Exploring the dynamics of changing teaching

Sally Hughes
Monash University
<sally.hughes@monash.edu>

This paper examines the use of two theoretical models to analyse the complex process of changing teaching practice. The models were considered complementary in forming a theoretical framework. Analysis of one teacher's change, from the second cycle of a design-based research project for an onsite collaborative professional learning program, provides the context for the study. The findings suggest that social dynamics between the researcher and teacher, and aspects of the institutional dimension were critical influences on opportunities to learn and change practice.

Introduction

Professional learning with a focus on improving teaching in mathematics, seems critical when effective classroom practice is recognised as a major factor influencing student outcomes in mathematics (Hiebert & Grouws, 2007). However, research literature suggests that changing teaching practice can be challenging (Hiebert, 2013; Goldsmith, Doerr & Lewis, 2014). The success of an intervention varies at both an individual level within a context, as well as across contexts (Arzarello et al., 2014; Goldsmith et al., 2014). Teacher learning has been described as an idiosyncratic, iterative, cyclical and complex interconnected process that requires further exploration (Clarke & Hollingsworth 2002; Goldsmith et al, 2014).

Much research literature has focused primarily on the overall effectiveness of professional learning, with teacher learning viewed predominantly as an indicator of program success (Goldsmith et al., 2014). However, there has been a recent shift to gain insights into learning processes within a particular context and the variability issue (Clarke & Hollingsworth, 2002; Arzarello et al., 2014; Goldsmith et al., 2014). The aim of this paper is to explore how two theoretical models: the Interconnected Model of Professional Growth (IMPG) (Clarke & Hollingsworth, 2002) and Meta-didactical Transposition model (MDT) (Arzarello et al., 2014) were complementary in forming a theoretical framework to analyse the process of changing teaching within a school setting. Findings from one aspect of the second cycle of a recent design-based research project with Year 3 practising teachers, provide an example of a professional learning project in which to explore this framework. Changes experienced by one teacher, the influence of the social dynamics between the researcher and teacher, and the institutional context will be discussed to illustrate the need to connect the two theoretical models.

Literature Review

Literature concerning the professional learning of teachers, specifically those that examine challenges with studying the processes of changing practice, the variability issue and the social dynamics of learning will be discussed respectively.

More recent studies on teacher learning in mathematics and science have shifted focus to examine processes involved in changing teaching (Wilkie & Clarke, 2015; Wilkie, 2017; Wongsopawiro, Zwart & van Driel, 2017; Zwart, Wubbels, Bergen & Bolhuis, 2017). A key finding from these studies reflects that of Clarke and Hollingsworth (2002) that professional learning programs seem to produce varied results at an individual level. Such studies have

2019. In G. Hine, S. Blackley, & A. Cooke (Eds.). Mathematics Education Research: Impacting Practice *(Proceedings of the 42nd annual conference of the Mathematics Education Research Group of Australasia)* pp. 364-371. Perth: MERGA.

used the IMPG developed by Clarke and Hollingsworth (2002) because it takes into consideration the idiosyncratic nature of professional learning when examining learning processes. It seems that a research framework that considers this factor is essential in studying teacher change.

Institutional factors appear a significant influence on variability in the success of interventions to change teaching (Clarke & Hollingsworth, 2002; Arzarello, 2014; Wongsopawiro, 2017). Findings from Goldsmith et al. (2014) suggest understanding issues with variability is necessary if professional learning programs are to be designed to be compatible for teacher learning within a particular context. They highlighted the negative impact that misalignment between different aspects of a program can have on professional learning. For example, discrepancies between curriculum materials and national testing programs. This resonates with Desimone (2009) who also emphasised the importance of consistency with school policies and perspectives in providing opportunities for teachers to learn. The influence of institutional factors on changing teaching highlights the need for a research framework that recognises the significance of this issue.

The influence of social dynamics is a further consideration when studying teacher learning. A study by Wongsopawiro et al. (2017) found involvement of university staff in the study had the most significant impact on learning, highlighting the importance of a research framework that allows for a focus on the relationships between participants and researchers. This reflects recommendations from Justi and van Driel (2006) who emphasised the importance of opportunities for teachers and researchers to interact throughout the duration of a professional learning program. Consideration for a focus on the dynamics between teachers in collaborative learning experiences has been emphasised (Arzarello et al., 2014; Goldsmith et al., 2014; Wilkie, 2017) and is a factor to be considered when examining learning processes.

A review of the literature highlights a myriad of factors to be considered when exploring learning processes and how finding a framework that encompasses these might be challenging. The aim of this paper is to explore how the IMPG and the MDT model connect to provide a framework to examine key influences on the processes of changing teaching. The central research question for this study was:

> In what ways do aspects of the teachers' internal (personal) domain, and external factors in the change environment, influence opportunities to learn and change practice?

Theoretical Framework

Social constructivism, often referred to as interpretivism, was chosen as the theoretical perspective on learning underpinning the study. From an epistemological position, this allowed changes in teaching practice to be viewed through individual experiences of the teacher participants, with the researcher co-constructing understandings through interactions with the teachers (Creswell, 2013). This study connects two theoretical models: the IMPG developed by Clarke and Hollingsworth (2002) and the MDT developed by Arzarello et al. (2014) to examine processes of change, and the influence of factors within the change environment. Each model will be explained in turn.

The IMPG, shown in Figure 1, supports either a cognitive or situative perspective on learning, recognises multiple pathways and the idiosyncratic nature of teacher responses to external stimuli (Clarke & Hollingsworth, 2002). The IMPG is comprised of four change domains: Personal Domain (teacher knowledge, beliefs and attitudes), Domain of Practice (professional experimentation), Domain of Consequence (outcomes salient to an individual teacher) and the External Domain (sources of information, stimulus or support). For the purpose of this study, in the Personal Domain the conceptualisation of the two main components of Mathematical Knowledge for Teaching (MKT) (Hill, Ball & Schilling, 2008)

were adopted; focus was on aspects of teacher disposition towards teaching and learning mathematics (Cooke, 2015). The four domains constitute the personal and professional world of the teacher and are situated in the Change Environment, which is the context in which teachers work. Elements of the Change Environment can either constrain or support professional learning. When change occurs in one domain, the mediating processes of reflection (represented by the dotted arrow in the model) and enactment (represented by the bold arrow in the model) connect the various change domains. In this model reflection is considered "as active, persistent and careful consideration" (Clarke & Hollingsworth, 2002, p. 953) and is associated with a change in cognition. Enactment is distinct from acting, in that it involves cognitive processes and displays a change in behaviour (Zwart et al., 2007). The mediating processes of enactment and reflection essentially conceptualise the process of change. A change sequence is said to occur when a change in one domain can be connected to another domain (Clarke & Hollingsworth, 2002).

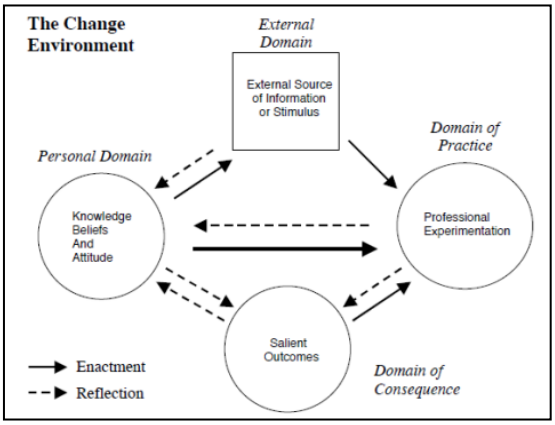

Figure 1. The interconnected model of professional growth (Clarke & Hollingsworth, 2002, p. 951).

The MDT, shown in Figure 2, is descriptive, interpretative and considers the "complex dynamic interplay" between teachers and researchers, when both engage in professional learning (Arzarello et al., 2014, p. 351). For the purpose of this paper, the focus is on the use of the MDT to examine the influence of the interactions between the researcher and teacher (social dynamics) and institutional constraints. For this reason, only features relating to this are explained. Central to this model is the notion of praxeology, which consists of "the tasks, techniques, and justifying discourses" that develop during professional learning experiences (Arzarello et al., 2014, p. 353). Interactions between teachers and researchers can result in the development of new praxeologies; teachers' praxeologies can change from being external to internal through an internalisation process. For example, in the project reported on in this paper, teachers experimented with the use of number strings as a new didactic praxeology to elicit student reasoning about mental computation strategies. The brokering process describes the "transition of mathematical concepts from one community to another" (Arzarello et al., 2014, p. 357). In the context of professional learning, broker actions by the researcher support the transfer of mathematical concepts to teachers. The model recognises that the participatory experiences of teachers and researchers may be constrained by aspects of the social context in which they are situated, referred to as institutional constraints. These constraints can be external such as national curriculum requirements, or internal factors such as school traditions.

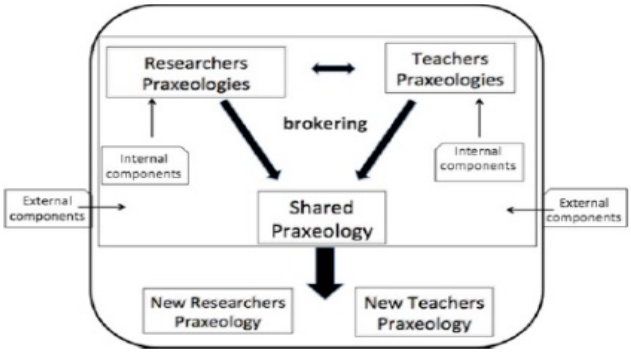

Figure 2. The meta-didactical transposition model (Arzarello et al., 2014, p. 355).

Methodology

The study adopted a design-based methodology, which connects theory and educational practice; is grounded in interactions of local practice involving researchers and teachers working collaboratively to improve teaching and learning; and aims to gain insights into how theory can be developed to improve teaching practices and learning outcomes through iterative cycles of refinement (Baumgartner et al., 2003).

Integral to the study was an intervention to suggest a (potentially) different approach to teaching mental computation. The teaching intervention provided the context for the study; the vehicle for studying teacher professional learning. For this cycle of the intervention, participating teachers attended a professional learning session, observed a sequence of three modelled lessons with their class (including lesson debriefs) and were provided with a teacher resource book and professional readings to support planning and teaching. In addition, the researcher attended weekly planning meetings to provide external support.

The purpose of the intervention was to gain insights into processes involved in changing teacher practice through a school-based collaborative professional learning program, specifically how any changes in teachers' knowledge, disposition and practice might relate to their interactions with the researcher and other participating teachers. The study also considered how aspects of the institutional context either constrained or afforded opportunities to learn and change practice.

The study was conducted at a Catholic Parish primary school located in the suburbs of South East Melbourne. The co-educational school caters for students in Years P – 6. The first phase of the intervention was conducted over a three week period at the beginning of Term 2; the second iteration was for one week at the beginning of Term 3.

Data collection and analysis

A range of qualitative data were collected to allow for in-depth analysis of change processes (Creswell, 2013) and to represent both the researcher's interpretation and self-perceived changes from the teacher's perspective. Sources of data related to the teacher's own perceptions of professional learning and change included: pre-intervention survey, individual semi-structured interview, post-professional learning session survey, post-intervention survey and focus group. Data on changes, as perceived by the researcher, included a lesson observation (post-intervention), recordings of informal lesson debriefs and discussions at the professional learning session and meetings. A researcher's journal was used to document informal conversations with the participants.

An interpretive approach to data analysis was adopted, the intent of the researcher was to interpret data reflexively from both the perspective of an experienced primary school

practitioner and as a researcher. Each data source was coded using NVivo qualitative analysis software. Initial broad codes were based on the framework of the IMPG (Figure 1). For example, the Personal Domain was sub-divided into two main categories: knowledge and disposition, coding was later refined to include sub-codes for relevant aspects of MKT conceptualized by Hill et al. (2008). Once the data were coded, criteria adapted from the work of Justi & van Driel (2006) were used to determine relationships between changes and the domains of IMPG. The IMPG was used to depict the change sequence, as interpreted by the researcher. Diagrams for each teacher within a school were compared and checked for similarities and differences in the pathways. The MDT (see Figure 2) was to analyse and describe different influences on learning processes within the domains of the change environment. The MDT was also used for further analysis of institutional constraints on changes to professional practice within change sequences.

Findings

Following brief contextual background information on Deryn (pseudonym), data relating to her change sequence and learning processes will be analysed.

Deryn was an experienced teacher; she had been teaching for 16 years and assigned responsibility for coordinating the Year 3 team. Although she had spent four years teaching at the middle primary levels, her experience was extensively with the junior years. During the modelled lessons, her interaction with students suggested that she assumed a teacher-centred role in her classroom; this interpretation was corroborated by her reflection in the focus group:

> ...I think it's probably made us more aware of...actually doing it in your head and valuing the importance of doing it in your head. Not just teaching the process...(Focus group)

The pedagogical approach seemed a contrast to the explicit modelling of strategies for students to practise, it involved asking students to think mentally first and reason to justify their strategy.

The IMPG was used to examine the process of change for Deryn; her change sequence is summarised in Table 1. Deryn's change sequence suggests that she reflected on various external stimuli which appeared to instigate initial changes in her Personal Domain; this led to enactment of new knowledge (predominantly aspects of PCK) and subsequent changes in her Domain of Practice. The data suggest that it was the opportunity to observe a sequence of modelled lessons and participate in collective planning sessions with the researcher, that were significant in igniting change in her Personal Domain. It appeared there were influences on learning other than the mediating process of reflection within the domain. The learning processes stimulated by these two components of the professional learning program, will be described in turn.

The opportunity to observe the researcher in the modelled lessons seemed an important external stimulus for Deryn. Although she had experienced number strings in the professional learning session, it was only when the researcher brokered the process of using this instructional tool to elicit student reasoning in a classroom situation that she appeared to internalise the purpose and design of number strings. Reflecting on the most valuable thing she had learned, she considered development in her PCK, which she largely attributed to learning to use number strings as an instructional tool:

> …I suppose for me it's been the building on knowledge…I suppose the number strings is the bit I've taken out of it, as how to build on their knowledge if that makes sense. (Interview)

This reflection indicates that she had internalised a new approach to teaching mental computation and that her praxeology on how students learn to compute mentally was beginning to align with that of the researcher.

Table 1. *Change sequence for Deryn, as interpreted by the researcher*

Domain Link	Mediating Process	Description of learning process
ED to PD	Reflection	Reflects on external stimuli: professional learning session, modelled lessons and related professional conversations, teacher resource book. She has new Pedagogical Content Knowledge (PCK); how to use number strings as a tool to facilitate student centred learning (and support a transition from explicit teaching) / or mental computation strategies. She experiences a change in her disposition, she is enthused about using new instructional tools.
PD to DP	Enactment	Enacts new knowledge about teaching mental computation. She begins teaching a new sequence: using the jump strategy to subtract mentally. She focuses on allowing time for students to engage with the task first (think mentally) before using visual representations to share their thinking with the class.
DP to DC	Reflection	Reflects on student learning outcomes: student affect, student development of mathematical language to articulate thinking; improvement in accuracy in mental computation. Reflects on outcomes in terms of her own professional learning: how to use number strings as a tool to build on student knowledge.
DC to PD	Reflection	Deryn reflected on changes in her PCK, specifically changes KCT and SCK as a result of classroom experimentation. Her reflections indicated a change in her disposition, namely her attitude regarding mathematics in the classroom and everyday life.
PD to DP	Enactment	Enacts her learning about mental computation strategies (KCT) to teach a new sequence of lessons on indirect addition.
DP to DC	Reflection	Reflects on salient outcomes in terms of her own professional learning; deepening of her knowledge about mental strategies (SCK); student learning and changes in her own disposition.

The codes representing the Domain links in Table 1 are: ED (External Domain), PD (Personal Domain), DP (Domain of Practice) and DC (Domain of Consequence).

It appeared that it was not simply the opportunity to observe and reflect on the modelled teaching that acted as the stimulus for new learning. Deryn was an active participant in the lessons. She was involved in orchestrating class discussions by helping the researcher select examples of student thinking (recorded on mini-whiteboards). It seemed that this bi-directional interaction between the researcher and Deryn, was an important part of her internalising the process of facilitating productive classroom discussion based on the five practices developed by Stein, Engle, Smith and Hughes (2008). The evolving social dynamics with the researcher, described as brokering and bidirectional interactions in the MDT, appeared a critical influence on her learning.

Deryn placed emphasis on participation in collective planning meetings as an important influence on her learning:

> ...You listened to us say, how kids aren't ready for that or those numbers are too high and things like that. It was great seeing that you could actually modify it. So there was a basic skeleton of it that you could go higher or lower with it…Yeah, having those discussions in between was good. (Interview)

> …You know, you listened as we talked in planning meetings about the needs of our kids and where our kids were at, to be able to modify it. (Focus group)

Deryn's reflections highlight the importance of the bi-directional interaction between the researcher and teacher. It seemed that the researcher listening and responding flexibility by

working with teachers to modify resources, was considered an important element of the learning process. During the planning sessions the researcher and teachers drew on each other's knowledge to co-construct resources; this bi-directional interaction is theorised by MDT as the double-dialectic. It should be noted that collective planning was a practice embedded within this school culture; an affordance of the school context. It was apparent that Deryn was comfortable with interacting with the researcher and the Year 3 team.

In addition, there were other institutional aspects that influenced opportunities for Deryn to learn and change practice. It seemed that school ethos on professional learning was an affordance to change. It was an annual school requirement that teachers in each Year level work collectively on an action research project with the goal of improving an aspect of teaching and learning. Deryn was required to engage in a certain amount of professional reading and present the findings of the project to the Principal. The decision to participate in this research project had a dual purpose of supporting teachers in meeting school professional learning requirements. It appeared that the institutional context had provided Deryn with a vested interest to engage in the research project. This finding raises the question of whether she would have responded differently to the project had she not be subjected to the same expectations and accountability from the school leadership.

Discussion

The IMPG was used to describe the change sequence for one teacher, Deryn. Whilst some changes could be explained through the mediating processes of reflection and enactment, the data suggested additional influences on the change processes within domains. It appeared that bi-directional interactions between Deryn and the researcher were pivotal in developing aspects of her knowledge and changing practice. Initially her praxeologies were very different from those of the researcher, her usual approach involved explicit teaching of a computation process for students to practise. It appeared that opportunities within the professional learning program for the brokering process and for dialogic interactions seemed to allow her praxeologies to develop and become more aligned with those of the researcher. During the modelled lessons, brief discussions occurred as joint decisions were made on student strategies to facilitate productive discussion. The influence of the bi-directional interactions and the role of the double dialectic was further highlighted in the planning sessions, as the researcher and teachers discussed student learning needs and modified resources and lessons accordingly. The MDT, which explicitly focuses on the dialectic between researchers and teachers, allowed interpretation of the social dynamics within domains (Arzarello et al., 2014).

Although affordances and constraints are conceptualised within the change environment in the IMPG, it did not explicitly address the influence of institutional aspects within Deryn's change sequence. The culture of collective planning and the school ethos on professional learning appeared to afford learning opportunities for Deryn.

Concluding comments

The focus of this paper was to illustrate how connecting two theoretical models was critical to describe and interpret the complex process of changing teaching. The IMPG was used to describe the change processes and sequence for one teacher. The MDT allowed for a focus on important influences, such as the dialectic between researcher and teacher and the relationship with components of the institutional dimension, which are more implicit in the IMPG (Arzarello et al., 2014). These findings resonate with those of Wilkie (2017), who also considered it necessary to combine the IMPG and the MDT to analyse the influence of institutional contexts within change sequences. It is acknowledged that only findings for one

teacher from a small-scale design-based project study was reported in this paper, making it difficult to generalise. The researcher remained conscious of the risk of bias interpretations due to her involvement in the process. Further investigation into the use of this theoretical framework across different contexts and teachers is needed.

References

Arzarello, F., Robutti, O., Sabena, C., Cusi, A., Garuti, R., Malara, N., et al. (2014). Meta-didactical transposition: A theoretical model for teacher education programmes. In A. Clark-Wilson, O. Robutti & N. Sinclair (Eds.), *The mathematics teacher in the digital era* (pp. 347-372). Dordrecht: Springer.

Baumgartner, E., Bell, P., Hoadley, C., Hsi, S., Joseph, D., Orrill, C., et al. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947-967.

Cooke, A. (2015). Considering pre-service teacher disposition towards mathematics. *Mathematics Teacher Education and Development, 17*(1), 1-11.

Creswell, J. (2013). *Qualitative inquiry and research design: choosing among five approaches* (3rd ed.). California, CA: Sage.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualisations and measures. *Educational Researcher, 38*(3), 181-199. http://dx.doi.org/10.3102/0013189X08331140

Goldsmith, L.T., Doerr, H.M., & Lewis, C.C. (2014). Mathematics teachers' learning: a conceptual framework and synthesis of research. Journal of Mathematics Teacher Education, 17, 5-36.

Hiebert, J. (2013). The constantly underestimated challenge of improving mathematics instruction. In L.R. Leatham (Ed.), *Vital Directions for Mathematics Education Research* (pp. 45-56) doi:10.1007/978-1-4614-6977-3

Hiebert, J., & Grouws, D.A. (2007). The effects of classroom mathematics teaching on students' learning. In F.K. Lester Jr. (Ed), *Second handbook of research on mathematics teaching and learning* (Vol. 1, pp. 371-404). Charlotte, NC: National Counting of Teachers of Mathematics.

Hill, H.C., Ball, D.L., & Schilling, S.G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic specific knowledge of students. *Journal for Research in Mathematics Education, 39*(4), 372-400.

Justi, R., & van Driel, J. (2006). The use of the Interconnected Model of Teacher Professional Growth for understanding the development of science teachers' knowledge on models and modelling. *Teacher and Teacher Education, 22*(4), 437-450.

Wilkie, K. (2017). The challenge of changing teaching: investigating the interplay of external and internal influences during professional learning with secondary mathematics teachers. *Journal of Mathematics Teacher Education,* doi: 10.1007/s10857-017-9376-0

Wilkie, K., & Clarke, D. (2015). Pathways to professional growth: Investigating upper primary school teachers' perspectives on learning to teach algebra. *Australian Journal of Teacher Education, 40*(4), 87-118.

Wongsopawiro, D.S., Zwart, R.C., & van Driel, J.H. (2017). Identifying pathways of teachers' PCK development. *Teachers and Teaching, 23*(2), 191-210.

Zwart, R.C., Wubbels, T., Bergen, T.C.M., & Bolhuis, S. (2007). Experienced teacher learning within the context of reciprocal peer coaching. *Teachers and Teaching: Theory and Practice, 13*(2), 165-187.