, having different perspectives and the feeling of inclusion as opposed to the isolation sometimes experienced in teaching.

“It was a unique experience to share my observations among a group, gain feedback and also respond to aspects of the lesson which they liked or were not happy with.”

(Colm, Group 5, Reflection)

“Often watching someone else teach offers the best form of learning. I was enabled to discover new ideas and techniques for teaching maths while watching Nadia teach such as, how effective persistence with a topic can be.”

(Pia, Group 4, Reflection)

“When you’ve five opinions it makes things so much easier, five ideas.”

(Orla, Group 3, Interview)

“From lesson study I also learnt the importance of teacher’s collaborating together. As we have all learnt from teaching practice, preparation for teaching can be an often lonely place as it is a very solo job by its nature...Lesson study has thought (taught) me that in terms of teaching I think it is important that as teachers we do talk to each other more and collaborate to ensure that we are not as isolated as we can sometimes feel.”

(Bernadette, Group 3, Reflection)

“We had five in our group. The first time we met up we had five different ideas. Then kind of bring it together and pick and choose bits and pieces, what will work, what might not work.”

(Group 1, Group Presentations)

“Like we got very stuck on what to do when they said we needed a context...until one of the lads said oh what if we just...could we not change it to $4x+1$ and I don’t think I would ever have thought of that”

(Helen, Group 1, Interview)

4.9 Important Role of the Mentor in the Lesson Study Process

The role of the mentor was hugely important throughout the lesson study process. The pre-service teachers had already been taught the importance of the objectives, the lesson introduction and the lesson conclusion numerous times during their initial teacher training. However as this was not reflected in their draft lesson plans the mentors highlighted those aspects as areas that needed more attention. Then during the course of the lesson study process the pre-service teachers began to see how these components of teaching that they were overlooking affected the overall success of their lesson. In their reflections and their presentations the pre-service teachers regularly acknowledged the guidance from the mentors.

“The advice and ideas which we received [from the mentors] were certainly applied to the lesson which ensured a well-structured and student friendly lesson.”

(Evan, Group 4, Reflection)

“The initial feedback we received from lecturers recommended the establishment of a realistic context”.

(Group 2, Assignment)

“From our meetings with the maths team I learnt the importance of prediction when carrying out probability games.”

(Bernadette, Group 3, Reflection)

“The most useful thing that I have taken from lesson study...was the importance and value of activities... This became evident after the first lesson, brought to our attention by the maths lecturers.”

(Orla, Group 3, Reflection)

The mentors also provided a critical perspective during the implementation stage. They gave advice to the pre-service teachers on different aspects of their lessons they could improve.

This ‘outside perspective’ was appreciated by the pre-service teachers.

“It was useful to have an outside influence, as we had become so engrossed the lesson, it was difficult to detach ourselves and see it from an objective prospective.”

(Orla, Group 3, Interview)

Finally the pre-service teachers had very little experience of teaching the topics which were taught during lesson study therefore the mentors were invaluable in providing insights into teaching the topic. They were also able to deal with any misunderstandings that the pre-service teachers had regarding their mathematical content knowledge.

Table 4.1: Benefits of Lesson Study in the Context of Pre-Service Teacher Education

PSTs Learned the Importance of Different Components of the Lesson	Improving the Flow of their Lessons	Providing Suitable Challenge for Students	Refining Important Teacher Skills	Reaffirming Beliefs about Teaching Methodologies	Improving Pedagogical and Content Knowledge	
Objectives	Organisation	Catering for All Abilities	Questioning	Group Work	Use of Contexts	
Purpose of the Activities	Decisions about Sequencing		Responding to Students' Ideas	Use of Manipulatives	Incorporation of Research into Teaching	
Introduction	Pacing of Activities		Reflection	Real Life Examples	Improvement in Confidence	
Conclusion					Class Discussion	Choice of Representation
					Discovery Learning	Anticipating Students' Responses
		Activity-Based Learning			Terminology	
Feedback						

4.10 Conclusion

In this study the author sought to explore if incorporating lesson study in initial teacher education could assist pre-service teachers in bridging the theory-practice gap. Evidence outlined in this chapter revealed that implementing the lesson study model as part of the primary pre-service teacher education programme was an effective approach to help pre-service teachers to bridge the theory-practice gap. The pre-service teachers developed several valuable skills; they learned the importance of using a context to engage their students with mathematics and the importance of understanding student thinking and anticipating their responses, they developed valuable instructional techniques and they learned to analyse their lessons in view of learning goals. The qualitative data presented here also provides valuable insights as to what particular features of lesson study contributed to its success and these will be discussed further in the next chapter. Feedback from the pre-service teachers on lesson study was also extremely positive. However it is important to highlight once again that the role of the mentor was pivotal in the success of lesson study in bridging the practice-theory gap. They played a vital role in instructing and guiding the pre-service teachers throughout the learning process. Therefore implementing a lesson study approach, with the necessary support, in initial teacher education has the potential to help pre-service teachers bridge the theory-practice gap and become better teachers.

Chapter 5: Discussion

5.1 Introduction

In the last chapter the results of the study were outlined. The main findings were:

- The lesson study model proved to be an effective approach in supporting the pre-service teachers in bridging the theory-practice gap.
- The mentors played a vital role in the success of the lesson study model, in supporting the pre-service teachers to bridge the theory-practice gap.
- During the lesson study process the pre-service teachers experienced a shift in values, they began to judge the success of their lessons in terms of student learning rather than teacher activity.

The shift in values the pre-service teachers experienced mirrors the findings of Sims & Walsh (2009) who found that through lesson study pre-service teachers learned to think more deeply about learning goals and began to analyse the success of their own lessons in terms of these learning goals. Hiebert et al. (2007) suggest

“that assessing whether students achieve clear learning goals and specifying how and why instruction did or did not affect this achievement lies at the heart of learning to teach from studying teaching.”

(p.48)

Given these results it appears that the lesson study model has succeeded, within the modest setting of this study, where other teaching placements have failed. By supporting pre-service teachers to integrate research knowledge and theories acquired in previous teacher education modules into their teaching, lesson study has facilitated the pre-service teachers in bridging the theory-practice gap. In this chapter the author will examine the findings of the study which were particularly surprising and discuss the aspects of lesson study that led to the success of the lesson study model. This will be done by examining how lesson study overcame the factors which have previously contributed to the theory-practice gap using the various conceptualisations of teacher knowledge (outlined in Chapter 2) as a framework.

5.2 Appreciation for the Complexity of Teaching

In previous chapters the author examined the contributory factors of the theory-practice gap and discussed why it is more manifest in education than in other disciplines. It was acknowledged that current initial teacher education practices were not fully taking into consideration the many “interrelated factors” which make teaching such a “complex cultural enterprise” (Leikin & Levav-Waynberg 2007, p. 366). However lesson study has been

praised for its focus on finding solutions to concrete problems that arise in the context of a real classroom. Stigler and Hiebert (1999) recognise that “by attending to teaching as it occurs, lesson study respects teaching’s complex and systemic nature, and so generates knowledge that is immediately usable” (p122). This approach proved more effective than the traditional approach adopted in initial teacher education in which pre-service teachers are expected “to take knowledge gained in one context and translate it into the messy and complex world of the classroom” (Stigler and Hiebert 1999, p.122). Lesson study gave the pre-service teachers the opportunity to examine practical problems they encountered in real contexts with respect to various aspects of their teaching, such as classroom organisation, pacing of activities and decisions about sequencing. These issues were then closely analysed in the post-lesson meetings where the observations of the pre-service teachers were supplemented with insights and theoretical notions from the mentors. Korthagen (2010) considers this provision of theoretical notions to be a very important competency of any pre-service teacher mentor. This feature [post-lesson analysis] of lesson study allowed for provision of knowledge about the best teaching strategies at the critical time. The positives of receiving knowledge about teaching at the right time have been previously identified by Long et al (2012). They found that pre-service teachers liked to “come back to topics already discussed when the time was right” (p632). This concept of “timeliness” was facilitated by both the analytic nature of lesson study and constant collaboration, another feature of the lesson study model. An added benefit afforded by the lesson study model was that the pre-service teachers had an opportunity to reteach the same lesson again to a new group of students. This allowed them to experience the benefits of the new strategies they had gained in the discussions after the first lesson.

However, during the course of this study it was noted that the pre-service teachers were not always able to recognise the issues that were hindering the success of their lessons. At various times it was necessary for the mentors to highlight certain issues that the pre-service teachers were overlooking. This need for an objective perspective in the analysis of teaching was frequently acknowledged by the pre-service teachers but is also recognised in the research. Sims and Walsh (2009) found that “teachers – especially new teachers – require support to direct their attention to the salient features and to talk about the details of classroom practice” (p.728). Lewis and Tsuchida (1998) reported that teachers engaging in lesson study, who they interviewed thought that “the comments from other teachers helped them to see things about their teaching that might otherwise have escaped them” (p. 15). Perry, Tucher and Lewis (2003) propose that the diverse interpretations of classroom events,

facilitated by the lesson study process, provide rich opportunities for the development of understandings about teaching and learning. Similarly, the results of this study also showed the value of having another perspective, be it the mentors or their peers.

Despite the considerable support for the provision of opportunities to be observed and get feedback from another perspective, this is not the norm in current practice. Conway et al (2011) found that pre-service teachers on teaching practice have relatively few opportunities to be observed by their cooperating teachers and that such mentoring practices are often lacking. Furthermore Korthagen (2010) has highlighted that mentoring practices, such as those described in this study, would require the mentor to be “competent at promoting further awareness and reflection in student teachers” (p.418), something for which cooperating teachers in Irish schools currently receive no training. This means that although this was a successful approach for this small group of students, provision of mentoring at this level to the whole cohort (in excess of 450) of pre-service teachers would be difficult. However other aspects of lesson study also helped to alleviate problems that the pre-service teachers had previously encountered on school placement, regarding the complexity of teaching. These included; the focus on problems which arose for the pre-service teachers in a real context and the collaborative nature of lesson study.

5.3 Observation at the Heart of Pre-service Teacher Development

Just as the opportunity to be observed by the mentors was important, the pre-service teachers also benefitted from the opportunity to observe each other. In the literature review the author examined issues that arose due to the ‘apprenticeship of observation’ (Lortie, 1975) all pre-service teachers experience before entering the teaching profession. This ‘apprenticeship of observation’ illustrates how pre-service teachers develop preconceptions regarding teaching through observation of their teachers while the pre-service teachers themselves were still in school. It was then discussed how these preconceptions that pre-service teachers have on entering the teacher education programme can inhibit what they can learn during initial teacher education. Furthermore, Cheng et al (2010) proposed that this ‘apprenticeship of observation’ continues during their teacher education programme and that observation of good practice can positively affect their teaching. This raises several issues with current practice on school placements;

1. Studies have revealed that pre-service teachers have few opportunities to observe experienced teachers during teaching practice (Conway et al, 2011; Gilleece et al, 2009).
2. Pre-service teachers “often encounter a very different approach to teaching and learning in their field experiences” from those considered best practice (Morrison and Marshall 2003, p293).

However several features of the lesson study model helped to alleviate these issues for the pre-service teachers. During the lesson study process all the pre-service teachers got a chance to observe a lesson being taught at least once. Opportunity to observe teaching and learning is considered a vital aspect in gaining teaching expertise (Hiebert et al, 2007). Indeed, many of the pre-service teachers insights into best practice came from observations they made through watching their fellow pre-service teachers teaching the lesson.

“Often watching someone else teach offers the best form of learning. I was enabled to discover new ideas and techniques for teaching maths.”

(Pia, Group 4, Reflection)

Through careful guidance from the mentors, improvements made from the first to the second lesson gave the pre-service teachers opportunities to experience the value of the best teaching strategies, they had been taught about during their teacher education programme. This finding that observation or exposure to best practice was imperative in the pre-service teachers’ decision to adopt best strategies permeated the results from all data sources. This emphasises again the importance of how the theory regarding best teaching strategies is delivered to pre-service teachers. Hiebert et al (2002) recommend that “knowledge for teaching is most useful when it is represented through theories with examples” (p.7). They believe that representing knowledge for teaching, for pre-service teachers, through real life experiences is important so as to “keep the theories grounded in practice and reveal the meaning of verbal propositions” (Hiebert et al 2002, p.7). These opportunities to closely analyse practice were particularly valuable in strengthening views that the pre-service teachers already held about teaching.

Lewis and Tsuchida (1998) suggest that lesson study also provides opportunities for teachers to develop views on teaching which they might not have acquired during their teaching programme.

“Research lessons bring together teachers from the whole spectrum of viewpoints. It seems likely that the more frequently different educational philosophies come into contact the more

likely teachers are to notice the strengths of approaches that are different from their own and modify their practice.”

(Lewis and Tsuchida 1998, p. 17)

Ben expressed similar views in his interview when he was discussing why some pre-service teachers may not adopt the best teaching strategies despite knowing the theory that supports them:

“People need to be convinced really. They’re not going to change their ways unless they can see the benefits”

(Ben, Group 5, Interview)

In this study the collaborative nature of lesson study played an important role in the pre-service teachers’ exposure to new ideas and philosophies.

The sort of collaboration experienced by the pre-service teachers during lesson study is in marked distinction to the feeling of isolation often experienced by pre-service teachers on school placements (Long et al, 2012), a finding which was strongly portrayed in the pre-service teachers reflections. This represents a positive shift in practice as learning to teach in isolation has been found to be “a constraining factor in becoming a competent teacher (Conway, 2011). On the contrary collaboration in teaching has been repeatedly vaunted as having the potential to seriously improve both teaching and learning.

“Collaboration includes continuing interactions about effective teaching methods plus observations of one another’s classrooms. These activities help teachers reflect on their own practice and identify things that can be improved.”

(Stigler and Hiebert 1999, p.124)

Lewis and Tsuchida (1998) believe that collaborating during lesson study: “is a source of feedback and of new techniques”, “a chance to think through problems and question other teachers” and an opportunity for “exploring conflicting ideas” (pp. 15,16).

5.4 Collaboration as a Pathway to Pre-service Teacher Growth

The collaborative nature of lesson study also has the potential to help pre-service teachers cope with a phenomenon known as “transition shock”. “Transition shock” is a term coined to describe the tendency of newly qualified teachers and pre-service teachers to abandon university theory and emulate the practice of teachers around them in an attempt to fit in (Korthagen, 2010). Long et al (2010) found that novice teachers “can be unsure about ideas that are not mediated in the school practice site” and “can easily be persuaded to leave not only theory but novelty aside” (p361). This is particularly worrying at a time when pre-

service teachers are being encouraged in their teacher education programme to swap the traditional approaches to teaching for more constructivist approaches.

However in this lesson study experience the pre-service teachers were collaborating with their peers most of whom had similar approaches to teaching and the mentors who are lecturers on the teacher education programme. This created a supportive environment where they were encouraged to try out the constructivist methodologies and hence experience the benefits of them first-hand. Opportunities to become practiced and confident in these teaching methodologies is very important particularly if the pre-service teachers have come from education where the teaching methodologies used were qualitatively different from how they are being asked to teach (Corcoran, 2005). The supportive, safe environment provided by lesson study led to the strengthening of the pre-service teachers' previously held beliefs regarding particular teaching methodologies, as outlined in the results. This is an important finding as the teaching methodologies and theoretical perspectives of pre-service teachers are categorised in the foundation knowledge category of Rowland's knowledge quartet and dimensions of this category are considered the foundation on which the other categories of teacher knowledge are built (Rowland et al, 2005).

These findings therefore have implications for the support provided to newly qualified teachers. It suggests that providing lesson study groups for newly qualified teachers similar to those provided in Japan, where newly qualified teachers form lesson study groups with other newly qualified teachers in the district, could be effective in counteracting the 'transition shock'. Having support from similarly minded teachers reduces the risk of newly qualified teachers being persuaded to abandon university theory and emulate the teachers around them. Particularly as "opportunities for deep professional engagement" such as those experienced during lesson study are extremely rare in initial teacher education according to the recent OECD's Talis study (Conway et al 2011, p. 11).

5.5 Intertwining Theory with Practice

Lesson study also provides an experience where theory and practice are treated as tightly intertwined entities. This differs from current practice in initial teacher education in which theory and practice are treated as separate entities. Teacher education courses are generally divided into two complementary parts: "the university experience with tutorials, lectures and workshops and the school placement experience" (Long et al, 2012, p. 620). However several issues have been raised with such practices:

- According to Long et al. (2012) some pre-service teachers find themselves on teaching practice “in schools where these support structures are minimal and so there is a lack of uniformity across the spectrum” (p620).
- Conway et al (2013) have found that “more often than not, work rather than learning appears to be the leading activity in schools during initial teacher education” (p. 35).
- Morrison and Marshall (2003) state that theory being learned in universities is not being reinforced during their teaching placements.

This has several consequences for pre-service teachers, namely it makes it difficult for them to present themselves as learners in their teaching placement schools. However lesson study provided an experience which differs from those teaching placements in numerous ways, each which will be looked at in more detail in the following sections:

- Lesson study provided the pre-service teachers with a safe environment to analyse their teaching. “Lesson study has stemmed from a culture where self-critical reflection – is emphasised and esteemed” (Lewis and Tsuchida 1998, p.51).
- The lesson study structure ensured that there was a firm emphasis on the pre-service teachers as learners throughout the process.
- The mentors provided a constant link between theory and practice.

5.5.1 Learning to Teach in a Safe Environment

Previous studies of teaching placements have found that pre-service teachers take “observation to be the equivalent to exposing themselves to potential weakness which they did not want to admit in public” (Long et al 2012, p. 630). This ‘dislike’ or ‘fear’ of observation was something frequently alluded to in the reflections and interviews of the pre-service teachers in this study. In lesson study however, a critique is typically not focused on an individual as the

“collaborative nature of lesson study balances the self-critiquing of individual teachers with the idea that improved teaching is a joint process, not the province or responsibility of any individual.”

(Stigler and Hiebert 1999, pp. 124-125)

The “collaborative planning of research lessons means that criticism is generally shared with several colleagues” (Lewis and Tsuchida 1998, p. 51) or in the case of this study between a group of five pre-service teachers and three mentors. Indeed it was this idea of shared responsibility that the pre-service teachers felt created a feeling of safety about revealing the weaknesses they felt the lesson had.

“They [the mentors] made it clear from the start that if it doesn’t go well, the fault isn’t on anyone in particular, we [the group members and the mentors] all need to work together to make it better” (Helen, Group 1, Interview)

5.5.2 Emphasis on the Improvement of Teaching and Learning

The focus lesson study places on the improvement of teaching and learning rather than on the individual had several interesting repercussions for the development of the pre-service teachers during the study. It gave them a feeling of freedom which enabled them to participate in the most open and honest reflection on their teaching they had ever engaged in. The added impetus of knowing they had to teach the lesson again also meant that they paid more attention to the subtle details which could potentially improve their lesson. Along with developing the ability of pre-service teachers to research, Kellaghan (2004) also advocates the development of pre-service teachers’ abilities to reflect:

“All we can be certain about is that the future is uncertain. This means that some of the skills and knowledge that students acquire today may be largely irrelevant in the future. To address this situation, students should be provided with a solid base for keeping abreast of new developments (e.g., developing habits of enquiry and reading) and with opportunities for problem-solving and reflection in the hope that they will be adaptable, questioning, critical, inventive, creative and reflective.”

(p.23)

Given the emphasis initial teacher education places on pre-service teacher reflection it was not expected that the pre-service teachers would have had such a negative impressions of previous forms of reflection or that they would respond so favourably to the reflection facilitated by lesson study.

“It’s [reflection] more about giving the supervisor what they want than actually doing any sort of genuine reflection.” (Sophie, Group5, Interview)

“For this [false reflection] to change the structure would need to change, the students [pre-service teachers] are reacting to the system.” (Sophie, Group 5 Interview)

Reflections from the pre-service teachers such as these, raises serious questions about the current system of teaching placement in initial teacher education. The pre-service teachers’ comments imply a serious power imbalance between the supervisor and the pre-service teacher that is potentially having a negative impact on the pre-service teachers’ opportunity to

learn. The nature of the relationship between pre-service teacher and the mentors in the lesson study process was completely different due to the shared responsibility of both parties for the lesson study. The pre-service teachers were more welcoming of feedback from the mentors because they felt it was focused on the lesson rather than the individual.

“It kind of takes the focus away from that [the individual teaching] and just on what’s the best way to teach this lesson.” (Sophie, Group 5, Interview)

The attitude of the pre-service teachers suggests that they took the advice of the mentors by choice rather than feeling they had to. This was demonstrated by their attitude that if something is wrong with the lesson then you “couldn’t not do something about it” (Ben, Group5, Interview) if you were going to teach the lesson again. They chose to change the lesson to improve teaching and learning rather than changing it to please the mentors.

5.5.3 Availability of Relevant Research

The mentors also provided a link between the theory and practice of teaching throughout the lesson study process. This proved to be particularly important in the development of the pre-service teachers’ pedagogical and content knowledge. The readings provided by the mentors played a significant role in the pre-service teachers understanding of issues that arose during their teaching. This was clear from both the reflections of the pre-service teachers, the pre-service teachers lesson plans and the discussions during their group meetings where they frequently referred to the pedagogical insights they gained from the materials the mentors had provided. Availability of relevant research was deemed very important by the pre-service teachers in the development of their pedagogical knowledge and contrasted with the experiences the pre-service teachers had on prior teaching placements:

“You don’t really know where to go, so a lot of the time that you are researching is kind of wasted, typing random things into Google and hoping something comes up. So at the end of the day you might have very little to show for the time that you put into research”

(Helen, Group 1, Interview)

This provision of relevant research by the mentors ensured that the factors often contributing to the theory-practice gap; lack of awareness of effective research (Spencer and Logan, 2003) and the research audience for research being primarily other researchers (Klein, 1992) were avoided.

It was the availability of this relevant research that allowed the pre-service teachers to make significant growth in their pedagogical knowledge. The pre-service teachers demonstrated growth particularly in the pedagogical dimensions categorised in the transformation and contingency dimensions of the knowledge quartet (Rowland et al, 2009).

One dimension where they demonstrated major improvement was choice of representation. In the latter weeks of the lesson study process their actions in the classroom, their reflections, their discussions in the group meetings and their presentations indicated sophisticated decision making regarding choice of representations which were not present in the initial weeks of lesson planning. The extent of growth in pre-service teachers' pedagogical knowledge during the lesson study process was one of the most surprising findings. The pre-service teachers even demonstrated proficiency in areas where pre-service teachers have been previously found to be lacking such as anticipating student responses and thoughtful questioning (Burroughs and Luebeck, 2010; Sims and Walsh, 2009). This indicated a mathematical knowledge which Ball et al, (2005) consider to be “‘specialized’ to the work of teaching that only teachers need to know” (p. 22). The readings and feedback from the mentors were instrumental in developing various aspects of this ‘specialized’ pedagogical including:

“understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of the most frequently taught topics”

(Shulman 1986, p 9)

This showed that although the pre-service teachers might not have had the knowledge themselves before participation in lesson study, the availability of the knowledge during the lesson study process allowed them to design instruction which demonstrated proficient ability to use their newly obtained ‘specialized’ knowledge. Although provision of relevant research is not usually a feature of lesson study, research always plays a major role in lesson study.

5.6 Nature of Knowledge Provision

The availability of theory clearly had a major role to play in the success of the lesson study model in helping the pre-service teachers bridge the theory-practice gap. However the type of knowledge being provided also had a vital role in its success. In the literature review the type of knowledge being provided was highlighted as being a factor contributing to the theory-practice gap. The knowledge being provided in initial teacher education was criticised for being “abstract, systemised and general expert-knowledge” (Korthagen 2010, p.409). Issues were raised regarding the treatment of theory and practice as separate entities. Pre-service teachers were expected to apply abstract theories, acquired in their teacher education programme, in their teaching placement. This study emphasised the difficulties pre-service

teachers have in this application. The first drafts of their lesson plans and researcher observation from the first lessons showed that the pre-service teachers were struggling to apply knowledge they had previously acquired in their teacher education programme to the particular teaching situations they found themselves in. They were displaying weaknesses in their teaching which are synonymous with teachers starting out in the profession. For example they neglected to pay attention to important components of the lesson such as the lesson objectives, the purpose of activities and the lesson conclusion. Hiebert et al.'s (2007) belief that teachers often find it "tempting to assess teaching effectiveness based on what the teacher does rather than how the students respond" (p. 52) is reflected in comments Sophie made regarding the tendency she had in prior teaching placements to concentrate on surface details and embellishments as opposed to focusing on what is a good lesson for her students. Similarly many of the groups gave little consideration to the lesson conclusion, a component of the lesson which Hunt et al (2009) say "is often neglected by some teachers because they tend to concentrate their attention on the body of the lesson" (p. 70).

However, the lesson study process and the support of the mentors proved particularly effective in alleviating this problem. The group meetings in the planning phase of lesson study proved to be the ideal opportunity to highlight the importance of different components of the lesson. Then in the subsequent lessons the pre-service teachers had the opportunity to witness first-hand the benefit which the increased attention to the various components of the lesson could make to their teaching. The pre-service teachers' reflections and interviews after lesson study showed that lesson study had renewed their focus on these components of the lesson. This was particularly evident with regard to the emphasis they began to place on the importance of learning objectives in the analysis of teaching. The data collected maps a shift in the pre-service teachers focus from the brilliance of the activity the teacher chooses to the actual benefit of the activity in terms of student learning. For example, in their reflections the pre-service teachers recalled prior teaching placements where they chose activities "to be the singing and dancing element in case the supervisor comes into the room" (Sophie, Group 5, Reflection) or simply because they liked the activity. In contrast to this, in their reflections and presentations during lesson study, the pre-service teachers justified the use of activities in terms of its effect on student learning. Hiebert et al (2007) believe that this "shift from focusing on the teacher to focusing on the students represents, by itself, a significant development" and that when teachers begin making "instructional decisions based on each students' learning rather than on their perceptions and expectations" it represents a "move toward more equitable instruction" (p.51, 57). That lesson study could initiate such a shift in

the pre-service teachers focus over such a short space of time was surprising given that the pre-service teachers had carried this belief through numerous teaching placements to their final year of initial teacher education. Given that these pre-service teachers had completed all their required teaching placements before participating in lesson study and that they were still focusing on teacher activity rather than student learning as a gauge of their teaching effectiveness also raises major issues with the current teaching placement system. However it also demonstrates that having support and guidance from the mentors at the appropriate time was paramount to this shift in the pre-service teachers thinking. This highlights, yet again, the notion of ‘timeliness’ identified by Long et al (2012) and recognises that the lesson study model implemented in this study facilitated the provision of support at crucial stages of the pre-service teachers’ learning.

5.7 Conclusion

The findings yielded by this study are very encouraging and both support and are supported by the work of other researchers in the field. The pre-service teachers in this study demonstrated substantial growth in their knowledge and practice of teaching. However, given the small sample size, caution must be applied, as the findings might not be transferable to a larger group. This will be discussed further in the next chapter. In the next chapter the author will also identify the conclusions that can be drawn from the findings of the study and make several recommendations for future study in the field.

Chapter 6: Conclusion and Recommendations

6.1 Introduction

This study set out to examine the theory-practice gap as it exists for pre-service teachers in a third level college of education and to determine if participation in lesson study assists them in bridging the gap. In particular the author sought to answer the following research questions:

In what ways does participation in the lesson study process support pre-service teachers in incorporating research knowledge and the theories acquired in previous teacher education modules into their teaching, hence facilitate them in bridging the theory-practice gap?

What improvements if any could be made to the lesson study model in order to better facilitate the pre-service teachers in bridging this theory-practice gap?

Given the gravity and persistence of the problem, it is imperative that an appropriate solution be found. A case study method of enquiry, as recommended by several researchers (Yin, 2009; Cohen et al, 2007; Swanborn, 2010; Khanzode, 2004), proved a successful approach in addressing and shedding light on these research questions. In this chapter the author summarises the main findings obtained through this case study, discusses implications of these findings, outlines limitations of the study and provides recommendations for further research in this field.

6.2 Summary of Findings

Corresponding to the findings of other researchers in the field of initial teacher education, the presence of a significant theory-practice gap was evident in both the pre-service teachers' lesson planning and implementation prior to the commencement of lesson study. Evidence included: the pre-service teachers' inattention to important structural components of the mathematics lesson, under challenging primary level students, misrepresentation of mathematical concepts and challenges relating to the apparent lack of authentic reflection on practice. Following participation in the lesson study process, the pre-service teachers demonstrated significant development in various aspects of teacher knowledge and practice in the area of mathematics. These included:

- Recognising the importance of key components of the lesson plan.

- Improving aspects of their pedagogical knowledge, particularly knowledge categorised as transformation knowledge and connection knowledge by Rowland (2012) and knowledge categorised as knowledge of content and students and knowledge of content and teaching by Ball et al (2008).
- Advancing their teaching skills for example: questioning, responding to students' ideas, researching and reflection.

These findings provide significant evidence that lesson study has the potential to help pre-service teachers close the theory-practice gap. However the considerable reliance of the pre-service teachers on their mentors during the process raises some issues for future implementation of lesson study in pre-service teacher education.

6.3 Limitations

Although this lesson study experience proved to be successful in helping the pre-service teachers bridge the theory-practice gap there are several barriers to rolling out such a model initial teacher education. As was mentioned previously, throughout the lesson study process the pre-service teachers had an immense reliance on their mentors. The mentors could cope with the immense reliance in this situation as lesson study was undertaken by only a small group of pre-service teachers who had elected to take a curriculum specialisation in mathematics. However in Ireland many teacher educators have to work with large cohorts of pre-service teachers which means that such close personal guidance would not be possible. Korthagen (2010) suggested implementing systems of peer-supported learning when faced with similar issues of 'scaling up'. However given the extent of the pre-service teachers' reliance on the experience and knowledge of the teacher educators in this situation, it suggests that much work would need to be done to set up an effective peer-supported learning system.

6.4 Implications of the Study

Taking into consideration the barriers to rolling out such a model in initial teacher education the author deems it important to acknowledge the prominent features of lesson study that were key to its success. The insights this study gives may provide perspective as to which features of lesson study could potentially improve pre-service teacher learning if

adapted to fit current models of initial teacher education. The crucial features of lesson study identified in this study were:

- Lesson study is embedded in the classroom and allows pre-service teachers to identify and examine issues that arise for them within their practice.
- It provides a network for collaboration with both their peers and subject experts (their mentors). This gives the pre-service teachers an added perspective and helps them to analyse their experiences and interpret them in light of the relevant theory.
- The integral position afforded to research within the lesson study process also helped the pre-service teachers in interpreting their experiences. However it also had a key role to play in the development of the pre-service teachers' content and pedagogical knowledge of mathematics.
- The focus on the improvement of teaching and learning rather than focus on the individual teacher alleviates issues of self-consciousness and allows for a more balanced relationship between mentor and pre-service teacher.

These were the elements of lesson study recognised as having the greatest influence on pre-service teacher development in this study.

6.5 Recommendations for Future Study

This research has thrown up many issues in need of further investigation. Further investigation is needed to establish if a sustainable model of teacher education which incorporates the key features of lesson study can be developed. In the shorter-term more research is needed to establish how current initial teacher education programmes can deal with the serious issues raised pertaining to current practice. The need for an objective perspective in analysing pre-service teacher practice needs to be addressed immediately. This is critical given the lack of guidance some pre-service teachers are receiving in their teaching practice schools (Conway et al, 2011) and the pre-service teachers' apparent inability to recognise issues that are hindering the success of their lessons (as the findings of this study highlighted). Another issue relating to current practice which needs to be addressed promptly is the negative impact power imbalances in the pre-service teacher – supervisor relationship are having on the honesty and authenticity of pre-service teacher reflection. Further research might also explore the feelings of isolation some of the pre-service teachers reported having experienced on previous teaching placements.

6.6 Conclusion

Considering the importance of pre-service teacher education it is encouraging to have found an approach which has resulted in such growth in pre-service teacher knowledge and practice. Despite the fact that such an approach does not seem sustainable on a larger scale this study has identified key features of the model which have the potential to help pre-service teachers bridge the theory-practice gap. This is an important step towards resolving the conundrum of the theory-practice gap. Further encouragement, for supporters of lesson study, can be taken from the recent establishment of the International Journal for Lesson and Learning Studies. This journal “publishes lesson and learning studies that are pedagogically aimed at improving the quality of teaching and learning in formal educational settings” (Emerald, 2013). This provides a forum for the sharing of this novel type of research, which according to Hiebert et al (2002) is crucial in the translation of this type of practitioner knowledge into professional knowledge.

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Appendices

Appendix A

Student Information Sheet

Mary Immaculate College



Research Study Title: How Lesson Study Can Help Students Bridge the Practice-Theory Gap

17/01/2013

Dear Student,

You have selected to participate in a curriculum specialisation in Mathematics Education. As part of this course you will be engaging in Japanese lesson study. I am a Masters student in Mary Immaculate College carrying out a research study on how the lesson study process, you will be participating in as part of your mathematics education module, helps pre-service teachers bridge the practice-theory gap. This means I am looking to see how the lesson study process helps you, to use the knowledge you have gained from research and/or other modules you took during your course, to select the best teaching strategies.

If you agree to participate, your participation would involve filling out of a short questionnaire and participation in a group interview. It would also mean allowing me access to pieces of coursework you produce and permission to include it in my research. However your name will always be protected.

Participation in this study is completely voluntary and you can withdraw your participation at any stage during the study. It will not affect your participation in the module in any way. None of the lectures of the module will know whether or not you agree to participate.

Please complete the permission form on the following page. If you have any further questions regarding the research study you can contact me at claire.carroll@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:

MIREC Administrator
Mary Immaculate College
South Circular Road
Limerick
061-204515
mirec@mic.ul.ie

Yours sincerely,
Claire Carroll

Appendix B

Informed Student Consent Form

Mary Immaculate College



Research Study Title: How Lesson Study Can Help Students Bridge the Practice-Theory Gap

I have read and understood the participant information sheet. I understand what the project is about, and what the results will be used for. I know that my participation is voluntary and that I can withdraw from the project at any stage without giving any reason. I am aware that my results will/will not be kept confidential.

I _____ (*insert name*) agree to participate in this research study and for my work to appear in any research publications which result from this research study.

I _____ (*insert name*) do not agree to participate in this research study and for my work to appear in any research publications which result from this research study.

Signature

Date

Appendix C

Parent / Guardian Information Sheet

Mary Immaculate College



Research Study Title: How Lesson Study Can Help Students Bridge the Practice-Theory Gap

Dear parent/guardian,

The mathematics education faculty at Mary Immaculate College are involved in teaching a curriculum specialisation in Mathematics Education. Student teachers taking this course are required to complete 'Lesson study' which involves the research and design of a lesson in Probability. Once a lesson has been designed and evaluated by faculty, students are required to teach the lesson in a 'real' classroom context as an opportunity to evaluate the adequacy of the lesson in the live classroom setting. Your child's class has been selected for this project. As part of the 'Lesson Study' process, we would like to collect examples of students' work and photos of students completing mathematical activities. These may be used when publishing research articles. However, students' names will always be protected.

Optimum participation is important in order to represent mathematics teaching in a real classroom. Therefore we would be grateful for your support in this project. If you have any questions about this project, contact us at Mary Immaculate College e-mail:

aisling.leavy@mic.ul.ie or marie.lane@mic.ul.ie or mairead.hourigan@mic.ul.ie

Please complete the permission form on the following page and return it to your child's teacher. Retain this information page for your own records. Please return the permission form by Friday. Thank you for your cooperation.

Yours sincerely,
Dr. Aisling Leavy

Dr. Mairéad Hourigan

Marie Lane

Claire Carroll

Appendix D

Parent / Guardian Information Sheet

Mary Immaculate College



Research Study Title: How Lesson Study Can Help Students Bridge the Practice-Theory Gap

Dear parent/guardian,

The mathematics education faculty at Mary Immaculate College are involved in teaching a curriculum specialisation in Mathematics Education. Student teachers taking this course are required to complete 'Lesson study' which involves the research and design of a lesson in Probability. Once a lesson has been designed and evaluated by faculty, students are required to teach the lesson in a 'real' classroom context as an opportunity to evaluate the adequacy of the lesson in the live classroom setting. Your child's class has been selected for this project. As part of the 'Lesson Study' process, we would like to videotape the mathematics lesson(s) taught by the student teachers. All videotaping will be done during your child's regular mathematics class in the classroom. We are seeking your permission to videotape these lessons. These tapes will only be used for research and professional development purposes in Mary Immaculate College. The videotapes will be stored in Mary Immaculate College in a locked cabinet in a secure location. Examples of students' work and photos of students completing mathematical activities may be used when publishing research articles. However, students' names will always be protected.

If you do not give permission for your child to be videotaped, your child will still receive instruction and will still fully participate in all class activities during videotaping. Children who do not have permission for videotaping will be seated near each other in the classroom and the camera will never be directed to them. The camera will be directed only towards the student teachers and those children who have permission to be videotaped. Your decision to permit or deny videotaping will not influence your child's instruction.

Optimum participation is important in order for the videos to represent mathematics teaching in a real classroom. Therefore we would be grateful for your support in this project. If you have any questions about this project, contact us at Mary Immaculate College e-mail: aisling.leavy@mic.ul.ie or marie.lane@mic.ul.ie or mairead.hourigan@mic.ul.ie

In order to make arrangements for the videotaping, please complete the permission form on the following page and return it to your child's teacher. Retain this information page for your own records. Please return the permission form by Friday. Thank you for your cooperation. Yours sincerely,

Dr. Aisling Leavy

Dr. Mairéad Hourigan

Marie Lane

Claire Carroll

Appendix E

Parent / Guardian Consent Form

Mary Immaculate College



Research Study Title: How Lesson Study Can Help Students Bridge the Practice-Theory Gap

I give permission for my child _____ (insert name) to participate in this lesson and for his/her work or photograph to appear in any research publications which result from this research project.

I do not give permission for my child, _____ (insert name) to participate in this lesson and for his/her work or photograph to appear in any research publications which result from this research project.

Signature of Parent or Guardian

Date

Appendix F

Parent / Guardian Consent Form *Mary Immaculate College*



Research Study Title: How Lesson Study Can Help Students Bridge the Practice-Theory Gap

I give permission for my child, _____ (insert name), to be videotaped as part of the 'Lesson Study' project. I give permission for his/her work or photograph to appear in any research publications which result from this research project.

I do not want my child, _____ (insert name), to be videotaped as part of the 'Lesson Study' project. I do not give permission for his/her work or photograph to appear in any research publications which result from this research project.

Signature of Parent or Guardian

Date

Appendix G

Mary Immaculate College



17/01/2013

Dear Board of Management,

The mathematics education faculty at Mary Immaculate College are involved in teaching a curriculum specialisation in Mathematics Education. As part of this module we are providing our student teachers with the opportunity to engage in Japanese lesson study. Lesson study will require students' engagement in the design of one lesson in the area of Probability. Involved in the design of the lesson is in-depth research on current curriculum, children's mathematical thinking, and innovative instructional approaches in the teaching of Probability. Once the lesson has been designed and evaluated by faculty, students are required to teach the lesson in a 'real' classroom context as an opportunity to evaluate the adequacy of the lesson in the live classroom setting.

We are very much interested in having students teach the lesson in your school and are seeking permission for each group of student teachers (maximum of 5 students in the group) to have access to a 5th class group of students. A member of the mathematics education faculty will be present with the students to observe the lesson. During the teaching session, one student teacher will teach the lesson while the remainder of the group observes the teaching. 'Examples of students' work and photos of students completing mathematical activities may be used when publishing research articles. However, students' names will always be protected.

We enclose a copy of the letter seeking parental permission for these activities for your perusal. We would appreciate the opportunity to engage in this research at your school site. The research design outlined above represents a summary of the proposed study. Further details such as the lesson plan and specific research questions can be provided. We are available to provide additional information that may be needed in order to grant access to your school. We would be grateful if you could respond to our request at your earliest convenience.

Yours sincerely,

Dr. Aisling Leavy

Dr. Mairéad Hourigan

Marie Lane

Claire Carroll

Appendix H

Mary Immaculate College



17/01/2013

Dear Board of Management,

The mathematics education faculty at Mary Immaculate College are involved in teaching a curriculum specialisation in Mathematics Education. As part of this module we are providing our student teachers with the opportunity to engage in Japanese lesson study. Lesson study will require students' engagement in the design of one lesson in the area of Probability. Involved in the design of the lesson is in-depth research on current curriculum, children's mathematical thinking, and innovative instructional approaches in the teaching of Probability. Once the lesson has been designed and evaluated by faculty, students are required to teach the lesson in a 'real' classroom context as an opportunity to evaluate the adequacy of the lesson in the live classroom setting.

We are very much interested in having students teach the lesson in your school and are seeking permission for each group of student teachers (maximum of 5 students in the group) to have access to a 5th class group of students. During the teaching session, one student teacher will teach the lesson while the remainder of the group observes the teaching. A member of the mathematics education faculty will be present with the students to observe the lesson.

The teaching shall be digitally recorded. The recorded dvds will be used by the mathematics education faculty in Mary Immaculate College for teaching, research and professional development purposes only. The dvds will be stored in Mary Immaculate College in a locked cabinet in a secure location. 'Examples of students' work and photos of students completing mathematical activities may be used when publishing research articles. However, students' names will always be protected. We enclose a copy of the letter seeking parental permission for these activities for your perusal.

We would appreciate the opportunity to engage in this research at your school site. The research design outlined above represents a summary of the proposed study. Further details such as the lesson plan, and specific research questions can be provided. We are available to provide additional information that may be needed in order to grant access to your school to carry out the research on lesson study. We would be grateful if you could respond to our request at your earliest convenience.

Yours sincerely,

Dr. Aisling Leavy

Dr. Mairéad Hourigan

Marie Lane

Claire Carroll

Appendix I

Children's Information Sheet

Dear _____,

We are doing a project as part of our University work. It's like a project you might do in school. Some people in our college are learning about ways of teaching children maths. So if you agree we would like to use some examples of the work you do in your maths classes.

This will help teachers to see the best ways to teach maths to children.

We would also like to take some photos of you doing some maths activities. While you are being photographed there will be other children being photographed at the same time so that might make it easier.

If you don't want to be photographed that's okay. When we are photographing you can move away to another table that is not being photographed. You can still take part in the activities we will be doing, we just won't photograph you.

When people see the photos we might talk about some of the things you have done in maths class. But we won't use your name so people won't know who you are.

If you have any worries after we take our photos you can come talk to us or to your teacher or parents.

Appendix J

Children's Information Sheet

Dear _____,

We are making a video for our University work. It's like a project you might do in school. Some people in our college are learning about ways of teaching children maths. So if you agree we would like to video you in your classroom while you do some maths with the rest of your friends. This video will help teachers to see the best ways to teach maths to children.

When you are being videoed there will be other children being videoed at the same time so that might make it easier. It's not like a test - there are no right or wrong answers. We will be doing some activities together and thinking about maths.

If you don't want to be videoed that's okay. When we are videoing you can move away to another table that is not being videoed. You can still take part in the activities we will be doing, we just won't video you.

The video tapes will only be seen by us, some people in the college who are learning to teach maths and maybe some other people who want to make videos like this. We will not let anyone else see the video because those are our University rules.

When people watch the videos we might talk about some of the things you have done in maths class. But we won't use your name so people won't know who you are.

If you have any worries after we make our video you can come talk to us or to your teacher or parents.

Appendix K

Children's Consent Form



Mary Immaculate College

I agree, _____ (insert name), to participate as part of the 'Lesson Study' project. I give permission for my work or photograph to appear in any research publications which result from this research project.

I do not want, _____ (insert name), to participate as part of the 'Lesson Study' project. I do not give permission for my work or photograph to appear in any research publications which result from this research project.

Signature

Date

Appendix L

Children's Consent Form



Mary Immaculate College

I agree, _____ (insert name), to be videotaped as part of the Lesson Study project. I give permission for my work or photograph to appear in any research publications which result from this research project.

I do not want, _____ (insert name), to be videotaped as part of the Lesson Study project. I do not give permission for my work or photograph to appear in any research publications which result from this research project.

Signature

Date

Appendix M

Content Knowledge Questionnaire

I. D. _____

Probability Definitions:

1. How would you define or explain the term random?

2. What is a mutually exclusive event? Give an example.

3. What is a dependent event? Give an example.

Probability Measurement:

4. a. Which of the following is the most likely result of five flips of a fair coin?

- a) HHHTT
- b) THHTH
- c) THTTT
- d) HTHTH
- e) All four Sequences are equally likely

Why? _____

b. Which of the following sequences is the least likely to occur?

- a) HHHTT
- b) THHTH
- c) THTTT
- d) HTHTH
- e) All four Sequences are equally likely

Why? _____

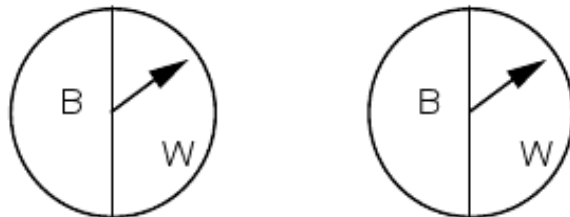
5. Give a **ratio** to represent the probability for each of the following events:
- a) Tossing a coin and getting heads _____
 - b) Rolling a 1 with a normal die _____
 - c) Drawing a King from a fair deck of cards _____

Probability Comparisons:

6. Which one of the following three events do you think would be most likely? Please explain your answer.
- a) Draw a red marble from a bag containing 50% red marbles and 50% white marbles
 - b) Draw a red marble 7 times in a row from a bag containing 90% red marbles and 10% white marbles
 - c) Draw at least one red marble in 7 tries (with replacement) from a bag containing 10% red marbles

Why? _____

Probability Sample Space:



7. The two fair spinners above are part of a carnival game. A player wins a prize only when both arrows land on black after each spinner has been spun once. Jeff thinks he has a 50-50 chance of winning. Do you agree?
- Yes No

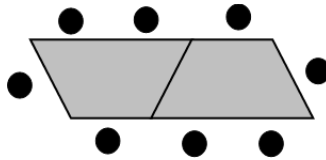
Why? _____

Algebra Problems

Table and Chairs Problem:

8. Mrs Chen got new trapezoid shaped tables for the canteen. She decided she would place the chairs around each table so that 2 chairs will go on the long side of the trapezoid and one chair on every other side of the table. This way 5 students can sit around 1 table.

Then she found that she could join 2 tables like this:




Now 8 students can sit around 2 tables.

- a) How many students can sit around 3 tables joined this way?

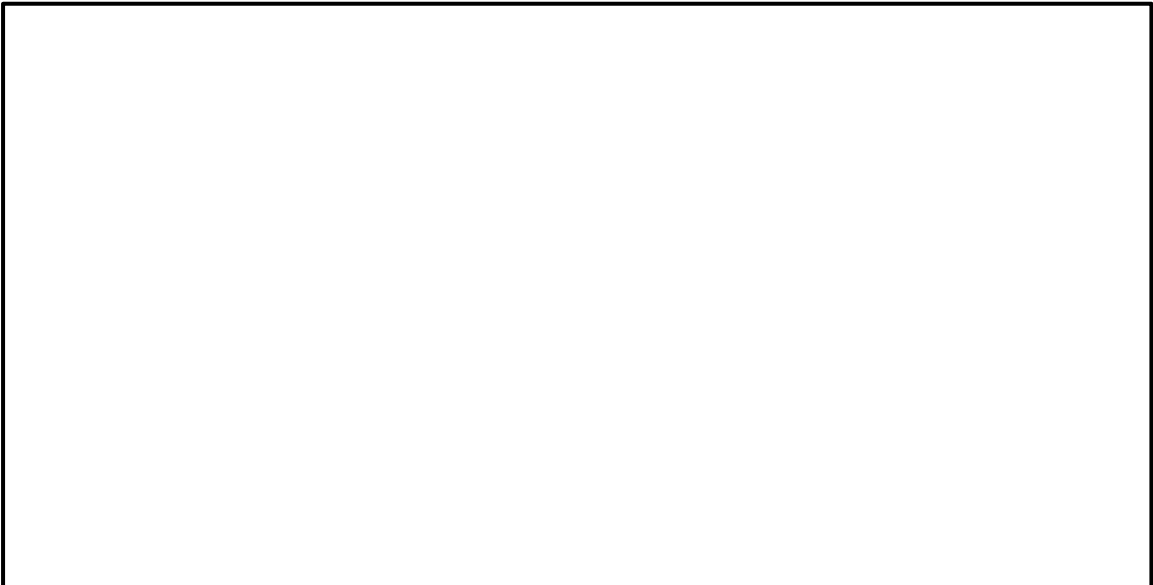
Crossing the River

9. A group of 8 adults and 2 children need to cross a river. A small boat is available that can hold 1 adult, or 1 child, or 2 children. Everyone can row the boat.

a) How many one-way trips does it take for them all to cross the river?



b) Can you find a rule that will allow you to predict the number of one-way trips for any number of adults and two children?



Appendix N

Pre-service Teacher Data Questionnaire

Section 1: Personal Details

1. Name: _____
2. Date of Birth: ____/____/____
3. Degree Programme: B.Ed B.Ed Psych
4. Arts Subject: _____
5. Leaving Certificate Mathematics Level: Higher Ordinary Foundation
6. Leaving Certificate Maths Grade: _____

Section 2: Mathematics Attitudes

7. Was mathematics your first choice of subject you wished to study? Yes No
8. If not, which choice was it? 2nd 3rd 4th Other
9. If it was your first choice, what was the **main reason** you chose this mathematics course? _____

10. If it wasn't your first choice, now that you are taking this mathematics course what are the **main** things you would like to get from this course?

11. At the moment would you feel confident teaching mathematics in a school next September? Yes No
Why or Why not? _____

12. The two topics you will be teaching in the lesson study aspect of this course are Algebra and Probability. How do you feel about these particular topics in mathematics?

Algebra: _____

Probability: _____

Appendix O

Sample Transcript of Pre-Service Teacher Interview (Helen)

Interviewer: Okay, so let's just start off by looking at what were your feelings overall kind of about lesson study or what did you think of it?

Helen: Okay. Am, it's a nice idea like the...and it should work, well but, I just like the work distribution was just so unequal like. I'm sure in every group there was some people who did nothing and some people who did everything.

Interviewer: Yeah, everyone was saying the exact same thing.

Helen: Yeah, am... We can guess what people are doing the interview like but...it's just, and then in the end there's no way of showing it because...and then in the end we just write down one thing in the log, oh what did everyone do but do you know, the people you're in the group with, for the most part, you're friends with them so...

Interviewer: Yeah.

Helen: ...if they, you're not going to combat them and say, 'I don't think you really did that and you have to take that off...

Interviewer: Yeah.

Helen: You know so...do you know, it's kind of unfair in that sense.

Interviewer: The group grade?

Helen: Yeah, well just even, like, writing down say oh, we edited the lesson plan after every lesson. There's a big difference between someone coming on and changing the word 'the' to 'a' and someone coming on and re-writing the whole thing for four hours but it's the same thing...

Interviewer: Yeah, yeah.

Helen: So, I don't know. That was just being...

Interviewer: Yeah.

Helen: Picky and stuff... Well that's the same with all kinds of group work I suppose.

Interviewer: You know, they're the kinds of things.

Helen: All of it.

Interviewer: Yeah I know. I know but it's a valid point as to why it might not work as a teaching methodology.

Helen: But it was good like because, in some senses that am, do you know having more ideas, do you know if you, if we had it on our own, do you know, you'd be a lot, like we did

share ideas a good bit on things, like we got very stuck on what to do the...when they said we needed a context for our cube things, we were really bogged down on just using cubes with stickers and stuff and we were thinking of all sorts of crazy things that this cube sticker thing could be until...

Interviewer: Yeah...

Helen: ...one of the lads said 'Oh, what if we just...could we not change it to $2X$ plus 1, or $4X$ plus 1?'...

Interviewer: $4X$ plus 1.

Helen: And...I don't think I would have ever thought of that, no matter...

Interviewer: Mmmm...

Helen: You know, such a simple thing but...do you know when...So it's good, it was good in that sense.

Interviewer: Yeah so, kind of different perspectives. Yeah.

Helen: Yeah. It was good in that sense. Am but as well like do you know the whole lesson thing, it has to flow, like do you know even writing the lesson, they said first off they could tell straight away that three different people wrote it. Someone wrote this, someone wrote this and someone wrote this. And they said, 'Oh it all has to sound the same'. Which basically implies one person has to go back and do the whole thing so that it sounds the same, you know?

Interviewer: (laughing) Yeah.

Helen: So it's Just...

Interviewer: So it's tough that way?

Helen: Yeah, am...but...it was, it was good like, like I...I'm happy, I'm happy enough we did it. It was a nice, it was a nice project...am...

Interviewer: It's just the group work issue...

Helen: The group work issue...

Interviewer: ...which is what everyone is saying, yeah.

Helen: Yeah. But if like...for our lesson like we didn't have to change much in between the two lessons at all, only small things but it being, do you know, well we were on our own so, I presume for the other groups, they had a lot more to...well, to change or...some...

Interviewer: Yeah some of the groups had loads, yeah..

Helen: ...or make revisions. So like, then, in that case, it was a really nice project, do you know, because most of the time you like only ever get to teach one lesson once like...really like, on teaching practice...

Interviewer: Mmm...

Helen: ...or anything. So it was nice to go back and like make it better. Do you know...?

Interviewer: Yeah, okay. Okay so, just a little bit more on that working as a group that you mentioned, so...it was difficult but worthwhile is kind of what everyone is kind of saying.

Helen: Yeah.

Interviewer: So, collaboration is obviously important, and when ye go out as newly qualified teachers ye have still so much to learn like. Obviously ye haven't learned everything in here but then as well as that ye bring out kind of new ideas that have...ye've got from college that maybe teachers out there haven't got. So, there's a lot to be said for collaboration between newly qualified teachers and teachers that are out there already. Am, so my question kind of is, do you think that's feasible in teaching? Is it done enough? And would you do be feel comfortable kind of going out into a school and looking for help or do you think that the culture of Irish schools is kind of supportive of that? So loads of things to think about there.

Helen: Am...Well it's obviously a good idea, you know? Like, they...when we go out we might have new ideas that they might, that older teachers mightn't have, but they have so much more experience and we might need help with let's say, do you know, disciplinary issues, do you know? Because they might know some of the students in the school and what works for them...

Interviewer: Mmm...

Helen: Do you know?...Just anything like that or...am, but I don't think it happens too much. Ah, I don't know. Unless...Unless, someone specifically, next year, approached me, saying, do you know, 'Oh, if you have any problems', do you know, 'come to me' and that, I don't think I'd be eager to be the first one to go up and ask for help or to initiate the...unless it was very explicitly made clear that it was...the offer was perfectly there...

Interviewer: But it is difficult in schools to do that, yeah.

Helen: Yeah. Do you know so...

Interviewer: Yeah, because you don't know how they're going to react or what they're used to and you're kind of trying to fit in when it's your first year. Yeah. That's perfect so, am...So another big aspect of lesson study was, do you know, researching topics. So, ye obviously got research materials on the actual Maths that ye were teaching and on how Maths is taught and the kid thinking on it and specific ways of teaching the different Maths and ye used bits of that to come up with your lesson. How did you find that aspect of it and do you think that it's something that you might do when you go out teaching, is it feasible with your

like twelve subjects to kind of research or is there something that you might pick up on if you had difficulty with something or...?

Helen: Am... Well it's not feasible to do it for everything all the time but am, for things that you wouldn't be that familiar with, because we didn't really know much about growing patterns, we never taught them before, we never... I don't think we ever studied them so we didn't know too much about it. So, in that sense it was, it was really helpful to look it up and things like that and get examples of different lessons and stuff and to read different things about it but am... I suppose, only if it was something that you'd feel, that you'd feel out of your depth teaching...

Interviewer: Mmm... Yeah.

Helen: Am... other than that, I don't have enough time I'd say.

Interviewer: Yeah. Okay, that's perfect. Am...

Helen: As well as that, you don't really know, where to go, so a lot of the time that you're researching is kind of wasted typing random things into google... and hoping something comes up and...

Interviewer: Yeah.

Helen: ...do you know? So, it's a lot, do you know? At the end of the day, you might have very little to show for the time that you put in...

Interviewer: Yeah...

Helen: ...to research so ...like different combinations of words and stuff... to find something new...

Interviewer: I know, yeah. Yeah, because there's so much out there that it's hard to pinpoint the good stuff. Yeah, that's very valid. Okay so, you're obviously almost finished third year, on the last stretch (laughs). So, do you think this was a good time to have the lesson study module or do you think it would be better off if you had it earlier on in the course or...?

Helen: No, am, I think it definitely needs to be towards the end, am... it's, for one thing, it's very intimidating for anyone to even to, you know, to get up and teach it like, for anyone, especially when there's so many people in the room and there's cameras, there's people watching and there's, oh it's for supporting settings...

Interviewer: Yeah, so... so you'd need to be confident in your own ability?

Helen: You'd need... do you know, you'd need a bit of confidence or...

Interviewer: Yeah.

Helen: ...am, you know and it helps at this stage we kind of know each other as well so, that kind of helped in that sense. But am, as well as that for... there's a lot of group work involved

in it and so, you kind of need some like...backbone, and stuff like (laughs) at this stage in it too...

Interviewer: Yeah.

Helen: ...kind of get things done and stuff so...

Interviewer: So you think you'd be kind of too immature in kind of first year or that, well, say you might have as much experience...

Helen: Yeah, am, I definitely think it would be so...it would be kind of overwhelming for anyone to teach it in first year in front of that many people because micro-teaching was the biggest thing in first year when you had to do it in front of a couple of your friends and stuff...

Interviewer: Yeah, yeah.

Helen: So, to do it in front of a class with a video camera with other lecturers...

Interviewer: It would be too much...

Helen: ...would be way too much. Am, but as well there's a lot involved in it; the research, the meeting up and all of that and kind of I think, at the end of it you kind of see the need for it and stuff because you have been out on teaching practice and you know the variety, like that there's no knowing what they're going to say to you and that so...

Interviewer: Yeah, yeah. So you think you wouldn't have had enough experience from the start? Yeah.

Helen: No. I don't think so.

Interviewer: Okay. Am, okay so, from your assignment and your group, am...work and your individual kind of reflections, it's really clear that nearly everyone in the course has the view that we must have active learners in our classes, we're going to be the non-traditional kind of teacher, you know, you're a facilitator rather than a teacher, so do you think you're kind of well-developed as a teacher, you kind of have your ideas coming in here, how you like to teach and how you like to kind of take your class but were there any kind of specific things that you felt you developed like individually or kind of personal to you. Things that you developed during lesson study or things maybe you thought about a little bit harder or...

Helen: Am...I'm sure it was the same for most people but really kind of that, do you know that column in the lesson plan that says 'Expected Student Responses', that kind of got people thinking more, me especially...me included and a lot of people said it about you're, you're thinking all the time, what questions will you ask but you're not really focused on what they're going to say back. You might have designed the perfect question but you haven't really thought about what the answers are going to get, so...

Interviewer: Yeah if you get a totally random answer, how are you going to approach that...

Helen: Yeah, so that was kind of useful and especially like we got directed in some of the discussions they said, oh if they give you this, what are you going to say in reply to this answer and kind of when you're, it happens a lot when you're teaching, it kind of takes, do you know, someone throws an answer at you and you're kind of like 'Uhh...'

Interviewer: Yeah.

Helen: ...you know so...am, it was kind of useful to...to plan that and to kind of am...take away that you'd think about it a little bit more after that, do you know when it'd be always in the back of your mind when you're planning like do you know, your questions or whatever like. What...is there anything that could pop, do you know, really obviously go wrong with this, do you know or something.

Interviewer: ...Yeah.

Helen: ...you never thought about it before but now it's kind of there.

Interviewer: Yeah. Am...

Helen: There's probably other stuff now. I should have had a read over my reflections.

Interviewer: It's fine because I read them. Am, so that was one thing I was going to ask you about responding to kids' ideas, so that's a very big thing. Am... okay so, you were looking at a little bit more into your reflections about Mathematical understanding and that pupils often solved the algebraic problem in a different way to how you might have expected...

Helen: Yeah, that was a big thing that I kind of didn't really know...kind of didn't...the kind of...I didn't really know when I started off growing patterns, when I started off looking at it, I didn't kind of realise it. But am, yeah, that was a big thing. Am, even doing all the readings, they kind of laid it out in some ways, oh you could see...look at it this way or you could look at it this way or you could look at it this way. And that was...as well when we were out in the class, the kids kind of came up with a different way.

Interviewer: Yeah.

Helen: So...it was kind of...it makes it a challenging thing to kind of teach because...

Interviewer: Because you always have to be thinking...

Helen: Yeah, because sometimes when they give you this response, everyone's like, take a second, get your pen out, everyone kind of looks down and it's like is that right, is that right, doing quick Maths, but am...So...

Interviewer: And do you think that that's specific to algebra?

Helen: Am...I suppose, I suppose not, I suppose in a lot of things there are different ways to look at it and it's...they might be all...they might each be justified. I can't think of any more specific examples but...

Interviewer: Yeah.

Helen: Am...I suppose it's just something to take away that even do you know, it mightn't be fully right but there might be elements of it right and that was what we found in some of the responses that we got back from the kids that they had part of the formula right and there was actually really good thinking going on but they just had left out a tiny bit so they were almost of the way there...

Interviewer: Yeah.

Helen: ...It's kind of like sometimes, like it's not just right and wrong like, do you know, if you're correcting spelling if they...there's a difference between marking something wrong if all the letters are all over the place or if someone has the... 'separate', if someone has 'e' in the middle of it, instead of 'a', like that's a really small mistake and it's really...do you know, so...You kind of have to...the...even if it's wrong, especially in algebra, it's easy to say, 'Oh, that's not the formula, it's wrong'. Do you know? It's kind of...that challenging part is kind of seeing where they got that formula from because they might just have like one letter wrong...

Interviewer: Yeah.

Helen: Do you know, they might be really nearly there...

Interviewer: Or like that kid in your group's class who just forgot the last little step of adding on the two at the end.

Helen: Yeah. They might be really nearly there.

Interviewer: Yeah, that's...is that kind of the first time that maybe you would have come across a specific example of that like...?

Helen: Yeah.

Interviewer: So did you find that it was good to kind of get them to be able to justify their answers so you can see where they're coming from?

Helen: Yeah, that's a really big thing because they say things and you're like 'How in the world...did you come up with that?'.

Interviewer: Yeah, yeah.

Helen: But then if you get them to explain or sometimes, often times if you get them to explain and say 'Right, what's that three for?' and they'll go, 'Oh yeah, I don't know where...', do you know, they might see themselves that it's wrong...

Interviewer: Yeah, yeah.

Helen: ...or else they...you'll see that...

Interviewer: They've a good reason for it...

Helen: ...they've a good reason for it, or that they're really close.

Interviewer: Yeah, yeah. Yeah, that's interesting actually. Am, okay... another thing you discussed in your reflections was the importance of...ah...representation in your lessons, so I think that was with regards to your picture...

Helen: ...tables, yeah. I think.

Interviewer: I think it was with regards how you were putting your picture of your builder across.

Helen: ...Oh yeah, we had am, it was kind of a combination of language and kind of visually representing it but we had one picture with all the different steps of the pattern but we called each step picture number...

Interviewer: Oh yeah, yeah, that was it.

Helen: ...and there was all of them within the one picture with no kind of position cards, it was kind of...it took a long while to explain it and then it was kind of roundabout way of talking about it...

Interviewer: So it took up time?

Helen: Am, so we kind of fixed that up for the second lesson and...we didn't...see the first time...we didn't really pay any attention to...well, we kind of overlooked that fact, we were like 'Okay, oh picture number, get the picture ready, just call a picture number', but when we were actually teaching it then and going around trying to explain, 'Right, we want you to look at picture number one in this picture', and do you know, it was, we kind of...we only kind of realised doing it that it was very unclear and stuff.

Interviewer: So, the importance of how you represent things.

Helen: Yeah... it made me think...I suppose one way, even a simple way to help this would be if you were planning on explaining something even just to talk it through because it might just...it mightn't even come out right.

Interviewer: Yeah.

Helen : Like, if we had said discussed it, if we had done a mock lesson between us and we had said to someone 'Oh'...to each other 'Right, look at picture...', do you know, we might have figured out...

Interviewer: Yeah.

Helen: ...ourselves that it was a bit...am, rough or...especially if we had talked to someone who wasn't in our group about it so, I suppose like a general thing from that is if, do you know, you could bounce ideas off someone else and stuff...

Interviewer: Yeah.

Helen: ...or run through, like if...if you were dealing with a confusing definition or a confusing explanation of something, like you could bounce it off another teacher and say 'Does that sound clear or anything you would change about it or...?' or something.

Interviewer: Yeah, yeah. And then the last thing which I wanted to come back to was the reflections that ye had to do for this. Am...specifically, the fact that ye were reflecting on a lesson that ye taught and ye were going to teach again. Did you think that the reflecting in this lesson was kind of different to reflections that ye had done before for say, teaching practice, because ye were going to be teaching the lesson again? So did you think it was different?

Helen: Yeah, well, on teaching practice, do you know, your inspector reads your reflections and they tick something about them and if they didn't come to see the lesson, I don't see why anyone would write down that it went terrible and that it was awful. Do you know, if your inspector wasn't there...

Interviewer: Yeah, yeah.

Helen: ...you might as well say that it went great.

Interviewer: Yeah, yeah.

Helen: You know? So in that sense like, reflections...other reflections, on teaching practice, they're kind of, unless the supervisor saw you teach it, you say it in the best possible light and you kind of tend to overlook things that actually went wrong but that's, do you know, it's not to say that you haven't learned from them but you're thinking about your grades at the same time.

Interviewer: Exactly.

Helen: At least, in this sense, it's...what was good about this was we actually felt that we could be honest, like it wasn't...they made it clear from the start that the grading kind of wasn't on how well the lesson went and do you know, it wasn't: we're going to grade you on this teaching and how well you did it and stuff and they kind of made it clear that: Oh, do you know, If it doesn't go well the fault isn't on anyone in particular. We all need to work together to make it better and stuff so we felt then in reflecting that we could actually say, 'Oh, we didn't do this well at all, do you know, we can change that', so it was actually, it was nice to be honest...

Interviewer: Yeah.

Helen: ...for a ch...well completely honest. I didn't lie in all my reflections now [laughs].

Interviewer: I know, I know it's difficult when you're reflecting...

Helen: But...so, we...I forget exactly what you asked me now...I'm...oh yeah...anyway it's kind of more like the reflection you'd be doing as a teacher...because if you were out there, you'd be really saying 'Oh, what went wrong or I'm not going to do that again and what went...how could I make this better', and that's exactly what we were doing here. Am, which we haven't really been asked to do before on anything that's not graded which, do you know, when you put it in that light, that's...it puts a whole different spin on it, do you know?

Interviewer: Yeah.

Helen: But, it was...the reflections were am, fairly sort of alright, do you know, in that sense.

Interviewer: Okay, well I think that's all my questions anyway. So, just if you just have any kind of last comments, you'd like to say about the lesson study. What you thought of it...did you think it was good, besides the whole team work aspect...?

Helen: No it was nice like I, I, I really enjoyed it over all and I think it was really beneficial. It was nice that we got...am...sub...concepts as well like, topic areas that we wouldn't usually teach too much so like do you know, if we, if we had got like shape and space or something, that's nice but it's kind of boring too like...

Interviewer: Yeah.

Helen: ...we've all taught that before, the kids have learnt that before like and to be fair nothing you do is going to be really original in shape and space because it's been done before.

Interviewer: Yeah.

Helen: So, it was nice that we all got something that,do you know, when we first, when they first threw them up there, I was like 'Oh God, what are these?' like.

Interviewer: Yeah.

Helen: You know, especially people with probability, one day, do you know, they were like 'What is this?' but am, it was nice anyway, in that, it was kind of the chance to plan something fresh, do you know, it wasn't...because there wasn't really, there wasn't really too many ideas in the books, especially I'm sure for other people, for ours, we kind of had to go with examples of growing patterns that were there, like we made our own things and the builders and stuff...

Interviewer: Your own twist, yeah.

Helen: But we had to am, adapt things that were there but am...

Interviewer: Yeah.

Helen: No, it was, it was nice and the chance, the chance to do it over actually really did...the fact that you had to teach it again, really made you actually reflect more than probably you usually would.

Interviewer: Mmm.

Helen: Am, so you actually picked up on things like if we hadn't been teaching it again, you wouldn't have put so much thought into how it went...

Interviewer: Yeah.

Helen: So you probably, well you might have said...picked out on a big thing and said 'Oh', do you know, the...putting the position cards in or something but when we actually said we had to do it again, you really pick out really little things that you're going to change...

Interviewer: Mmm.

Helen: ...and am, do you know, and from doing that, you kind of learn that the little things can make a big difference.

Interviewer: Yeah.

Helen: And so that's nice...

Interviewer: That's a lovely way to end [laughs].

Helen: Yeah...

Interviewer: Okay well I have no more questions for you so...

Helen: I don't think I've anymore to add.

Interviewer: That's great, well thanks a million for doing the interview and best of luck in your exams.

Appendix P

Algebra Readings

- Choreographing Patterns and Functions:
Hawes, Z., Moss, J., Finch, H. & Katz, J. (2013) 'Choreographing Patterns and Functions', *Teaching Children Mathematics*, 19(5), 302-309.
- Patterns as Tools for Algebraic Reasoning:
Herbert, K., & Brown, R. H. (1997) 'Patterns as tools for algebraic reasoning', *Teaching Children Mathematics*, 3(6), 340-344.
- Instructional Strategies for Teaching Algebra in an Elementary School: Findings from a Research Practice Collaboration:
Earnest, D., & Balti, A. A. (2008) 'Instructional Strategies for Teaching Algebra in Elementary School: Findings from a Research-Practice Collaboration', *Teaching Children Mathematics*, 14(9), 518-522.
- Patterns to develop Algebraic Reasoning:
Stump, S. L. (2011). Patterns to Develop Algebraic Reasoning. *Teaching Children Mathematics*, 17(7), 410-418.
- Developing Algebraic Thinking Through Pattern Exploration:
Lee, L., & Freiman, V. (2006) 'Developing Algebraic Thinking through Pattern Exploration', *Mathematics Teaching in the Middle School*, 11(9), 428-433.
- Early Algebra and Algebraic Reasoning:
Carraher, D. W. & Schliemann, A. D. (2007) 'Early Algebra and Algebraic Reasoning', in Lester, F. K., ed., *Second Handbook of Research on Mathematics Teaching and Learning, Volumes 1-2*, Charlotte, NC: Information Age Publishing, 669-705.

Probability Readings

- What a Pip! Probability and Efron's Dice:
Sloop, B. C., & Che, S. M. (2011) 'What a Pip! Probability and Efron's Dice', *Mathematics Teaching in the Middle School*, 17(2), 116-123.
- Research in Probability: Responding to Classroom Realities:
Jones, G. A., Langrall, C. W. & Mooney, E. S. (2007) 'Research in Probability: Responding to Classroom Realities' in Lester, F. K., ed., *Second Handbook of Research on Mathematics Teaching and Learning, Volumes 1-2*, United States: Information Age Publishing, 909-956.
- Navigations Series (Grades 3-5) Data Analysis and Probability: Is There Such Thing as a Lucky Coin?:
Chapin, S., Koziol, A., MacPherson, J & Rezba, C. (2003) *Navigating through Data Analysis and Probability in Grades 3–5*, Reston, VA: National Council of Teachers of Mathematics 68-72.
- Research on Students' Understandings of Probability:
Shaughnessy, J. M. (2003) 'Research on Students' Understandings of Probability' in Kilpatrick, J., Martin, W. G. & Shifter, D, eds., *A Research Companion to Principles and Standards for School Mathematics*, Reston, VA: National Council of Teachers of Mathematics, 216-226.

Lesson Study Readings

- A Lesson is Like a Swiftly Flowing River:
Lewis, C. & Tsuchida, I. (1998) 'A Lesson is Like a Swiftly Flowing River: Research lessons and the improvement of Japanese education', *American Educator*, 22(4), 14-17 & 50-52.
- Beyond Reform: Japan's Approach to the Improvement of Classroom Teaching:
Stigler, J. W. & Hiebert, J. (1999) *The Teaching Gap*, New York: The Free Press, 103-127.

Appendix Q

Sample of Lesson Plan (First)

I. Background Information

A. Goal of the lesson study group:

During our home teaching practice we found that children faced significant difficulty in solving mathematical problems. We feel this lesson will help the children develop their problem solving skills and to think independently.

B. Narrative Overview of Background Information:

Earlier in the week the children were introduced to describing likelihoods, Comparing and Explaining likelihoods. In this lesson study the children will build on their skill set by Ordering Likelihoods.

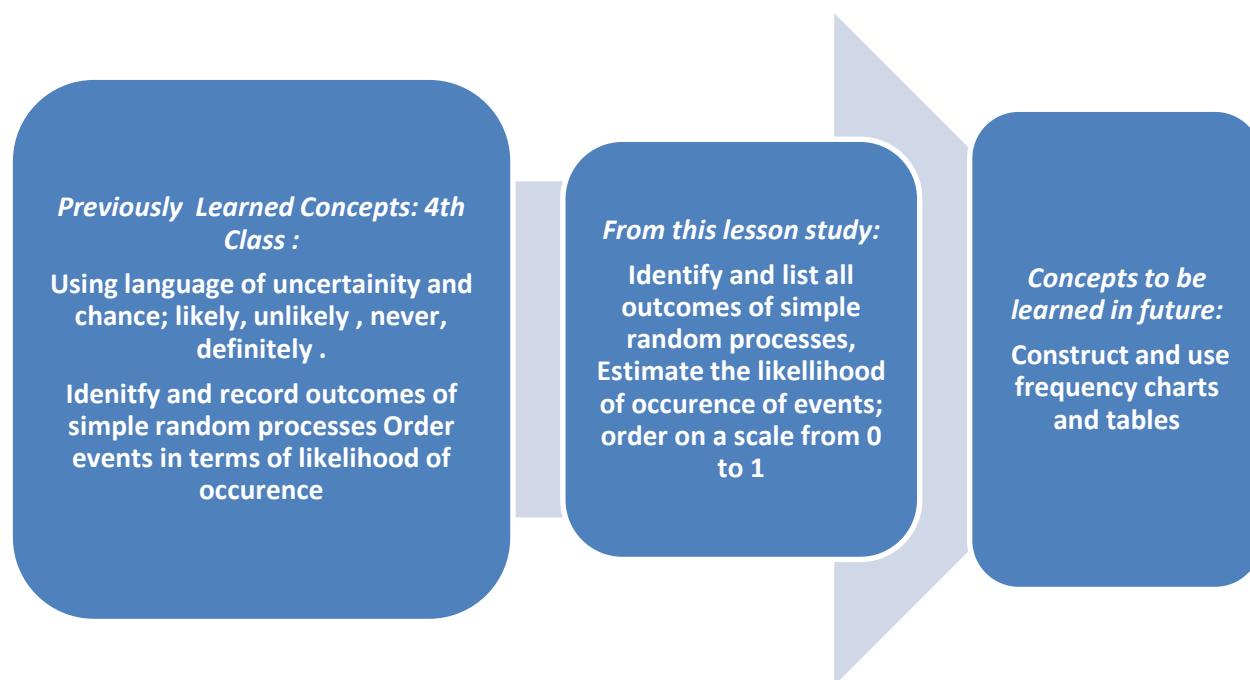
II. Unit Information

A. Name of the unit: Data; Chance; Ordering Likelihoods

B. Goal(s) of the unit:

Identify and list all outcomes of simple random processes,
Estimate the likelihood of occurrences of events; order on a scale from 0 to 1

C. How this unit is related to the curriculum:



D. Instructional sequence for the unit:

Theme 1; Lesson 1; Describing Likelihoods; Introduction to foundational concepts of chance, Investigation of situations involved in chance, Exploring misconceptions that may occur in relation to probability

Theme 2; Lesson 2 Identifying and describing outcomes of simple events, Developing understanding of fairness, Exploring understanding conceptions relating to likelihoods

Theme 3; Lesson 3 Ordering likelihoods, making predictions based on data, Measuring and representing probabilities.

Theme 4 Lesson 4: Sampling and Probability; Theoretical vs. Experimental probability , Samples and Sampling, The Media and Sampling.

III. Lesson Information

A. Name of the study lesson: Ordering Likelihoods

B. Goal(s) of the study lesson: This lesson will

1. help children identify sample space as a benchmark to measure probabilities and represent these on the range from 0-1
2. foster children's ability to order likelihoods
3. Develop student's capacity to make predictions based on data.

C. How this study lesson is related to the lesson study goal:

This lesson cultivates the concepts previously taught earlier in the week. Children in Sixth class according to the Biggs and Collis general developmental model are at the concrete symbolic stage which translates into the transitional or Level 2 of the Jones et al Probability Framework. Children at this level will be able to list the sample space for a simple event but not for an event which involves two or more variables e.g. the sample space of two coins. This study lesson as outlined in the lesson study goal will focus on helping the children negotiate a system to ascertain the sample space in a compound event.

D. Process of the study lesson:

Steps of the lesson: Learning activities and Key questions (and time allocation)	Student activities/ expected student reactions or responses	Teacher's response to student reactions/ Things to remember	Goals and Method(s) of evaluation
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<p>Introduction: Revising language of probability; Certain, Likely, Equally Likely, Unlikely, Impossible; via a maths game that will engage and stimulate the children.</p>	<p>Interactive maths game</p>	<p>Scaffolding is key throughout the entire lesson</p> <p>Teacher needs to remember that not all students will grasp the concept of proportionality. With regards to the spinners, the students may find it difficult to visualise the likelihoods of the predicted outcomes.</p>	<p>Maths Game to revise and elicit the language of probability from previous lessons. Successful completion of the maths game will act as a means of evaluation.</p>
<p>Range 0-1 Using various spinners and number line to teach the children about the probability continuum 0-1.</p>	<p>Experiment and engage with spinners and determine the place of the spinners on the probability continuum.</p>	<p>Teacher should always remember to link back to the probability continuum throughout the lesson</p>	<p>Spinners - that the students will understand all likelihoods and order them correctly along the continuum. Successful completion of this will act as a means of evaluation and assessment.</p>
<p>Fractions Using the Efron die to help the children associate and order fractions with probability.</p>	<p>Children will make associations between fractions and outcomes through hands on experimentation with Efron die.</p>	<p>Be conscious that the student that is usually competent at maths may find this topic challenging</p>	<p>Fractions - That the students will understand the relationship between outcomes and fractions and that they will be able to relate this to other real life situations. This will be evaluated through observation and teacher questioning.</p>
<p>Sample space Do a simple event by using one coin and list all possible outcomes. Using double coin toss to determine all possible outcomes of a compound event.</p>	<p>Double coin toss In pairs the children will manipulate two coins and determine all the possible outcomes this will help the students develop and strengthen their understanding of sample spaces.</p>	<p>Be sure to allow sufficient time for students to experiment and grasp concepts and ideas</p>	<p>Sample Space – That the students recognise all possible outcomes of an event so that in turn the students will understand the concept of sample</p>
<p>Developing the</p>	<p>The children will</p>		

<p>children's understanding of sample space by determining all possible outcomes of the Efron die.</p> <p>Conclusion of the lesson will consist of an open discussion based on the concepts covered in the lesson through the use of concrete everyday examples.</p>	<p>then experiment with Efron die to further compound this understanding.</p> <p>Class discussion Problem solving Formulating and asking questions</p>		<p>space. This will be evaluated through the use of the Efron die.</p> <p>The students will be evaluated through their responses and ability to formulate and answer questions/problems.</p>
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E. Evaluation

F. Appendix

Appendix R

Sample of Lesson Plan (Final Amended)

I. Background Information

C. Goal of the lesson study group:

During our home teaching practice we found that children faced significant difficulty using fractions and solving mathematical problems. They were mostly concerned about getting the correct answer rather than thinking mathematically about the question. The children used standard algorithms; without understanding the purpose of such formulas. We feel this lesson will help the children develop their problem solving skills and to think logically about probability. Linking fractions with probability is a difficult concept to grasp; so a variety of methodologies will be used to develop their understanding; dice cards and spinners.

D. Narrative Overview of Background Information:

Earlier in the week the children were introduced to describing likelihoods, Comparing and Explaining likelihoods.

In this lesson study the children will build on their skill set by Ordering Likelihoods in fraction form on a probability continuum from 0-1; this will naturally link with listing the sample space of an event.

We have taken into consideration the environment; it is important the children enjoy and feel accomplishment and fulfilment as they successfully understand the relationship between fractions and making predictions using theoretical data. Thus, we plan to have a variety of games under a carnival theme in which the children will participate. There will a number of group and paired activities. Thus, this will ensure the children will have adequate support and motivation to engage with the game.

Unit Information

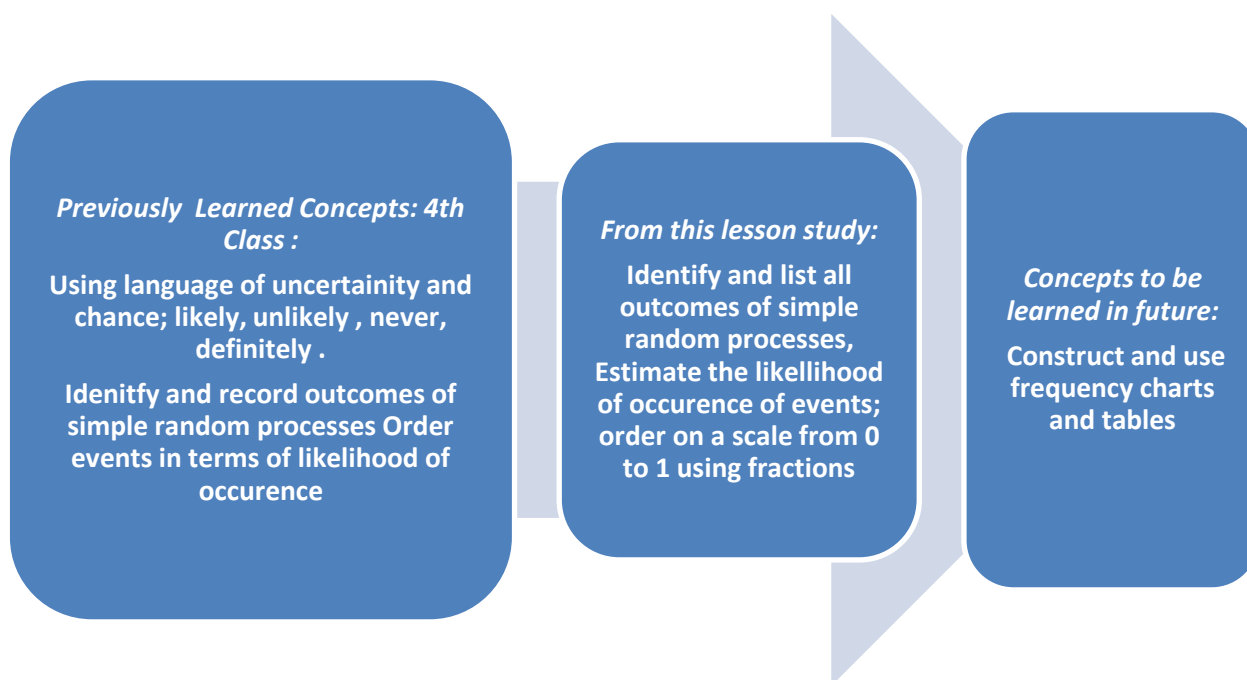
E. **Name of the unit:** Data; Chance; Ordering Likelihoods

F. **Goals of the unit:**

Identify and list all outcomes of simple random processes,

Estimate the likelihood of occurrences of events; order on a scale from 0 to 1

G. How this unit is related to the curriculum:



H. Instructional sequence for the unit:

Theme 1; Lesson 1; Describing Likelihoods; Introduction to foundational concepts of chance, Investigation of situations involved in chance, Exploring misconceptions that may occur in relation to probability

Theme 2; Lesson 2 Identifying and describing outcomes of simple events, Developing understanding of fairness, Exploring understanding conceptions relating to likelihoods

Theme 3; Lesson 3 Ordering likelihoods, making predictions based on theoretical data, Measuring and representing probabilities.

Theme 4 Lesson 4: Sampling and Probability; Theoretical vs. Experimental probability, Samples and Sampling, the Media and Sampling.

Lesson Information

Name of the study lesson: Ordering Likelihoods

Goal(s) of the study lesson: This lesson will

4. Help children identify sample space as a benchmark to measure probabilities and represent these on the range from 0-1
5. Foster children's ability to order likelihoods on the probability continuum using fractions

6. Develop through whole class and group work student's capacity to make predictions based on theoretical probability and sample space of a compound event. For Example if a die is rolled there is a $\frac{1}{6}$ chance that it will land on any of the six numbers

How this study lesson is related to the lesson study goal:

This lesson cultivates the concepts previously taught earlier in the week. Children in Sixth class according to the Biggs and Collis general developmental model are at the concrete symbolic stage which translates into the transitional or Level 2 of the Jones et al Probability Framework. Children at this level will be able to list the sample space for a simple event but not for an event which involves two or more variables e.g. the sample space of two coins.

This study lesson as outlined in the lesson study goal will focus on helping the children negotiate a system to ascertain the sample space in a compound event; two die. This skill will aid them in making predictions based on theoretical data.

Lesson Setting: Carnival theme/ games theme

Materials Needed:

Chart aid to help understanding of fractions, Individual continuums for each child, 64 normal dice, cups, large spinner, large continuum, 4 sets of cards, 1 set of large cards, magnets to stick cards to the board, 8 games of the board die dilemma, continuum divided into 36 sections,

Steps of the lesson: learning activities and key questions and time allocation	Student activities, expected student reactions or responses	Teacher's response to children's reactions/ Things to remember	Goals and method of evaluation
<p><u>introduction</u> (15 minutes) Teacher will open with a question; How do you picture probability? This will act as a focus question. To introduce the lesson Each child will be given a continuum and separate</p>	<p>Children must order fractions correctly on the board. The fractions will be: $\frac{1}{8}$, $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{2}{4}$, $\frac{4}{8}$, $\frac{6}{8}$, $\frac{7}{8}$, $\frac{8}{10}$,</p> <p><u>Questions:</u> Create a context for each fraction $\frac{1}{8}$: If there were 8 boys in 5th Class</p>	<p>Scaffolding is key throughout the entire lesson. Students need to be encouraged to explore probability rather than focusing on attaining the correct answer.</p> <p>Teacher needs to remember that not</p>	<p>To introduce the probability continuum and convert theoretical probability to numerical values.</p> <p>To revise and order fractions with the students, successful completion of the task, teacher questioning and teacher observation</p>

<p>fractions on paper. One end of the continuum will be marked 0 and the other end will be marked 1. There will be a flashcard of the word certain and impossible. The children in pairs have to think-pair-share the way this could help them understand probability. What is the purpose of this line marked 0 to 1? What are the fractions/ words for? After 3 minutes we will have a whole class discussion to illicit the possible purpose of the line. There will be a blank continuum surrounded by a mixture of fractions on the board. The fractions will vary in denominators and the children will be asked to order the fractions along the continuum. This will act as a whole class activity. This will assess their prior knowledge of fractions.</p>	<p>What is the probability that any one of the boys will be sick tomorrow? $\frac{1}{6}$: What are the chances of any of the teams in the six nations tournament winning? $\frac{1}{4}$: If a pizza was divided up into four pieces and each of the had a different topping.. what are the chances of you getting any one of the toppings? $\frac{1}{2}$ If limerick were to play Tipperary in Match in the Allianz hurling league what are the chances of limerick winning?</p> <p>➤ ‘How do we know that the position of the $\frac{1}{4}$ is in the correct place?</p> <p>This will help children to visualize the probability of an event using fractions.</p> <p>For students who may have difficulty in grasping this concept the fraction wall will be displayed on the IWB for reference at</p>	<p>all students will grasp the concept of proportionality. With regards to the spinners, the students may find it difficult to visualise the likelihoods of the predicted outcomes.</p> <p>Teacher should always remember to link back to the probability continuum throughout the lesson as we are focusing on the ordering of likelihoods.</p> <p>Be conscious that the student that is usually competent at maths may find this topic challenging.</p> <p>Constantly affirm all efforts made by the students.</p> <p>Be sure to allow sufficient time for students to experiment and grasp concepts and ideas.</p>	<p>will act as a means of assessment.</p> <p>Spinner: To link fractions and probability in a visual way and also to introduce the students to fractions within probability games.</p>
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<p>Then, to set the scene 'In order to enter the probability fair you have to order the fractions correctly on the continuum'.</p> <p>Probability spinner: The students will be presented with a large scale spinner (similar to the big wheel of winning streak) at the top of the classroom. This spinner will have many different coloured sections. The teacher will illicit from the pupils in fraction form the probability of landing on 2. The children when they have succeeded in getting the correct answer (1/10- as their will be ten numbered coloured sections with 1 tenth represented by the number 2) will think-pair-share the method they used to decide on the fraction. The following method will act as an aid to focus the children on writing numbers in</p>	<p>all times.</p> <p>As we can constantly change the fraction proportions on the wheel, this task is easily differentiated so to cater for all learning abilities.</p> <p>The children will ascertain fractional value when there is half blue and half yellow Which colour is more likely to occur? Why? After assigning fractional probabilities to a number of scenarios the children will be asked If there was to be a $\frac{3}{4}$, $\frac{1}{8}$, $\frac{6}{8}$, $\frac{2}{3}$ chance of getting a blue look like on the spinner? The children here are creating the scenarios themselves</p>		
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<p>fraction form. Step 1: Count the number of sections labelled with the number 2</p> <p>Step 2: Count how many sections are in the spinner. Step 3</p> <p>step 1 is the numerator over step 2 the denominator. This will form the basis to help children develop a concept of forming fractions from spinners.</p> <p>The students will be invited to spin the wheel after predicting which colour the arrow will land on. The proportion allocated to each number will be changed. This will allow us to explore a number of fraction families; thirds, fifths, tenths, quarters, sixths and eights</p>			
<p>Aim: to determine the probability of an outcome using fractions</p> <p>The aim of this part of the lesson is to get students thinking about the sample space of a certain game, and what the</p>	<p>The students should realise from the start that there is a one in ten chance of any card being drawn from the pack at the start.</p> <p>Students will be asked which card will be first drawn (making</p>	<p>Students will be shown ten cards face down and told that they are numbered one to ten and are of the same suit.</p> <p>N.B. The card is always replaced before the next card is drawn</p>	<p>If students can work out the fractions and place them successfully on the probability continuum.</p> <p>Prediction of outcomes based on the most probable outcome.</p>

<p>outcome of a game is likely to be, based on assigning numerical values (fractions) to cards.</p> <p>To introduce the game the teacher will present ten playing cards of the same suit, numbered one to ten (one being the ace) on the whiteboard. They will be face down. The students will be told that the object of the game is, after the first card is drawn, to guess whether the next card will be of a higher or a lower value.</p> <p>Firstly the teacher will ask every child to discuss with a partner in think pair share, which is the most likely card to be drawn first. After one minute the teacher will ask a number of children which they think is most likely. The children should realise that each card has an equally likely chance of being drawn. The teacher will ask the children if they were to place the chance of drawing any card on the continuum, what fraction would they use and why. This has been covered in the</p>	<p>predictions) and they will have to assign a fraction to the possibilities of drawing a card at random. They will then draw a card and work out the chances of drawing a higher/lower card by counting up the amount of cards with a lower numerical value and the amount of cards with a higher numerical value, and placing that number over the total amount of cards in the deck (10).</p> <p>A numberline will be placed on the board this will act as an aid for the pupils when they're assigning the probabilities of the next card being higher or lower</p> <p>For students who may have difficulty in grasping this concept the fraction wall will be displayed on the IWB for reference at all times.</p>	<p>Constantly affirm all efforts made by the students.</p> <p>It is important to remember to link back to the probability continuum throughout the station work. The teacher should continually remind the students to place the fractional values on the continuum so to make the fractional value more realistic for the students.</p>	<p>That the students will understand the relationship between outcomes and fractions</p> <p>Recognizing that the unlikely outcome can also occur.</p> <p>Recognizing a definite outcome and also an impossible outcome e.g. a higher card than a ten will be drawn.</p>
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<p>introduction with the probability spinner. The teacher will then ask a number of students to draw a card at random from the board, to show that every card has an equal chance of being drawn.</p> <p>The teacher will then draw a card, record its value, and show it to the students before replacing it on the board. The teacher will then quiz the students, is the next card more likely to be higher or lower? The students will have 2 minutes to come up with a reason for their answer in think pair share. Students will realise that if the card is greater than 5, there is more of chance that the next card will be lower and vice-versa if the card is below 5. When this has been elicited from the students responses, they will be asked to assign a numerical value (fraction) to the chances of the next card being higher or lower e.g. a 7 is drawn there is a $\frac{3}{10}$ chance</p>			
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<p>the card will be higher and there is a $\frac{6}{10}$ chance it will be lower. The teacher will then place these fractions on the probability continuum.</p> <p>N.B the denominator will always be 10, as there is ten cards on the board at all times ($\frac{1}{10}$ chance of drawing the same card)</p> <p>The teacher will then hand out a ten cards to every group of four, and each child must take a turn of drawing a card, and telling the other 3 members of the group the fractional possibilities of the next card being higher or lower. The student will then draw a card again, and see did the more likely outcome occur.</p> <p>To challenge a group, the teacher could ask the probabilities of drawing a multiple of three or a multiple of two, and which is more likely to occur and why.</p> <p>Consolidation: Whole Class Discussion If I have 8 cards numbered ace-8 what is the probability of drawing any card?</p>			
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<p>If drew a 3 out of these 8 cards what is the probability of the next card being higher? What is the probability of the next card being lower? What is the probability of it being the same? What are the chances of me drawing an even number? What are the chances of me drawing an odd card?</p>			
<p>DICE To elicit prior knowledge, ask the pupils when they may use a dice and what is on each face of a dice. What shape is a dice? Does the size of the dice effect the overall result? Do you have more of an advantage if you use a large dice opposed to a small dice? What board games would you use a dice in? Through whole class discussion elicit that when the dice is thrown that there is an equal chance for either number of coming up. Elicit why this is also (Due to the fact that each side is the same size and shape)</p> <p>Reinforce the idea of using 1 Dice as fair Continuum 0-1 There will be a brief mention made towards the dice in this station,</p>	<p>The students should be familiar with the use dice so this activity should not be overly time consuming. The beginning of the lesson will begin with an oral discussion on the function of die and the likelihoods of getting a certain value. This section should not take too long as the pupils should be familiar with using a dice from the previous day.</p>	<p>Scaffolding is key throughout the entire lesson. The teacher will have to aid and guide the pupils in answering the questions correctly.</p> <p>When the teacher is making reference to the continuum ensure that you fill in the range accurately</p>	<p>The goal of this activity is to revise and recap the idea of the pupils using one dice and realising that you have an equal chance of getting any number.</p> <p>Once the pupils grasp the basic</p>

<p>as there is an equal opportunity for each number to occur, however elicit the pupil's prior knowledge by asking them where would 7 appear on the range. Scaffold and guide the pupils who may be having difficulty in understanding that 7 would be at impossible as 7 does not appear on a regular dice.</p> <p>Fractions When the regular dice are being used ask the pupils a selection of questions in relation to the dice.</p> <ul style="list-style-type: none"> ➤ What fraction of the dice has an even number? ➤ What fraction of the dice has an uneven number? ➤ What fraction of the dice is greater than two? ➤ What fraction of the dice is less than three? <p>Before providing all the pupils with the 2 die, the teacher will demonstrate at the top of the classroom on how you are to roll the two dice using the cup. The pupils will work in pairs for this activity where each pair will be</p>	<p>The pupils will be aiding the teacher in putting in various different fractions into the continuum. The pupils will get the opportunity to fill in the range themselves in pairs</p> <p>When asking these questions makes sure to give the instructions clearly such as what fraction of the dice is less than two? (Highlight the fact that you will not be counting the value of 2) The pupils will be asked to write the fraction form and order it on the continuum. These questions will be asked through whole class discussion</p> <p>The pupils will all be provided with a 2 die each, this will aid the tactile learners as they will all get the</p>	<p>The teacher will have to question the pupils responses in detail to elicit do they fully understand the concept. E.g. why is there a 1/6 chance of getting the number 6, ensure that the pupils highlight the fact that there are 6 faces on the dice opposed to the pupils saying an answer like there are 6 dots on that particular face</p> <p>When teaching about the 2 Dice, highlight the fact that we are getting the SUM of the 2 numbers. This is similar to monopoly where you add the two values of the two die When asked a question in relation to the die, try not to tell the pupils directly the answer, guide and scaffold the pupils into finding the answer</p>	<p>concepts of where the different numbers appear on the continuum the teacher can move onto the next activity</p> <p>Fractions - That the students will understand the relationship between outcomes and fractions and that they will be able to relate this to other real life situations. This will be evaluated through observation and teacher questioning.</p> <p>The goal with using the second dice will allow the pupils to discover that certain numbers can be</p>
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<p>given 2 die, the pupils will roll the die 15times each and their partner will record the results while this is occurring, the pupils will then swop turns and the other pupil will roll the dice and the other pupil will record the results</p> <p>Once the pupils have the outcomes listed, the pupils in the class will combine their answers using a tally system. When the pupils combine their answers, they will be asked to comment on trends that they notice Through whole class discussion, the pupils and teacher will be listing all the outcomes for getting a certain number. (To get the value 5 you can use 1+4, 2+3 3+2, 4+1) Each group will be provided with the tally sheet directly after they have the dice rolled 30 times.</p> <p>The teacher will then go through the possible outcomes for the first four numbers, the teacher will record the results on the board, each group will then be allocated a number where they must combine all the answers. The teacher will then record these results on the board</p> <p>The teacher will</p>	<p>opportunity to feel and hold the die each. The pupils will then be provided with a second dice and they will be discussing the possibility of getting a certain number. Initially they may feel that they have a 1 in 12 chance of getting any number, however this will be clarified during the lesson.</p> <p>The pupils will be working in pairs for this activity, The pupils will firstly have to write down the different results that they have gathered using the two dice, the pupils will combine their results, and write out the different outcomes. The pupils will work in groups of 4 to outline all the possible outcomes of a certain number</p>	<p>themselves</p> <p>Be sure to allow sufficient time for students to experiment and grasp concepts and ideas</p> <p>Provide the pupils with sufficient time for discovering and listing all the different outcomes for a certain value when using the second dice.</p> <p>Questioning will be important for this activity where the teacher will be eliciting the pupils predictions in relation to using two dice.</p> <p>The teacher will reveal all the possible outcomes on the board and there will be reference made to the continuum on display in the classroom.</p>	<p>formed easier than others, (You have a greater chance of getting a 7 with 2 dice than any other value between 2 and 12)</p> <p>The students will be evaluated through their responses and ability to formulate and answer questions/problems.</p>
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<p>explore the possibility of the 36 different outcomes</p> <p>Have the continuum on display with all 36 segments on it. Ask a selection of questions in relation to it.</p> <ul style="list-style-type: none"> ➤ Of all those outcomes, what is the possibility of getting an even number when you add your two numbers together? ➤ What is the possibility of getting an odd number? ➤ What is the possibility of getting a number greater than 15? ➤ What is the possibility of getting a number less than 15? ➤ What is the possibility of getting 7 when you add your two numbers together? ➤ What is the possibility of getting a number less than 3? ➤ What is the possibility of getting a 1? ➤ What is the possibility of 	<p>Question the pupils on why there are 36 different outcomes. Through scaffolding alert the pupils to the fact that $6 \times 6 = 36$ Likewise when you add all the outcomes together you will get 36.</p>		<p>Teacher assessment will be pivotal throughout this activity where the teacher</p>
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<p>getting a number made up from 2 even numbers? Conclusion of the work will consist of an open discussion based on the concepts covered in the lesson. The class will be discussing whether it is fair to use 2 dice? (if you one dice do you have an equal chance of getting a number? If you use two dice do you still have a fair chance? Why didn't we a 1 when we used the two dice?</p> <p>Is using a dice a fair way for playing a board game and why?</p>			
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<p><u>Evaluation</u></p> <p><u>Activity-Die dilemma</u></p> <p>In this activity, the children will further explore and develop their understanding of the sample space of 2 die. The children will be placed in groups of four for this activity. Each group will be given a large work card which will contain a large scale circle which is divided into 36 sections. Each child will be given one coloured counter to be used as a marker and each child will have a different colour. Children place counters at zero to begin with and race around the 36 steps back to zero. The group rolls the two die and depending on the outcome, they move along the 36 steps accordingly. For example, if 7 is rolled, the children will cover 6/36 of the circle as there are six combinations that add to 7 when two die are rolled. If time permits the children will play the game twice. This will help children to realise</p>	<p>The students will work together in teams of four engaging in practical hands on activity. Their aim is to race around the 36 steps of the circle. In order to move forward, the students will be required to refer to the number of combinations of each number rolled which will be displayed on the whiteboard. This aims to consolidate the student's learning.</p> <p>On completion of the previous activity, it is foreseen that the students will carry out this activity with enthusiasm. After clear and precise instruction all children should feel competent and enjoy this activity.</p> <p>Group work will facilitate the weaker students in the class leading to an element of peer tutoring.</p>	<p>The teacher will be required to give precise and clear instructions prior to the activity so to ensure all children understand the aim of the activity.</p> <p>Teacher will encourage students to refer to the combinations listed on the board if the students experiences difficulty.</p> <p>Teacher observation will ensure that all children participate in the activity and allow the teacher to assist students where necessary.</p> <p>It is important to keep the students focused and on task so that the learning objectives are met.</p>	<p>The goal of the activity is to explore and develop the students understanding of the sample space of two die.</p> <p>This activity aims to make the concept of the sample space of two die realistic and enjoyable.</p> <p>Regular monitoring of this activity will enable the teacher to evaluate and assess the students learning.</p>
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<p>that using two die isn't a fair game. They will order on the continuum the fractional chances of each number.</p> <p>In completing this activity, the concept of 36 possibilities will be consolidated and made real for the class.</p>			
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