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Teachers' collaborative inquiry featuring co-teaching: An adaptive professional learning design to support equitable mathematics achievement

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Abstract

This paper draws on a study exploring teachers' collaborative inquiry with a group of four teachers in a primary school in Wellington, New Zealand. The broad aim of the study was to capture the complexity of teaching and learning and explore the mechanisms and processes of collaboration that interact to promote the professional learning of teachers within the practice context. Collaboration was fore-fronted in the design of the study in which the researcher and the group of teachers inquired together to make sense of the teachers' professional practice and to understand how their teaching impacts on their students. A design-based research approach was used to iteratively co-design, test, refine, reflect on and then re-design the group's approach to collaborative inquiry. The design emerged as an adaptive model of professional development featuring teachers co-teaching and jointly reflecting upon mathematics lessons. The co-teaching model can be seen as a promising approach for supporting the implementation of key pedagogical practices and for fostering the development of an inquiry community. The design-based, participatory approach in which the researcher and participants enacted multiple roles appeared to be a valuable tool for enabling transformation at classroom and school levels.

Background

Addressing ongoing disparities in mathematics achievement between different groups of students is an educational imperative both internationally and for New Zealand (OECD, 2012). The problem persists despite a growing body of research suggesting effective approaches for the equitable teaching of mathematics (Anthony & Walshaw, 2007). The importance of effective professional learning for teachers is recognised based on the premise that what teachers know and believe about mathematics fundamentally influences what they do in their classrooms (Adler & Ball, 2009). It is possible for teachers' professional learning to promote pedagogical change that can "make dramatic differences […] for students who have traditionally been under-served by education" (Alton-Lee, in Timperley, Wilson, Barrar, & Fung, 2007, p. xx).

There is growing consensus in the literature in relation to characteristics of teachers' professional learning that can make a difference for teachers' practice and ultimately students' learning including: opportunities for active learning, sufficient time, collective participation involving interaction and discourse, a focus on important content, opportunities for active learning, and coherence with both policy and existing knowledge and beliefs (Desimone, 2009). A particular focus of the study is on teacher collaboration, taking up an ongoing interest in the notion of community in teaching sparked by Lortie's (1975) observation that teaching is primarily an individual activity and, as a consequence, teacher development is problematic. The value of teachers' interactive and collective engagement in professional learning within the practice context (e.g. Desimone, 2009) and the notion that community supports conditions that promote improved teacher practice and, consequently, student achievement (Eaker & Keating, 2012) are now widely recognized. Of particular interest to researchers, practitioners and policy makers has been the idea of the profession learning community (PLC) which builds on Lave and Wenger's (1991) notion of the community of practice which assumes that learning is socially situated and the development of identity occurs through engaging in practice. The notion of the professional learning community is a widely adopted notion in teacher learning practice (Horn & Little, 2010) and in policy. For example, New Zealand's practising teacher criteria include responsive participation in, and active contribution to, the professional learning community as key indicators (Education Council, n.d.).

While there is increasing understanding around the conditions for and characteristics of effective professional learning opportunities for teachers, and apparent consensus on the value of collaboration within a community for teacher learning, less is known about *how* teachers develop important knowledge, the specific processes and mechanisms involved (Owen, 2015). Professional learning models with similar characteristics can differ greatly in terms of their impacts (Opfer & Pedder, 2011), for example collaboration within community can be both counterproductive (Alton-Lee, 2008) and associated with neutral and negative student outcomes (Timperley et al., 2007). Koellner and Jacobs (2015) suggest that particularly useful distinctions can be made among models of professional learning in terms of how adaptive or prescribed they are. They describe adaptive models of professional learning as flexible and negotiated and suggest such models can promote productive shifts in the knowledge and practice of teachers.

This paper reports on a study aimed at exploring teachers' collaborative inquiry with a group of four teachers in a primary school in Wellington, New Zealand. The broad aim was to capture the complexity of teaching and learning, specifically in mathematics, and explore the mechanisms and processes of collaboration that interact to promote the professional learning of teachers within the practice context. A particular goal of this study was to design and test an adaptive model of teachers' professional learning taking up "the problem of how classroom teaching practice comes to be known shared and developed among teachers through their out-of-classroom interactions" (Little, 2003, p. 913); in this case through *designed* processes for collaborative interaction among teachers of mathematics within the context of their school. An explicit goal of the project was to transform practice through research and so the focus was on designing an intervention to support teachers to improve teaching and learning (Tobin, 2012). The research specifically aimed to investigate how teachers' collaborative inquiry can support teachers to promote the mathematics learning of target students identified by their teachers as at risk of underachievement.

Theoretical perspectives

In this study teachers' professional learning is viewed from a sociocultural perspective in which knowledge is assumed to be located within participation in social activity, and identity ascribed through practice (Jaworski, 2008). As such, knowledge can be viewed as situated and understood through action (Roth, 2007) and thus, in accordance with Vygotsky's (1978) observation that a phenomenon is best understood in the process of change, teachers' professional learning is considered both a process and product of their practice. The focus is on the system of collaborative inquiry in which teachers engage as learners and active creators of knowledge, reciprocally influencing and being influenced by the environment in which they practice.

Cultural-historical activity theory (CHAT) provided an underlying framework through which to explore the interrelationships among elements and the tensions produced within the activity of teachers' collaborative inquiry. Central to sociocultural theory is the idea that all action is mediated by tools and signs (Vygotsky, 1978). Accordingly, CHAT is premised on the idea that learning is socially situated and mediated by conceptual and material artefacts including objects and people, building on a Vygotskian socio-cultural understanding of learning as participation in legitimate, everyday activity. Engeström (2009) conceptualises an activity system (illustrated in figure 1 below) as consisting of: a *subject* or subjects, the people engaged in the activity; an *outcome* towards which the activity is motivated; an *object* which is acted upon in order to achieve the outcome; and material and conceptual *artefacts* or tools which mediate the activity. Action can be seen to be influenced by: the *rules* or norms that govern activity, both explicitly and tacitly; the *community* within and for which the activity occurs; and the various *roles* and responsibilities of participants, referred to as the division of labour, including who performs what tasks (horizontal) and the relative power and status inherent in roles (vertical). The arrows depict the relationships between various elements of the system: the subject can be seen to produce, and the object to consume, the outcome; the subject and the rest of the community engage in reciprocal interactions; and the relationship between the community and object is one of differentiated distribution (the community) and accumulation (the object) of the outcome.
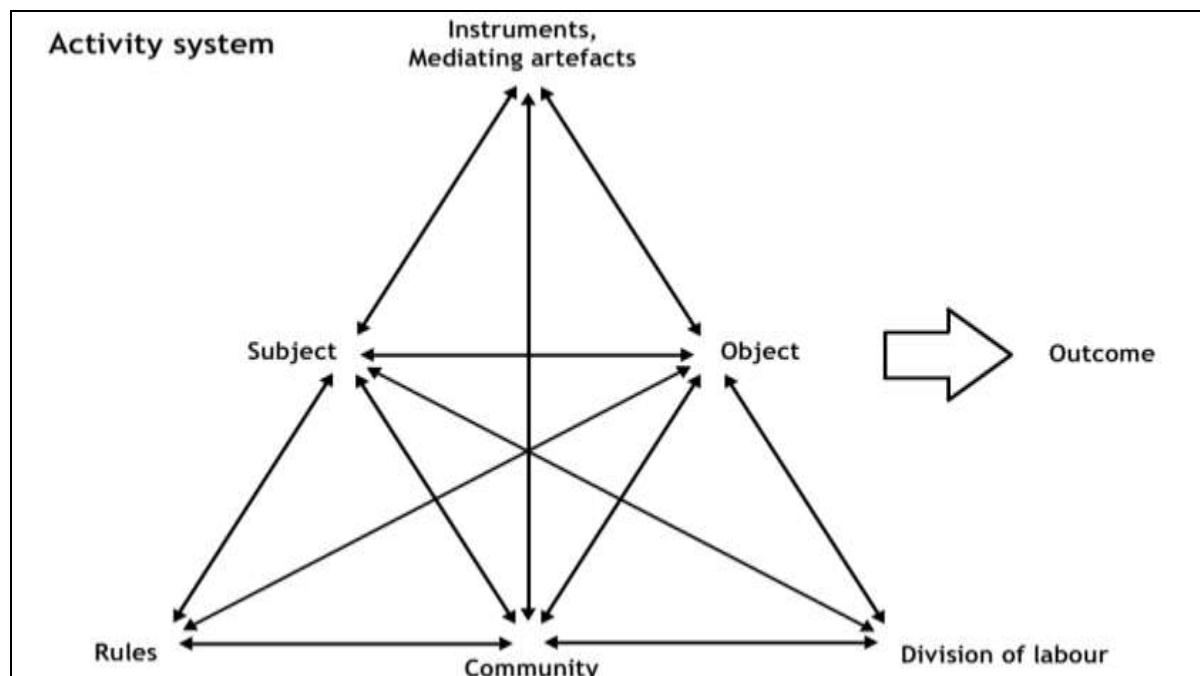
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Figure 1. Activity system framework

In such a system, the activity becomes the core unit of analysis and, according to Roth and Lee (2007), "learning occurs whenever a novel practice, artefact, tool or division of labour at the level of the individual or group within an activity system constitutes a new possibility for others ... leading to an increase in generalized action possibilities and therefore to collective (organizational, societal, cultural) learning" (p. 205). Using CHAT as an analytical framework provided a systematic way to capture the complexity of teachers' collaborative activity (Levine, 2010). The research context of teachers' collaboration can be seen at once to produce tensions and challenges that provide the catalysts for change and CHAT enables the researcher to inquire into both the means and ends of professional learning simultaneously. Consistent with William Sewell's (2005) notion that social life is characterised by patterns of thin coherence and contradiction, the ways in which the actions of teachers aimed at resolving contradictions opened space for an expanded set of actions (Engeström, 2009) was of particular interest. Human agency - the power to act to create one's lived world – is an important notion underpinning such a focus. The analysis drew on the notion of affordances to examine how learning was enabled or constrained through the use of various tools (Little, 2003). Specifically, what aspects of, and to what degree of depth and transparency, was teachers' classroom practice made accessible in their collaboration and in doing so how was teacher learning opened up or closed down within that collaboration?

Of particular interest here was how teachers' knowledge might mediate teachers' reasoning and actions to afford or constrain student learning and thus how the collaborative inquiry might open space to expand teachers' learning. Cochran-Smith and Lytle (1999) distinguish among three conceptualisations of teacher learning: knowledge-*for*-practice, formal knowledge and theory generated and codified by university-based researchers; knowledge-*in*-practice, that which is embedded in the practice and reflections of teachers; and knowledge-*of*-practice. The perspectives taken in this study draw on this third conceptualisation of teacher learning as knowledge-*of*-practice which assumes that teacher knowledge is generated within inquiry communities as teachers purposefully problematise, interrogate and interpret both their own practice contexts and the knowledge and theories of others. Thus "knowledge making is understood as a pedagogic act – constructed in the context of use, intimately connected to the knower, and … inevitably a process of theorizing" (p. 273).

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Research approach

The study employed a design-based methodology which Cobb, Confrey, diSessa, Lehrer, & Schauble (2003) describe as involving "both 'engineering' particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them" (p. 9). The approach involves a cyclical process of developing designs based on conjectures which are iteratively tested refined and redesigned (Herrington, McKenney, Reeves, & Oliver, 2007) as shown in figure 2 below.
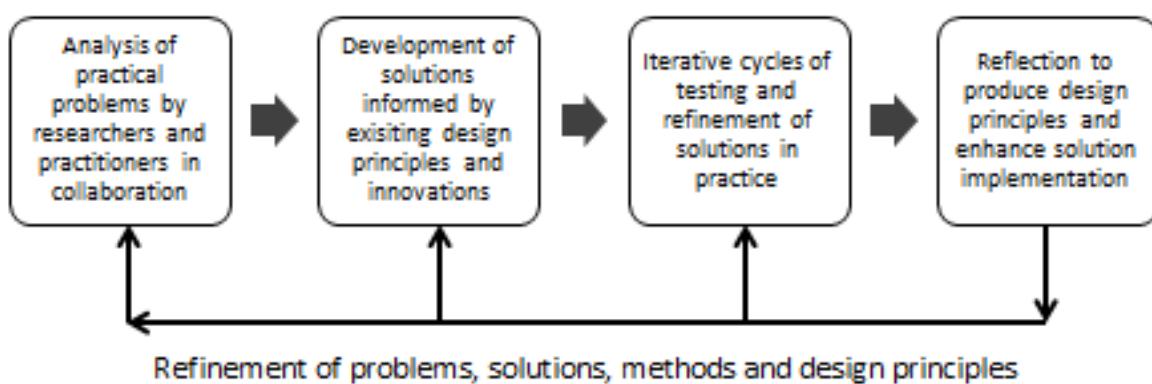

Figure 2. Design-based research process

The research was conducted concurrent with a collaborative teaching inquiry and involved iteratively co-designing, testing, refining, reflecting on and then re-designing an approach to the teacher inquiry. The choice of a design-based methodology was premised on the idea that it is a promising approach for revealing how teachers' actions "play out" in the classroom (Anthony & Walshaw, 2008) in this instance in the context of teachers' professional learning situated in practice. The design cycle was intended to broadly parallel a model of teachers' professional inquiry such as that adapted from Alton-Lee (2012) as shown in figure 3 below.
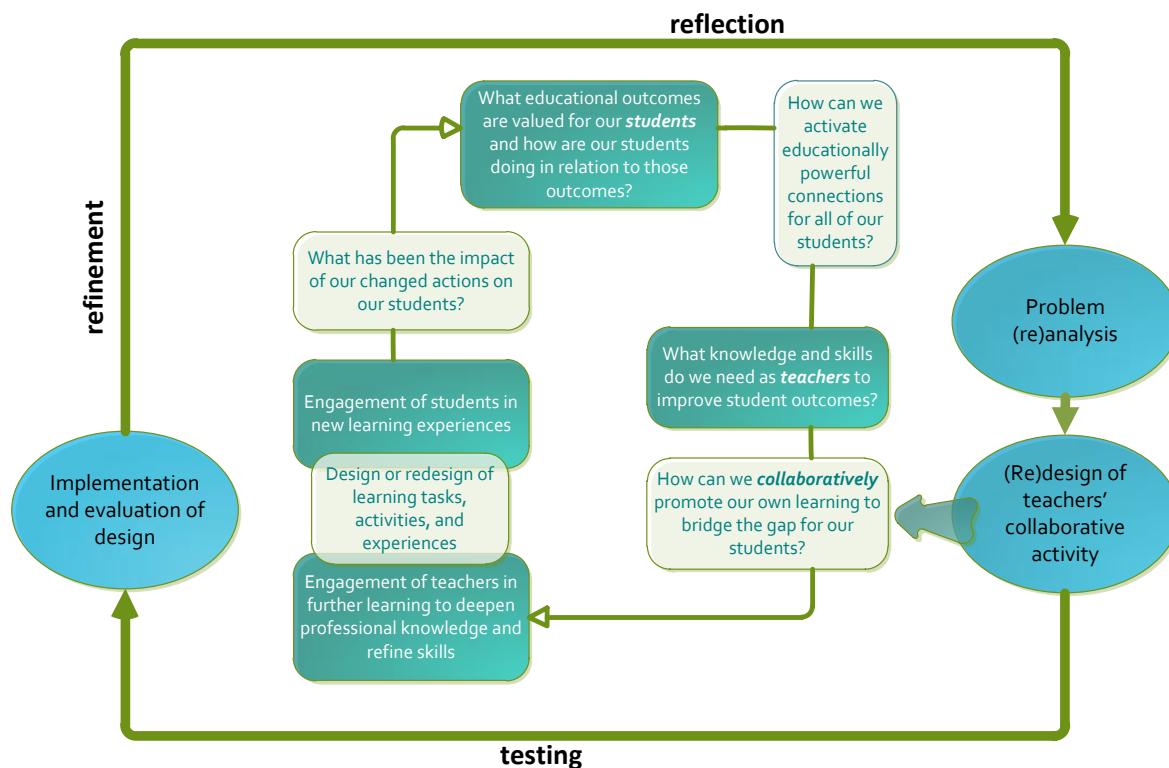
reflection

refinement

What educational outcomes are valued for our *students* and how are our students doing in relation to those outcomes?

How can we activate educationally powerful connections for all of our students?

What has been the impact of our changed actions on our students?

Problem (re)analysis

What knowledge and skills do we need as *teachers* to improve student outcomes?

Engagement of students in new learning experiences

Design or redesign of learning tasks, activities, and experiences

How can we *collaboratively* promote our own learning to bridge the gap for our students?

Implementation and evaluation of design

(Re)design of teachers' collaborative activity

Engagement of teachers in further learning to deepen professional knowledge and refine skills

testing

Figure 3. Combined professional inquiry and design cycle

The research site, a primary school in Wellington, New Zealand, met the criteria of being conveniently located in order to facilitate ongoing relationships among participants and the researcher, and having an explicitly stated goal of raising mathematics achievement for learners identified by their teachers as at risk of underachieving. Wellington has a relatively small education community and the researcher had pre-existing professional relationships with the school and all of the participating teachers. Initially four teachers volunteered to participate, however one withdrew from the latter stages of the project. The ultimate group of three teachers taught at different levels of the school ranging from Year 2 (pre-dominantly 6-year-olds) to Year 7 and 8 (pre-dominantly 11- and 12-year-olds) and held varied roles in additional to classroom teaching. One of the participants was responsible for mathematics leadership in the school which was a role she had taken on six months prior to the start of data gathering.

Over a 6-month period in the second half of the 2014 school year, the teachers and researcher met every three weeks for approximately one and half hours after school. The meetings, which were informal, followed a negotiated agenda and were aimed at exploring ways for the teachers to share and critically reflect on their mathematics teaching together with the primary aim of designing a flexible and adaptive model for teachers to enact a collaborative inquiry. The agreed shared focus of the inquiry was on the use of "talk moves" (Chapin, O'Connor, & Anderson, 2009), a pedagogical tool aimed at promoting target students' engagement in mathematical discourse and improving their understanding and use of precise mathematical language.

Data were collected from varied sources with the primary intention of capturing situated interactions among participants as they engaged in the collaborative inquiry and worked to make sense of it. Scheduled group meetings were video-and audio-recorded and verbatim transcripts were later prepared, supplemented by field notes. The individual and shared reflections of participants were collected in various ways including in emails and other written documents, and in audio-recordings of informal and planned conversations which were later transcribed. At the beginning and end of the study, semi-structured, face-to-face interviews of between 45 and 90 minutes were conducted with

teachers following an observation of a mathematics lesson in their classrooms. Recordings of the classroom observations and the researcher's field notes were then used to develop detailed descriptions of classroom events. Supplementary data such as copies of documents used and created in the course of the activity and photographs of students' work and classroom displays were also collected with permission. Additional mathematics lessons were video recorded by the teachers for use in their reflections and although these were not used as data per se, excerpts that were shared with the group for discussion were included in the data set.

Taking a view of teachers' professional learning as the generation of knowledge *of* practice, participants can be seen as engaging in oral inquiry through rich conversations (Cochran-Smith & Lytle, 1999). Thus data analysis started in the field whereby interpretations were jointly constructed within group interactions and emergent themes and significant events were identified and informed subsequent discussions. On exit from the field, the data corpus was analysed using cyclical processes of open-ended coding and analytic memo-writing (Saldana, 2013) to identify progressively fine-tuned themes and patterns, paying particular attention to data that departed from dominant patterns. Coding and the identification of themes and patterns were simultaneously deductive and inductive processes whereby the elements and relationships inherent in an activity system framework suggested some codes and themes while others arose from the data itself.

The emerging design: An adaptive model of collaborative teacher inquiry

Emerging findings suggest a promising design for teacher collaboration with the potential to promote professional learning within the context of teachers' day-to-day work. The following discussion explores some of the underlying design principles and characteristics of the collaborative inquiry model that was emerging at the end of the data gathering period. As such, the model is described at a particular point in an ongoing process of learning design and is not assumed to be a fully crafted final product. The initial design that was implemented and tested was broadly based on that of video clubs (van Es & Sherin, 2008) in that teachers were encouraged to video-record a mathematics lesson, review the video recordings and self-select an excerpt for the group to reflect on at the next meeting, representing one cycle of inquiry. The design also drew on principles underlying Japanese Lesson Study (Lewis, Perry, & Hurd, 2009) in particular by making explicit an intended focus on student thinking rather than on teacher performance in reviewing and reflecting on classroom teaching events.

In contrast, while the model that emerged at the end of the study retained some of the initial design principles, it featured co-teaching as a primary process of collaboration. Co-teaching is described by Murphy and Scantlebury (2010) in their introduction as editors of a volume on co-teaching in international contexts as "two or more teachers teaching together, sharing responsibility for meeting the learning needs of students and, at the same time, learning from each other" (p. 1). Consistent with this broad definition, the co-teaching model that emerged from this study consisted of pairs of teachers meeting to plan a lesson together, teaching that lesson in one teacher's classroom, then meeting to reflect together after the teaching. The co-taught lessons were video-recorded by the teachers and their shared reflection after the lesson was audio recorded. Video recordings of co-taught lessons were intended as a tool for teachers' reflections and were not collected as data for this study, however excerpts were shared and discussed in subsequent group meetings. The diagram in figure 4 below depicts one "cycle" of co-teaching whereby each teacher had the opportunity to co-teach twice with two different teachers – once in their own classroom and once in another teachers' classroom; the arrows represent a teacher co-teaching in a colleague's classroom.
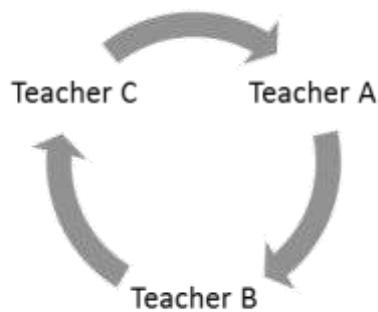
Figure 4. Cycle of co-teaching within a collaborative inquiry model

After each cycle of co-teaching, the group of three teachers met with the researcher to share and jointly reflect on the experience and the cycle was then repeated in the reverse order. Thus, after two cycles participating teachers had opportunities to co-teach in their own and each of their colleague's classrooms, varying where and with whom they co-taught each time.

The affordances of co-teaching: The restructuring of teachers' joint work

Of particular interest in the emerging findings of this study are the ways in which the teachers' joint work through a co-teaching structure appeared to open space for the collective generation of new knowledge through the appropriation of one another's practice, the explicit relinquishing and renegotiation of roles and the shifting of cultural norms. The co-teaching experiences can be seen as two teachers simultaneously engaging in the activity of teaching whereby their roles and the object of the activity were shared while each teacher could be seen to act individually. That is, individual teachers took their own actions during the co-taught lessons, some of which were explicitly discussed in advance while at other times the teachers "bounced ideas off" one another as the lesson proceeded. As Sullivan (2008) points out, teachers' knowledge, orientations and actions interact in complex ways to promote mathematics learning and "[i]t all has to come together" (p. 433).

As illustrated in figure 5 below, sharing a teaching role within a mathematics lesson afforded each teacher opportunities to appropriate aspects of the other's practice as a resource for their own teaching. Where there were differences in the teachers' practice they were experienced as contradictions that afforded an expanded set of possible actions for each of the teachers as they collectively generated new knowledge through the process of reconciling those differences.
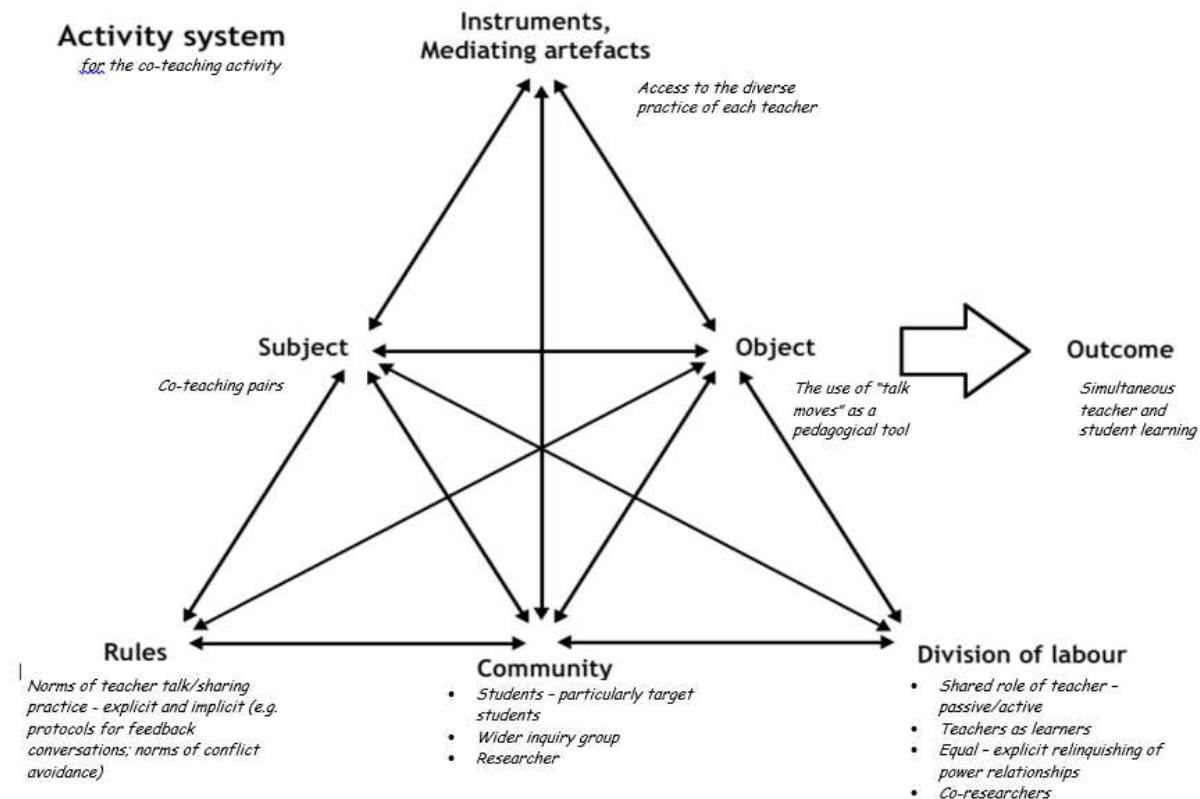
Activity system *for the co-teaching activity*

Instruments, Mediating artefacts — *Access to the diverse practice of each teacher*

Subject — *Co-teaching pairs*

Object — *The use of "talk moves" as a pedagogical tool*

Outcome — *Simultaneous teacher and student learning*

Rules — *Norms of teacher talk/sharing practice - explicit and implicit (e.g. protocols for feedback conversations; norms of conflict avoidance)*

Community
- *Students – particularly target students*
- *Wider inquiry group*
- *Researcher*

Division of labour
- *Shared role of teacher – passive/active*
- *Teachers as learners*
- *Equal – explicit relinquishing of power relationships*
- *Co-researchers*

Figure 5. Co-teaching activity system

Consistent with Tobin (2012), difference amongst teachers became a resource for their practice. For example, one teacher describes appropriating aspects of another's pedagogical practice - that of strategically using concrete materials to model and build understanding of mathematical concepts - in the course of a co-teaching episode:

> what was also great was that we were able to ... because every teacher's different and so we all brought some unique skills onto the table [others making noises of agreement] and so [teacher] was really good with the materials and she really helped me in terms of actually showing how to actually use those materials really well

Teachers had access to the practice of others within their own teaching context, that is, in their own classes with their own students, thus creating opportunities to notice the impacts of a novel set of actions in a familiar setting. Accordingly, teachers valued and actively sought out teaching approaches that were different to their own:

> we all had unique skills we all had different ideas and that and we were very willing to say ... show us … you know and go for it

The co-teaching arrangement created a dual teaching role that was dynamic and alternated between taking an active or more passive role in the instruction. One teacher evoked the metaphor of a dance in which partners step up to occupy, and step back to create, space:

> I think it's good because um … yeah when you'd mentioned something and then I came in with something else then you ... had you know it was almost like doing a dance in a way like ....knowing that you know you take a step back and this person comes forward and because you are it does give you a bit of time to think about where to next

The joint teaching activity opened space for teachers to reflect on their teaching practice "in the moment" as they shifted between an active and a more passive role. While one teacher assumed responsibility for moving the lesson along, the other could "stop and think" about their next move, or the impacts of their last. Both teachers remained engaged in the teaching moment and thus were afforded opportunities to immediately enact responses as the teaching and learning context was continuously restructured. As such, the teachers saw their shared practice as adaptive; they made explicit the need to be responsive to the students, each other and the contingent nature of lesson as it unfolded:

> we all agreed that we would make adjustments as we go along and that as we do it we talk
> and say ... whether something's not right and and ... you know when someone says
> something's not right then we actually have to listen and just think about what changes we
> could make

The teachers were each able to see themselves as having agency in the co-teaching arrangement and accordingly both assumed responsibility for the success of the lesson.

In the early stages of the group's work together, they explicitly negotiated and recorded their group kawa, or protocol for working together. Central to the discussion was an agreement that all members came to the group as learners and co-researchers thus explicitly surfacing the understanding that participants held multiple other roles, including those involving hierarchical power relationships and functions of performance appraisal and evaluation. Group members agreed that in the course of this work they were all assumed to hold equal status and power and their role was primarily that of a learner. This explicit relinquishing of identified roles, particularly school leadership roles, and the repositioning all participants as learners and co-researchers represents both a narrowing and levelling of the division of labour (in activity theory terms) and was experienced as a contradiction which appeared to create space for a restructuring of the social norms at play in the group conversations. Teachers appeared increasingly likely to challenge one another's practice ideas while also discussing the importance of protecting each other's "mana" (status or authority) and of not "stepping on the toes" of the other teacher thus illustrating the intertwined notions of trust in and accountability towards one another.

The cultural norms of a group are made up of assumptions, beliefs, values, expectations and habits, and dictate "the way we do things around here" (Eaker & Keating, 2012, p. 4) and group norms associated with conflict in teachers' shared activity can be seen as both an inhibitor and promoter of professional learning. Achinstein (2002), in a study of the micropolitics of conflict within teacher community, observed that conflict extends the boundaries of teachers' talk opening the space for important conversations and catalysing learning. This was evident when a teacher in our study repeatedly raised concerns that co-teaching for the purposes of her learning might be at the expense of the students' learning:

> I know I'm a learner as well but I … I feel it is my job to be ... supporting th- well not
> supporting, co-teaching so the co-teaching is teaching… it's not learning

This teacher's position echoes Grossman, Wineburg and Woolworth's (2001) observation that it is challenging to negotiate an "essential tension" whereby teacher learning is seen to detract from teachers' "real" work of classroom instruction thus teachers experience conflicting identities as teacher and learner. The explicit surfacing of this view, however, created space for a conversation that supported the repositioning of teacher learning as simultaneously and directly benefiting students:

> you know it's not often that you get to see or to work with another teacher and actually gain
> ... and I know it's all about the teaching and the children but I think it's also important for
> us as learners as well ... that we've learnt and picked up new skills … I thought ... the whole
> collaboration process … you know co-teaching all that ... it is invaluable … and that will
> make us a more effective teacher … when that teacher has now gone so ... I've as I said to
> you [teacher] I've picked up how to actually use the materials a lot … so now that you've

> gone it's up to me to take that that role and to take it further ... I wouldn't get that if you didn't come into the classroom ... therefore those kids would be stuck … you know you've actually helped me move them on

The cultural norms operating in the group allowed teachers to robustly challenge one another's positions thus opening conversations and surfacing otherwise tacit knowledge as actions were taken to reconcile differences. Through co-teaching, teachers were able to reposition themselves as both experts and learners which is in contrast to the expert-novice relationship commonly assumed to underpin teachers' professional learning. Through the sharing of practice the contributions of each teacher served as minor interruptions to the teaching of the other and thus each teacher's actions became a resource for the other's learning. Opportunities to appropriate another's practice opened space for an expanded set of actions for each of the teachers in their own practice.

Conclusion

The emergence of a promising design for teachers' collaborative inquiry featuring co-teaching answers Koellner and Jacobs' (2015) call for more research into adaptive models of teachers' professional learning. The co-teaching design builds on other such models however a key distinction of the co-teaching approach is that the teaching is a jointly enacted and shared experience. This contrasts with other models, such as video clubs (van Es & Sherin, 2008) and lesson study (Lewis et al., 2009) for example, where the collaboration primarily involves observations or representations of, rather than active involvement with, another teacher's practice. The co-teaching experience simultaneously affords teachers opportunities for "in the moment" reflection on and response to events as they unfold in the lesson, and a range of perspectives against which to test their interpretations of those events. Although the study was small-scale and the design is emergent, the flexible and negotiated nature of the design suggests the potential for the model to be expanded and applied within and across a range of schooling contexts. The findings add to the growing body of literature exploring co-teaching arrangements for teacher learning, in this case in the previously under-examined context of teachers' professional learning through collaborative inquiry situated in practice.

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