LESSON STUDY: RESEARCHING LEARNING ABOUT TEACHING FROM RESEARCH MATHEMATICS LESSONS

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Biographical Note

Dolores Corcoran is a lecturer in Mathematics Education in St Patrick's College, Drumcondra. She completed her doctoral study at the University of Cambridge, where the title of her thesis was: Developing Mathematical Knowledge in Teaching: A Three Tiered Study of Irish Pre-service Primary Teachers. Her research has led her to a growing interest in socio-cultural theories of learning with implications for teacher education and continuous professional development. Current research interests focus on working with teachers and colleagues, using lesson study to develop the teaching of mathematics, particularly in challenging situations.

KEYWORDS

Lesson study; mathematics teaching; pre-service teachers; community of practice; research lesson.

ABSTRACT

Lesson study is a form of teacher professional development that is intrinsic to the Japanese educational system in first and second level schools and in teacher education. Lesson study has been credited with the success of Japanese pupils in international comparative tests of mathematics achievement (Stigler and Hiebert, 1999). It is gaining international credibility as a means of enhancing the scholarship of teaching and promoting mathematical achievement in diverse school cultures (Asia-Pacific Economic Cooperation Education Network, 2008). Lesson study is a deceptively simple protocol with highly textured nuances. Each lesson study cycle involves a group of teachers, working collaboratively, and hinges on the detailed preparation of a research lesson, which is taught by one of the group and observed and reviewed by others. Increasingly, lesson study is being recognised as an inherently complex site of social, situated and distributed learning (Lave and Wenger, 1991) which challenges the researcher to find new markers of how and under what conditions, participation in the practice of lesson study builds mathematics teacher capacity and translates into more successful teaching of mathematics. Two conjectures have been formulated explaining why lesson study improves teaching and inviting research into the process (Lewis, Perry and Murata, 2006).

The study on which this presentation draws consisted of three tiers (Corcoran, 2008). In the third tier, a teacher development experiment was designed and implemented using lesson study on a yearlong education elective course to develop mathematics for teaching. In this presentation, the concept of *communities of practice* (Wenger, 1998) is used as a heuristic to examine notions of *engagement, alignment* and *imagination* in relation to learning about teaching mathematics on the part of the six student teacher participants. *Accountability to the enterprise* of lesson study and the development of a *shared repertoire* facilitated the *negotiation of meaning* of *research lessons*.

INTRODUCTION

The field of mathematics education - incorporating research into both the learning and teaching of mathematics at primary, secondary and tertiary levels - is one which is of considerable importance in many societies since achievement in mathematics is believed to contribute to economic success (Forfás, 2008). The persistent difference in the performance of Irish students between the reading and mathematical literacy domains (on the international Programme for International Student Assessment (PISA) is a cause for questioning how mathematics is being taught, and possibly not

learned, in Irish schools (Eivers, Shiel and Cunningham, 2008). In an interesting study, Schoenfeld (1988) highlighted the potential to develop expertise in problem solving that may have been present in student teachers, but which was hampered by their experiences of school mathematics. These experiences fostered a stifling rules and procedures approach to arrive at one, teacher-decided, right answer as quickly as possible. Research findings in an Irish study of second level mathematics classrooms indicated that self-styled 'good' and 'successful' teachers of mathematics equated improved learning with the memorisation of formulae and procedures (Lyons *et al*, 2003). The study reported here sought to trial the use of lesson study to promote the integration of teaching and learning of mathematics among a group of prospective primary teachers, by researching children's responses during mathematics lessons.

LESSON STUDY

Lesson study is a form of teacher professional development that is intrinsic to the Japanese educational system in first and second level schools and in teacher education. Lesson study has been credited with the success of Japanese pupils in international comparative tests of mathematics achievement (Stigler and Hiebert, 1999). It is gaining international credibility as a means of promoting mathematical achievement in diverse school cultures (Asia-Pacific Economic Cooperation Education Network, 2008). Lesson study is a deceptively simple protocol with highly textured nuances. One cycle consists of three interdependent parts, the first and third of which can be protracted according to the degree of the lesson study group's engagement with the enterprise. Each lesson study cycle involves a group of teachers, working collaboratively, and hinges on the detailed preparation of a ***research lesson***, which is taught by one member of the group, observed (usually video-recorded) and reviewed by others. The active presence of a Knowledgeable Other - someone from outside the participating teachers' immediate practice – for some or all of the lesson study cycle makes an essential contribution to achieving effective learning outcomes for mathematics teaching. Two conjectures have been formulated explaining why lesson study improves teaching. Conjecture one contends that, *"lesson study improves instruction through the refinement of lesson plans."* Conjecture two contends that, *"lesson study strengthens three pathways to instructional improvement; teachers' knowledge, teachers' commitment and community, and learning resources"* (Lewis, Perry and Murata, 2006, p. 5). In a context where there are perceived deficiencies in mathematics teaching, the possibilities inherent in conjecture two motivated my research.

THEORETICAL FRAMEWORK FOR DATA ANALYSIS

The full study on which this presentation draws consisted of three tiers (Corcoran, 2008). In the third tier, a teacher development experiment was designed and implemented using lesson study on a year-long education elective course to develop mathematics for teaching. Six student teachers chose the lesson study course as part of their third year Bachelor of Education degree programme. They engaged in three full cycles of lesson study, where the group of six prepared and reviewed lessons together but divided into two to teach and observe two research lessons in different school sites. Pseudonyms are used to protect the identity of all participants. I will describe here evidence from a single research lesson that was taught by Bríd during lesson study cycle two. Bríd had chosen to participate in the lesson study elective with the express objective of learning to teach mathematics well. The research lesson she taught was to a lively fifth class in a mixed primary school situated in a middle class suburban area of Dublin. This was a 'dive-in' lesson, without the benefit of background knowledge of pupils available to a school staff. Nonetheless, it was a valuable learning experience for the lesson study group. One incident from this research lesson is used to illustrate how learning about teaching mathematics occurred for one prospective teacher and her colleagues. The concept of "*communities of practice*" (Wenger, 1998) was used by the researcher as a heuristic to examine lesson study in relation to learning about teaching mathematics by the six student teacher participants. Three further notions elaborated by Wenger as essential to learning by participation in practice were also used in analysis. Evidence of "*accountability to the enterprise*" of lesson study, where in each cycle, student teachers' mutual engagement in the protocols of collaboratively preparing, teaching or observing a research lesson, and discussing evidence of pupils' learning observed during that lesson was sought. This accountability to communicating about the work of teaching mathematics resulted in the development of a "*shared repertoire of ways of doing things"* and facilitated the "*negotiation of meaning*" of research lessons by participating student teachers. Each of the research lessons themselves was analysed using The Knowledge Quartet (Rowland, Huckstep and Thwaites, 2005), a framework to identify mathematical knowledge in teaching devised along four dimensions, namely foundation, transformation, connection and contingency. This became a shared language for discussing mathematics teaching, with which to negotiate commonly agreed meanings of goals for the lessons and interpretations of children's mathematical thinking.

BRÍD'S RESEARCH LESSON ON FRACTIONS

Bríd volunteered to teach a lesson on fractions despite admitting to the group that she was "*scared of fractions*". The lesson study group had planned a lesson that was focused on developing children's understanding of unit fractions as a designated number of equal parts of a whole, and proposed using a pizza party context. At the outset, Bríd explained that the children were expected to work in pairs and show and justify their strategies to the class. Bríd and her planning colleagues expected that the use of equivalent fractions would be required of the children as they worked to solve the problems they had chosen. The class was invited to suppose that a child in the class, Cathal, was having a birthday party. He had enough money to buy six identical pizzas and invited seven friends to join him for the party. The research lesson plan had focussed carefully on choice of representation. Each pair of children was given an A4 page with six large circles drawn in a three by two array. These were to represent pizzas. Having set the context of a birthday party Bríd allowed the children to decide how they would divide the circular pizzas between eight children. She did not demonstrate what children were expected to do, but her instructions were clear and invitational. She emphasised the concept of 'equally shared' and invited children to find their own way of dividing the pizzas.

Confusion about the value of a unit fraction occurred more than once in the lesson – a confusion that was inadvertently fostered by the 'teacher'. When Bríd posed a second problem, the children were given fresh sheets of circles, the six pizzas were retained, but two extra persons were to attend the party, resulting in an expected answer of six-tenths (or its equivalent, three-fifths) of a pizza per person, when the six pizzas were to be divided into ten equal parts. During a plenary session in the lesson, it emerged that two boys had devised an alternative and elegant way of dividing the six pizzas between ten people that appeared to puzzle Bríd. Each pizza was divided into fifths and two pizzas were deemed by the boys to give one-fifth to each person, resulting in three slices (fifths) per child.

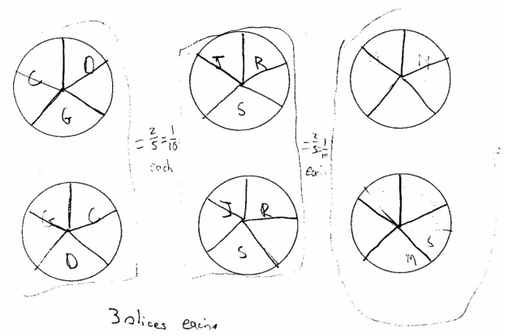

Figure 1: Children's worksheet

Bríd did not invite the boys to the board to draw their solution but tried explaining it to the class herself, in response to their instructions. However, she became confused by the use of fifths when dividing pizzas

between ten people:

Bríd: *Fifths … divide each pizza up into 5 … three slices each … which works out … what would you call that … as a fraction? So they got one slice … two slices … so that's one tenth each. First two, they get a tenth each. So they're getting two fifth each which works out as one tenth.*

At that stage Bríd wrote $\frac{2}{5} = \frac{1}{10}$ on the board and seemed unaware of the discrepancy. Neither did she appear cognisant of previous answers she had recorded nor those anticipated in her lesson plan. This confounding of fifths and tenths and inability to deal with discrepancy in children's articulation of their thinking is reminiscent of the "*limited and flimsy*" mathematics knowledge identified by Ma (1999, p. 68) among the US teachers in her study. It is true that at a procedural level Bríd could divide six pizzas between ten people correctly but the pedagogic approach she took in the lesson required that she be able to understand the many different ways children would approach the problem. A teacher in Ma's study, Mr Wang, observed in this context:

> *"But to catch students' new ideas [in the classroom you have to have a good understanding of mathematics. You have to catch it in a moment with the whole class waiting for your guidance"* (Ma, 1999, p. 139).

Mr Wang's words presuppose that the teacher holds firm subject matter knowledge in order to be able to respond to *contingency* opportunities. The lesson study group had planned to encourage children to devise and articulate their own equal sharing strategies yet when faced with a novel response Bríd was unable to recognise it and unintentionally imparted mathematical misinformation to the children.

After the lesson, Bríd collected the children's worksheets and the group scrutinised them carefully. These artefacts were a source of learning for the community of practice, but after the event. They could have been used more within the lessons and the incident outlined here was evidence for the group of the potential contribution that the children's worksheets might have made to mathematics teaching in the lesson. Figure 1 reproduces the worksheet of the boys who had divided two pizzas equally between ten people by giving each a fifth. They had arranged the pairs vertically and with a border drawn round each pair. Beside the first pair, they had written "$= \frac{2}{5} = \frac{1}{10}$ each" with "3 slices each" underneath the whole picture. The boys had articulated their thinking clearly, when she had called on them to do so, but Bríd's questioning may have led them to inscribe it incorrectly on the worksheet. Their intention appeared to be to express the fact that two pizzas divided into fifths yielded one portion each for ten persons and the writing of that certainly warranted further exploration in class.

CONCLUSION

This problem based lesson was devised by the lesson study group - six student teachers - and the author as Knowledgeable Other. It was an attempt to implement the primary mathematics curriculum (Government of Ireland, 1999) with a focus on children's mathematical thinking, different from the routine problems found in mathematics textbooks and aimed at developing the specific mathematics process skill of communicating and expressing mathematical ideas. By enacting this research lesson, Bríd allowed herself and her lesson study colleagues an opportunity to view the act of teaching through three lenses associated with Japanese teachers of mathematics: the 'researcher perspective' lens, the 'curriculum developer' lens and the 'student/ [pupil] learning' lens (Fernandez, Cannon and Chokshi, 2003). In doing so, she demonstrated the enterprise of researching learning in this manner to be a worth while exercise with multiple opportunities for learning about mathematics teaching afforded by engagement with the process. Lesson study has been recommended as a means of developing mathematics teaching at second level in Ireland (Conway and Sloane, 2005). Findings from this study indicate that engagement in lesson study enhances the teaching of mathematics among student teachers. Its potential for use by practising teachers to develop and enhance the teaching and learning of mathematics at all levels appears worthy of further investigation.

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