Chapter 4
Enacting Curriculum Reform Through Lesson Study in the Irish Post-primary Mathematics Classroom

Aoibhinn Ní Shúilleabháin

Abstract Lesson study was introduced in two secondary schools in the Republic of Ireland (ROI) at a time of mathematics curriculum reform. The research investigated lesson study as a model of professional development which might support teachers in implementing the revised curriculum. Twelve teachers participated in the research and data included transcripts of lesson study meetings, individual interviews, samples of student work, and research lesson plans. Findings suggest that, through their participation in successive cycles of lesson study, teachers were supported in: encouraging more student communication of mathematical thinking, developing their roles as facilitators of student learning, and incorporating contextualised mathematical tasks. The research indicates that lesson study can be utilised in the introduction of curriculum reform and provides evidence of the viability of school-based lesson study in the ROI.

Keywords Lesson study · Mathematics teacher education · Curriculum reform

4.1 Introduction

Over the past two decades, lesson study has grown in popularity as a form of teacher professional development and has been introduced as a model of teacher collaboration in a broad range of educational contexts around the world, from primary to third-level (e.g. Cerbin & Kopp, 2006; Huang & Shimizu, 2016; Leavy & Hourigan, 2016). Research on teacher learning in lesson study has demonstrated the potential of this model in developing teacher knowledge (e.g. Lewis & Perry, 2017; Ni Shuilleabhain, 2016) and impacting classroom practices (e.g. Olsen, White, & Sparrow, 2011). In this chapter, lesson study is investigated as a model of

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mathematics teacher professional development which supports the implementation of curriculum reform.

In 2010, the post-primary mathematics curriculum in the Republic of Ireland (ROI) was revised and changes were introduced both in the content and emphasis of teaching and learning approaches in the mathematics classroom (Jeffes et al., 2013; National Council for Curriculum and Assessment, 2012a, 2012b). This revised curriculum emphasised a sociocultural approach to teaching and learning mathematics, which highlighted the importance of students' sense-making and ability to apply their mathematical knowledge to non-procedural problems (National Council for Curriculum and Assessment, 2012a, 2012b). This reform demonstrated a dramatic shift in perspectives on teaching and learning mathematics, moving away from the traditional, 'transmission' approach commonly found in the Irish post-primary classroom (Lyons, Lynch, Close, Sheerin, & Boland, 2003).

As part of the introduction of this reform, centralised in-service professional development was made freely available to all post-primary mathematics teachers throughout the country. However, a report on the implementation of the curriculum found little change in the approaches to teaching and learning mathematics (Jeffes et al., 2013). In this research, lesson study was introduced to two case-study post-primary schools, as a potential alternative model to support teachers in the implementation of the revised curriculum. Twelve teachers across the two schools agreed to participate in the research and these two groups conducted successive school-based cycles of lesson study over one academic year.

Findings suggest that participating in school-based lesson study supported teachers in introducing new teaching and learning approaches related to the curriculum reform and impacted on their pedagogical practices outside of lesson study. The research also supports the introduction of lesson study as a viable, local model to support teacher learning in the ROI.

This work is grounded on the relationship between teachers' knowledge and beliefs about teaching and learning mathematics and their pedagogical practices (O'Shea & Leavy, 2013) and also recognises that classroom-level experiences are more influential than policy documents in the implementation of new curricula (Hopkins & Reynolds, 2001).

This chapter is related to findings reported in Ni Shuilleabhain and Seery (2017) and incorporates additional data from a second case study school.

4.2 Lesson Study in Ireland

Over the past 15 years, lesson study has been gradually included in research, policy, and practice in teacher education in the ROI. In 2003, Kelly and Sloane presented lesson study as a potential solution to an identified lack of alignment between research and practice in the Irish education system (Kelly & Sloane, 2003). In this initial reference to lesson study in the Irish context, Kelly and Sloane suggested that the incorporation of lesson study as school-based model of

professional development could provide opportunity for teachers to collaborate at county[1] (or district) level and, eventually, at a national level—thereby supporting the development of teacher knowledge in "an educational system that actively fosters professionalism by teachers in their own clinical development" (ibid., p. 34). In 2005, a report on international trends in post-primary mathematics education was published by the National Council for Curriculum and Assessment (NCCA), which highlighted the merits of lesson study as a model of teacher professional development in Japan. The authors, Conway and Sloane, noted that "the quality of instruction found in Japanese classrooms is something that should be emulated where possible" (2005, p. 68) and, while cognisant of the culturally based elements of lesson study, suggested this model be adopted in the Irish school system.

Lesson study began to be incorporated in mathematics teacher education in the ROI at a pre-service primary (see, for example, Corcoran (2007) and Leavy, Hourigan, & McMahon (2010)) and pre-service post-primary level. However, at the time of the curriculum reform (2010–2012) in-service teachers had little experience with school-based lesson study.

4.3 Revision of the Post-primary Mathematics Curriculum in Ireland

In Ireland, a centralised curriculum is written by a government education authority, the National Council for Curriculum and Assessment (NCCA), and distributed to teachers through syllabus documents (which are also available on-line). Following a review of international trends in post-primary mathematics education (Conway & Sloane, 2005) and discussions around the low numbers of students choosing to study mathematics at higher level (Oldham, 2010), the post-primary mathematics curriculum was revised. This new curriculum, colloquially known as 'Project Maths', explicitly encourages students' communication of their mathematical thinking, highlights contextual applications of mathematics, and emphasises the development of students' problem-solving skills (National Council for Curriculum and Assessment, 2012a, 2012b). This prominence of mathematical problem-solving is closely aligned with the primary mathematics curriculum, which also encourages students' communication of their mathematical thinking as part of classroom practice and highlights the role of the teacher as a facilitator of student learning (O'Shea & Leavy, 2013). This reform-oriented approach to teaching and learning mathematics contrasts with the more traditional, didactic approach prevalent in post-primary mathematics classrooms in the ROI (Lyons et al., 2003).[2] Instead, the revised approach emphasises classroom interactions where students

[1]The ROI consists of 26 different counties under one centralised curriculum system.

[2]Similar to the 'maths wars' in the U.S., this curriculum reform has also generated considerable debate in the Republic of Ireland (Lubienski, 2011).

learn to speak and act mathematically by developing core mathematical competencies (Goos, 2004; NCTM, 2010; Schoenfeld, 1992; Steele, 2001).

Although implementation of the new curriculum was supported with provision of extensive in-service professional development and complementary modular courses (National Council for Curriculum and Assessment, 2012c), many teachers remained concerned about the implementation of the revised curriculum (Irish Mathematics Teachers Association, 2013; National Council for Curriculum and Assessment, 2014). Furthermore, a study on the implementation of the curriculum reported continued widespread use of traditional practices, such as 'drill and practice' and students copying teacher work from the board (Jeffes et al., 2013).

Within this context, this research was conducted to investigate the impact of teachers' participation in school-based lesson study on enacting curriculum reform in the post-primary mathematics classrooms.

4.4 Lesson Study and Curriculum Reform

Across the globe, there has been a change in the emphasis of mathematics curricula from a strong weighting on mathematical procedures to an increased emphasis on the conceptual understandings related to those procedures (Prusak, Hershkowitz, & Schwarz, 2013). With this greater focus on the development of students' core mathematical competencies (NCTM, 2010), there has been renewed attention on classroom practices and approaches to teaching and learning mathematics. However, introducing curriculum reform is not a linear process and it is not often that standards set at policy level feed directly into teaching and learning experiences (Fung, 2000). In order to encourage and support educational change, teachers require opportunity to learn in new ways, to consider new ideas about teaching and learning, and to reflect on experiences of teaching and learning which may influence their beliefs and practices (Cohen & Hill, 2000; Remillard & Bryans, 2004).

Research has demonstrated that collaborative communities are a key element of successful educational reform (Lomos, Hofman, & Bosker, 2011), particularly in the implementation of reform curricula (Penuel, Fishman, Yamaguchi, & Gallagher, 2007). One of the challenges in supporting the enactment of curriculum reform is therefore the consideration that teachers often teach alone in isolated classrooms, without the opportunity to reflect on or observe other pedagogical practices. This is particularly relevant at post-primary level in the ROI, where levels of professional collaboration are low and where there is an absence of cultural and administrative school frameworks which support teacher learning (Gleeson, 2012). Further research on mathematics curriculum reform has found that the most significant learning for teachers occurs in processes of enacting the revised curriculum in the classroom (Remillard, 1999, 2000). In impacting teachers' beliefs and practices on teaching and learning mathematics, it is also important that teachers have opportunity to focus on student thinking (Mason, 1998).

The structure of lesson study provides teachers with opportunity to work collaboratively on teaching and learning, while also observing classroom practices and reflecting on student thinking (Lewis, Perry, & Hurd, 2009). This situationally contextualised professional development offers teachers the opportunity to work with colleagues and explicitly consider curriculum content, incorporate new and unfamiliar practices, and reflect on pedagogical strategies influencing student learning (Dudley, 2013). The sequence of phases within the lesson study cycle incorporates key elements of teacher professional development associated with mathematics curriculum reform (Ponte, 2012) and have been found to support reform in countries such as Japan (Lewis & Tsuchida, 1997; Takahashi, 2014).

In the ROI, teacher professional development is most often in the form of an "in-service" day held at an external location (Gilleece, Shiel, Perkins, & Proctor, 2009) and are often seen as an "add on" for teachers, who are neither incentivised nor formally acknowledged for their participation (Sugrue, 2006).[3] This structure of professional development has been criticised as diluting the autonomous role of the teacher as a professional with individual career preferences and aspirations, to that of a servant of the state (Kennedy, 2007). In contrast, lesson study provides teachers with a structure within which their professional knowledge, judgement, and autonomy are acknowledged in each phase of the cycle—affording teachers valuable opportunities to focus on and potentially refine their practices. In participating in lesson study, the challenge for teachers no longer emphasises changes to their practices, but rather focuses on identifying the kinds of innovation and reform that will improve students' learning experiences in the classroom. Lesson study therefore holds many key features of professional development which are likely to support teachers in implementing educational reform.

4.5 Methodology: Two Case Study Schools

This research was conducted in two case-study secondary schools: Doone and Crannog (all names used are pseudonyms). These schools were contacted through the school principal and, following an information meeting, a number of mathematics teachers within each school volunteered to take part in the research.

Participating teachers' years of experience ranged from 1 to 35 years and, as expected in the Irish post-primary system, a number of teachers reported themselves as "out-of-field" (i.e. teaching mathematics without full subject-requirements recognised by The Teaching Council (Ríordáin & Hannigan, 2011), see Table 4.1). In both Doone and Crannog, school management were supportive of teachers' participation in lesson study—an important factor in introducing this (as yet) unusual form of school-based professional development in the ROI.

[3]A policy on teacher education is due to be implemented by the Teaching Council, which will formally acknowledge teachers' participation in professional development.

Table 4.1 Participating teachers' years of experience

Doone		Crannog	
Name	Years of experience	Name	Years of experience
Kate	3 (out-of-field)	Dave	5
Lisa	7	Eileen	3 (out-of-field)
Michael	6 (out-of-field)	Fiona	31
Nora	30	Judy	19
Owen	1 (out-of-field)	Martin	27
		Stephen	9 (out-of-field)
		Walter	12

Table 4.2 Content and class focus of research lessons

School	Doone		Crannog	
Lesson study cycle	Lesson content	Student group	Lesson content	Student group
1	Introducing x-squared	Grade 7	Introducing quadratic patterns	Grade 8
2	Fractions—sense of measure	Grade 7	Factorising quadratic expressions	Grade 8
3	Exploring quadratic expressions	Grade 10	Factorising quadratic expressions (revised)	Grade 8
4	Introducing Pythagoras' Theorem	Grade 8	Introducing differentiation in Calculus	Grade 10

The research was conducted over the course of one academic year (2012–2013) and successive cycles of lesson study were conducted in both schools (four in Doone and three in Crannog) (see Table 4.2).

To determine if teachers' participation in lesson study supported them in their implementation of the revised curriculum, data was generated through a wide variety of sources including: transcripts of teachers' conversations and notes from all lesson study meetings, individual teacher interviews, research lesson plans, observation sheets and samples of student work from research lessons, and researcher field notes on observed lessons. The author, a former post-primary mathematics teacher, served as a participant-researcher on both sites (Bogdan & Biklen, 2007) and recorded a researcher log which guided, but did not form part of, the data analysis (see Ni Shuilleabhain (2015) for further details).

Each cycle of lesson study followed the structure of: formulating a goal and studying the curriculum, planning a research lesson with reference to literature and curriculum materials, conducting or observing the research lesson, and reflecting on the research lesson with opportunity to revise and re-teach the lesson if teachers felt that it did not meet the learning objectives of the lesson (Lewis, Perry, & Murata, 2006).

In both Doone and Crannog, teachers agreed to participate in the research as a way of supporting themselves in the implementation of the new curriculum and as a way of learning how to collaborate as a group of mathematics teachers. Unlike most in-service models of professional development presently available in the ROI, teachers had autonomy in choosing the subject matter focus of each of the research lessons. Teachers also had authority in deciding the number of research lessons which they would participate in over the course of the academic year. In both Doone and Crannog, teachers chose to plan lessons across a number of topics in the curriculum for a variety of student groups at both junior and senior post-primary level (see Table 4.2).[4]

Analysis of the data was conducted utilising a framework which reflected the goals of the revised curricula (National Council for Curriculum and Assessment, 2012a, 2012b) and aligned with pedagogical practices associated with sociocultural theories of learning (Goos, 2004; Schoenfeld, 1992; Steele, 2001):

1. Supporting students in communicating their mathematical thinking
2. Teachers acting as facilitators of student learning
3. Designing and incorporating contextualised content relevant to students' learning.

Analysis did not commence until all data had been generated and was triangulated through iterative analysis of teachers' collaborative conversations, materials generated in lesson study, and individual teacher interviews.

In establishing the base-line of participating teachers' participation in and implementation of the curriculum reform (Bubb & Earley, 2010), teachers were interviewed prior to their participation in lesson study. All teachers except Nora[5] had participated in the professional development courses offered as part of the curriculum reform. However, as can be the case with external professional development courses (Fung, 2000), teachers rarely utilised or trialled the curriculum materials and ideas introduced in these modules.

> They [referring to curriculum materials] kind of go in the pile and I'll say 'I'll come to it, I'll look at that again' and you just never do. (Kate, Interview 1)

Participating teachers' opinions of the revised mathematics curriculum varied. Nora (who taught remedial mathematics on a voluntary basis in the school[6]) was confident that her teaching already aligned with the new curriculum, but others remained unsure of how to incorporate new practices in their teaching. As an out-of-field teacher, Michael was wary of the reform and did not feel confident in his ability to teach mathematics. Others, such as Owen and Judy, were opposed to

[4]Grade 7 relates to 'first year' in the Irish system. Students in grades 9, 11 and 12 are preparing for important national examinations and teachers therefore chose not to include these year-groups as a focus of their research lessons.

[5]Nora was officially retired from teaching and was therefore not offered opportunity to participate in these courses.

[6]This is not common practice in the ROI.

the reform and the pedagogical practices espoused by the curriculum. None of the participating teachers were familiar with lesson study but, as reported in their initial interviews, they hoped that their participation would support them in their implementation of the revised curriculum and support them to collaborate with their colleagues.

> I think that we would have a better understanding of how to collaborate on what we are teaching and how to teach it. (Walter, Interview 1)

4.6 Findings

Three key findings related to the impact of teachers' approaches to teaching and learning mathematics are presented here, as relevant to the curriculum framework outlined above. These findings serve to demonstrate the opportunities provided to participating teachers to incorporate new and unfamiliar practices in research lessons, as a result of their participation in successive cycles of lesson study. The findings also document teachers' reported changes to their teaching and learning practices outside of lesson study.

Excerpts of qualitative data are used to provide the reader with examples of teacher learning during the research.

4.6.1 Emphasising the Social Dimension: Supporting Students in Communicating Their Thinking

A key finding of the study were the changes to teachers' approaches in supporting students to communicate their mathematical thinking. In Doone, at the commencement of the research the teaching and learning of mathematics had been of a direct nature, where students often worked individually and silently at their desks and where content was often introduced through exposition and repetition of tasks (Boaler, 1998). While teachers had explicitly wanted to incorporate more student communication in their first research lesson, neither the structure of the lesson nor tasks within the lesson provided students with opportunity to consider and communicate their mathematical thinking to one another or to the teacher. In their post-lesson discussion, teachers were disappointed with the lesson, noting a lack of engagement from the students and reflecting on the underlying structure of students' interactions in the lesson. Following this cycle, the conducting teacher, Lisa, changed her classroom layout from individual tasks to tables arranged for group work and shared her positive reflections on this new classroom environment with her colleagues during a planning meeting in the second cycle:

> They can all see each other's work. "You're not doing that right" [mimicking student]. I love it. I would never go back. (Lisa, meeting 3, cycle 2)

This change to Lisa's practice, relating directly to her teaching of the first research lesson, encouraged her colleagues to explicitly focus on encouraging more student communication in subsequent research lessons and, by the end of the year, all teachers within this group reported a new emphasis on student communication in their own teaching. This was most notable for Owen, an out-of-field teacher who, at the beginning of the research, described himself as "anti-Project maths" and described his mathematics classroom as very traditional. In his final interview, he noted the importance of students discussing their mathematical thinking:

> I would be conscious to have a chat about whatever [maths topic] we were doing. Even though it might waste twenty minutes, I don't think it's a waste. (Owen, interview 3)

In Crannog, teachers embraced the curriculum goal of incorporating more student communication of mathematical thinking from the initial lesson study cycle. However, while teachers were positive about incorporating this practice in their teaching, they did not feel confident in how best to encourage students' communication in class and wanted to utilise lesson study as an opportunity to trial this unfamiliar practice.

Fiona The class and myself both have to develop in improving group work techniques.

Walter What questions to ask, what tasks to set them and how to sort of facilitate that best.

Fiona Just to develop group teaching with group work.

Dave It's a different classroom culture. It's a very hard thing to change because we've had the same culture in so many of the classrooms in Ireland I think for so long.

The collective and collaborative exercise of planning research lessons provided the group with the opportunity to attempt this new practice and the teachers devised a mathematical task where students would work in groups to identify a quadratic pattern from a sequence of numbers. The teachers treated the research lesson as an experiment in how students would engage with and react to working in small groups and, in their post-lesson discussion, were excited to reflect on students' communication of their mathematical thinking during the lesson.

Fiona It worked! Those guys over there [referring to one group of students] I was watching, they really helped each other. They hugely helped each other, they were listening to each other. They had great discussions.

Walter That was all on task. Nobody, as far as I could see, nobody was talking about -

Martin They were really engaged in what they were doing. That dynamic is great to watch how they are hitting off each other and when they have their own ideas – it is good.

Judy They were all going "It's not linear". You know what I mean? They were delighted with themselves that they actually saw that -
Stephen They got there themselves.

Following this initial research lesson, the teachers were more positive about encouraging student communication during lessons and noted that, when given time to work on a collaborative activity, students stayed on-task in their mathematical work. The group continued to highlight and incorporate students' communication of their mathematical thinking in subsequent research lessons through pair-work, small group, and whole-class activities and discussions. At the end of the academic year teachers reflected on the impact their participation in lesson study had had on student learning and felt that students' experiences of sense-making would benefit their learning.

> Because even when they're having to work in groups and they're talking about maths, that has to help with those language-y questions, those wordy questions where they've been actually putting it into words themselves. (Fiona, final teacher meeting)

In both Doone and Crannog, teachers' participation in school-based lesson study provided them with a structure within which they could trial and refine the incorporation of students' communication of their mathematical thinking during research lessons. Over successive cycles of lesson study teachers integrated new ways to encourage students to verbally make sense of their mathematical thinking, in line with the goals of the curriculum reform. In their concluding individual interviews teachers also identified these practices in their teaching outside of lesson study.

4.6.2 Teachers as Facilitators of Student Learning

Incorporating more student communication of their mathematical thinking requires the role of the teacher to shift from that of a knowledge-provider to a facilitator of students' learning—moving from 'show and tell' to facilitating mathematical discussions (Stein, Engle, Smith, & Hughes, 2008). This was a new departure for almost all teachers participating in this research, who were more comfortable and familiar with a direct approach to teaching and learning mathematics through teacher exposition and repetition of tasks. By incorporating more organisational forms in the mathematics classroom, the role of the teacher began to evolve and, in both schools, the planning of research lessons began to explicitly incorporate the teacher's role as that of a facilitator who guides and sequences student learning.

From the first research lesson in Doone, teachers began to note the import of the teachers' role in responding to students' questions and utilising students' prompts to guide a discussion towards the learning goals (Webb et al., 2009). In their planning of a research lesson introducing x^2, the teachers had not anticipated a student query related to the exponent: "*Is the number [of the power] always 2?*". The conducting

teacher, Lisa, was unsure of how to respond and ignored the student's question during the lesson. In their post-lesson discussion, Kate noted that this question would have been a valuable opportunity to discuss the representations of indices. The teachers realised that facilitating discussions related to students' thinking was a valuable element of introducing new concepts (Stein et al., 2008) and they began to focus more on how teachers could guide students in their understanding. As part of their planning, they began to anticipate questions which students might ask during a lesson and incorporated potential teacher responses in their planning.

Similar teacher learning occurred during the first lesson study cycle in Crannog where, in their post-lesson discussion, teachers realised that they had not anticipated all of the strategies students might consider in identifying a quadratic pattern.

Dave I think two or three of the groups got the thing the wrong way around, the levels 1, 2, 3, 4. Your group did and yours as well, yeah.
Eileen Mine did, yeah.
Walter I don't think we spotted it as a potential.
Dave No we didn't.

In subsequent cycles, teachers paid explicit attention to considering all possible strategies students might have in solving a mathematical task, in order to ensure the conducting teacher would be equipped to respond to students' work during the research lesson. In their second research lesson, teachers spent a considerable amount of their planning sessions thinking about various ways of factorising a quadratic expression (see Fig. 4.1). Due to these conversations, teachers in the group felt more knowledgeable on various factorising strategies and better equipped to deal with students' misconceptions.

Eileen noted that, in an attempt to incorporate more student group work into her own teaching, she was also engaging in anticipating students' responses to mathematical tasks outside of lesson study.

> I probably would ask myself a bit more like "How would they react to this?" or "What questions will they have?" Like, pre-empt their questions or pre-empt their confusion. Em, yeah, I would think about that a little bit more. (Eileen, interview 3)

Over successive lesson study cycles, teachers in Doone and Crannog began to incorporate their knowledge of student learning into the planning or refining of research lessons and, in anticipating student responses to mathematical tasks, began to refine their roles as facilitators of student learning (Stein et al., 2008).

As well as incorporating ideas on students' anticipated responses, both groups also began to pay more attention to the questions asked by the conducting teacher in research lessons. Research lesson plans began to include scripted questions as a tool to support the conducting teacher in their role as a facilitator of student learning. This element of planning required teachers to write questions which deviated from the closed questions often asked as part of traditional classroom teaching (Lyons et al., 2003). In the post-lesson discussion of research lesson 3 in Doone, where

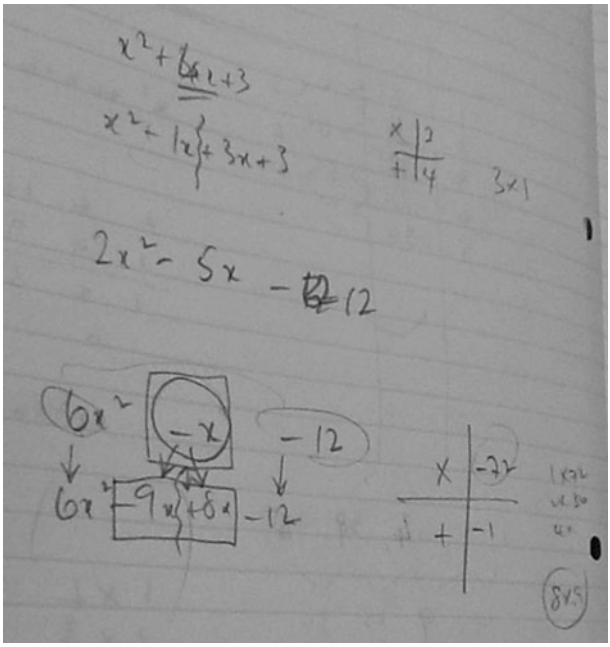

Fig. 4.1 Photograph of Crannog teacher planning notes—trialling various strategies of factorising a quadratic expression

students had worked in groups on exercises and shared their responses as a whole class discussion, Kate (the conducting teacher) commented that:

> There was very little teaching involved in it really. Just kind of facilitating – which is what it's all about. (Kate, post-lesson discussion 3)

She later noted that she wanted to continue to work on the skill of facilitation: "*That pure questioning will be going into my repertoire now*". Teachers reported that these experiences impacted on their practices outside of lesson study. In his final interview, Owen, who at the beginning of the research noted that it was "*hard to let go*" of his direct approach to teaching, noted that his participation in lesson study encouraged him to focus on his role of guiding student learning.

> From these meetings, as well, I'm conscious of open-ended questions rather than "this is what it is. This is the answer". (Owen, interview 2)

Walter, in Crannog, acknowledged that acting as a facilitator of learning required him to allow students more time to work by themselves and he considered this new practice to be much more beneficial to students' learning.

Over successive cycles of lesson study, individual teachers began to evolve in their roles as facilitators of learning and encouraged more "reasoning and sense-making opportunities" in teaching and learning mathematics, as outlined in the reform curriculum (National Council for Curriculum and Assessment, 2012a, p. 10).

4.6.3 Designing and Incorporating Contextualised Content

As part of their role as facilitators of student learning, teachers chose to incorporate mathematical tasks which would engage students in their learning and highlight the application of mathematics in the world around us. Task development is a critical element of lesson study (Doig, Groves, & Fujii, 2011) and, throughout the course of this study, teachers in both schools explicitly focused on incorporating tasks which were relevant to the mathematics, but also held meaning or had context for students (Lampert, 2001).

Prior to the introduction of the curriculum reform, textbooks in the ROI had been found to emphasise abstract and procedural tasks, with little prominence of situated problem-solving tasks (O'Keefe & O'Donoghue, 2011). As part of the lesson study planning phase, teachers rarely found appropriate mathematical activities in the text-books and were therefore prompted to modify tasks from other sources (for example from teacher magazines or alternative textbooks) or design their own tasks. This was a new departure for teachers since, in the ROI, textbooks often act as a mediator between curricular intention and implementation (Looney, 2004). This *kyozai-kenkyu* element of planning the research lesson (Doig et al., 2011) broadened the range of sources which would usually be utilised by teachers in their planning.

In Doone's first research lesson, tasks were based on a rural farmer calculating the area of a field and held little meaning for grade 7 students in an urban school. In their post-lesson discussion teachers resolved that, in order to further motivate students to engage with mathematical content, tasks should be relevant and have context for learners (Stanic & Kilpatrick, 1989). In subsequent research lessons teachers enjoyed collaboratively designing mathematical tasks which would be of interest to students, see Fig. 4.2 as an example.

In their post-lesson discussions, teachers noted how students were prompted to further engage with the mathematical content of the activity, due to the context.

Michael They were talking about the temperature rising and then they were saying, well, they were joking, "she's going to explode!"… But that shows that they understand what they are being asked.

Kate Even one group were saying like "Ah, this couldn't be true"… He [the student] was like "the temperature would clearly rapidly increase and then slowly come down".

Teachers reflected that explicitly providing context for mathematical activities provided students with meaningful representations for mathematical content, which benefitted their engagement in the lesson.

In each successive research lesson in Crannog, teachers also purposefully designed tasks which would provide relevant activities for students learning new mathematical content. In their final cycle, teachers devised a series of lessons to introduce the concept of differentiation through experiments and simulations.

After years of research and clinical trials, 2 biologists have shown that the temperature of a person suffering from the flu can be modelled by the function:

$$T = -0.1t^2 + 1.2t + 98.6$$

Where T is the temperature in degrees Fahrenheit, at time t, in hours.

Una is feeling unwell and visits Dr Nolan's surgery. Dr Nolan diagnoses her with the flu.

a) Predict her temperature after 1 hour.

b) Predict her temperature after 2 hours.

c) After how many hours will her temperature peak?

Fig. 4.2 Application of quadratic functions—contextualized activity from Doone research lesson 3

Modifying a task provided in curriculum materials (which none of the teachers had yet incorporated in a lesson), teachers constructed a task where students could develop a conceptual understanding of calculating an instantaneous rate of change, before being introduced to the methodology of differentiation by first principles (see Fig. 4.3).

Over the course of the academic year, teachers in both Doone and Crannog enjoyed the opportunity to design and develop their own mathematical tasks as relevant to the revised curriculum. Through this collaborative work teachers devised tasks which were directly relevant to their own students and demonstrated the application of mathematics in context, as opposed to a solely abstract or procedural approach.

4.7 Discussion: Incorporating Lesson Study in the Irish Post-primary System

Participating in successive cycles of school-based lesson study supported the teachers in Doone and Crannog to implement the revised post-primary mathematics curriculum. By taking part in this collaborative work, teachers engaged directly with curriculum documents and materials and were provided opportunity to devise research lessons in an environment which allowed them to: take risks in their

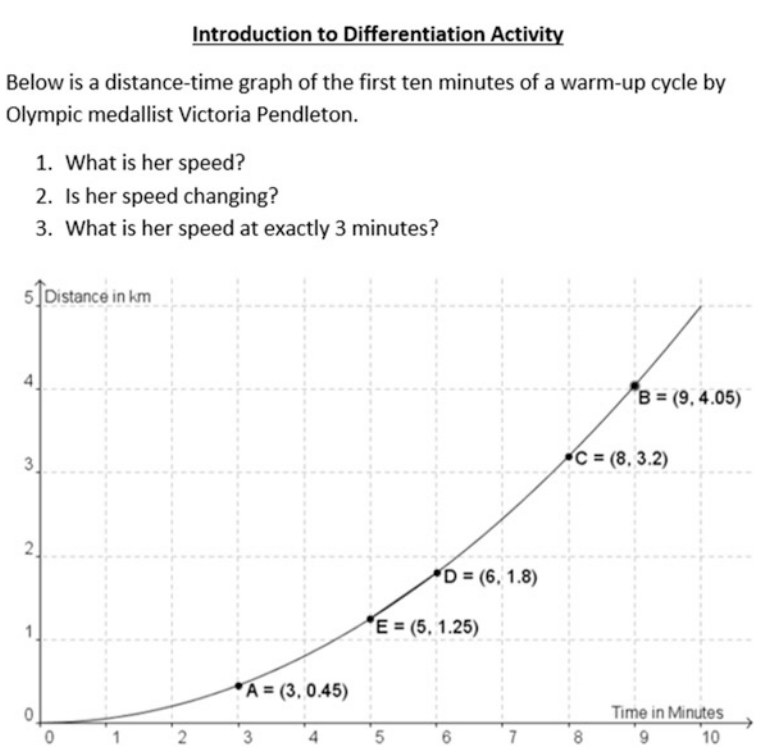

Fig. 4.3 Introducing differentiation—contextualised activity from Crannog research lesson 3

classroom practices (Dudley, 2013), collectively design lessons related to the curriculum, and reflect individually and co-operatively on teaching and learning. Over successive cycles, teachers in both schools began to develop research lessons which aligned with the reform curriculum by encouraging student communication of mathematical thinking, supporting the role of the teacher as a facilitator of learning, and emphasising contextual mathematical tasks as relevant to their students' learning.

By providing teachers with opportunity to work with their peers in a situated, school-based model, these participants felt supported in their efforts to implement the new curriculum.

> I think getting together like this formally is kind of, you know, it's vital. We talk all the time about how we're teaching and what we're teaching… If you're putting in place the opportunity for people to work together, I think it's going to be a good thing. (Dave, final meeting)

In their final interviews, all participating teachers felt they had gained from their participation in lesson study and felt more confident in implementing the revised curriculum. All teachers noted that they would like to continue to participate in lesson study. However, without official recognition or structural support, they did

not consider they would be able to do so. Aligning with other literature on collaborative professional development, each of the participating teachers highlighted the voluntary and autonomous nature of their participation in lesson study as an important factor of their buy-in and engagement (Robutti et al., 2016). Teachers valued that, unlike traditional in-service professional development, they chose the focus of mathematical content and decided which class groups they would like to plan a research lesson for. In addition, they could independently consider what pedagogical approaches they might adopt in planning the research lesson. Teachers' reflections on the import of their autonomy in participating in this form of professional development may be relevant in future policy-making on teacher education in the ROI.

In addition to systems around teacher professional development, school management and structures are key elements of teachers' meaningful participation in lesson study (Groves, Doig, Vale, & Widjaja, 2016). In Crannog, school management supported teachers in pursuing lesson study for the following academic year by ensuring mathematics teachers had a common double free-period where they could conduct meetings around pedagogy. This was, unfortunately, not possible in Doone and, while teachers continued to collaborate on an informal basis, school-based lesson study was not sustainable without policy provision on incorporating and supporting collaborative forms of school-based professional development.

A wide-scale introduction of lesson study is now being introduced across the ROI by the Department of Education, with over 250 teachers from 110 post-primary schools taking part in school-based and district-based groups (Maths Development Team, n.d.). Similar to Groves et al. (2016), this particular introduction of lesson study emphasises the implementation of structured problem solving in the mathematics classroom and support from the Mathematics Development Team is provided in the form of an induction programme with follow-up support from lesson study associates (similar to Maths Coaches in the USA). Since 2015, an annual conference has taken place where teachers participating in lesson study can showcase their work and observe live research lessons (Maths Development Team, n.d.). In contrast to the introduction of lesson study as a top down professional development initiative (Kusanagi, 2014), this national initiative is intended as a grass-roots programme for teachers to voluntarily participate in lesson study.

4.8 Conclusion

Educational systems require alignment and inter-connection of curriculum, assessment, teaching and learning practices, and policy in order to achieve the shared goal of improving students' learning experiences and outcomes. However, curriculum reform is often introduced through top-down policy mechanisms, which are not always paralleled in classroom practices (Fetters, Czerniak, Fish, &

Shawberry, 2002). In this chapter, teachers' participation in lesson study in two case studies in the ROI demonstrated the potential of this model to support the implementation of a mathematics curriculum reform. By participating in lesson study, teachers had opportunity to enact reform practices in classrooms to encourage students' communication of their mathematical thinking, develop the role of teachers as facilitators of student learning, and design tasks which provided context to relevant mathematical content. Each phase of the lesson study cycle provided teachers with opportunity to incorporate and utilise curriculum materials, plan content as relevant to their own students, observe the enactment of the curriculum in the research lesson, and reflect on how the goals of the research lesson were met as relevant to the reform. The swan-like nature of lesson study, with its deceivingly simple structure on the surface hiding a depth of knowledge and work incorporated and undertaken in a cycle, provides a model of professional development which supports teachers to introduce and enact curriculum reform.

As well as demonstrating the potential of lesson study to support teachers' engagement with curriculum reform, in this chapter lesson study has been confirmed as a practicable and feasible model of teacher education at post-primary level in the ROI. With pending policy changes to teacher professional development (The Teaching Council, 2011), lesson study can provide teachers in the ROI with sustainable opportunities of school-based collaboration within the continuum of teacher education.

Related to findings discussed in this chapter, further research is required to investigate the potential of this form of professional development in smaller schools in the ROI, where only a small number of teachers are available to engage in lesson study groups. In addition, an evaluation of the introduction of lesson study as a large-scale, national initiative on both teacher and student learning will be of value to both educational research and policy in the ROI.

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