# Proposed Structural Refinements to the Interconnected Model of Teacher Professional Growth

Laurinda Lomas
*Australian Catholic University*
<laurinda.lomas@det.nsw.edu.au>

This paper proposes structural modification of the Clarke and Hollingsworth (2002) Interconnected Model of Teacher Professional Growth (IMTPG) based on results from doctoral research that studied the changes in mathematical knowledge and beliefs of two Year 5/6 teachers as they implemented a four-week, innovative curriculum unit. These inclusions into the current model expand its analytical, interrogatory and predictive functions. This in turn increases its relevance for those implementing professional learning at the school level, enabling them greater insight into the aspects of a teacher's world that require more support, and possibly more challenge.

The process of teacher change is an important element in the overall success of professional development programs, yet one that many such initiatives fail to consider (Guskey, 2002; Justi & Van Driel, 2005). Research on the features of professional development that promote teacher change (Clarke, 1997; Elmore, 2002; Sowder, 2007) suggest learning occurs gradually and iteratively, and that the success of interventions depends on the individual and context. This variability has led to calls for a research emphasis away from *whether* a program is effective or not, to a focus on *how* programs work in particular settings to promote teacher learning, and what the learning pathways of teachers with different knowledge, beliefs and pedagogical practices look like (Goldsmith, Doerr, & Lewis, 2013; Simon & Tzur). The product of this shift presents 'naturalistic' generalisation opportunities (Stake, 1995) for schools designing and implementing similar professional learning strategies.

The purpose of this research was to explore the impact of teaching an innovative mathematics curriculum on teachers' knowledge and beliefs about mathematics and mathematics teaching and learning. As innovative tasks are conceptually demanding, such immersion experiences have the potential to build mathematical knowledge while teaching. The Interconnected Model of Teacher Professional Growth (IMPTG) (Clarke & Hollingsworth, 2002; see Fig. 1) provided a lens to describe and interpret meaning constructed by teachers in this change environment. The epistemology of constructionism was chosen to explore teacher's constructed realities as they engaged with their world. A theoretical perspective of intepretivism was employed as this study aimed to draw an in-depth understanding of the interpretations each teacher made within the school context. Case study was the adopted methodology as it complemented the study's epistemology and theoretical perspective, facilitating an understanding of the complexity of the phenomenon under study (Merriam, 1998).

The IMTPG sets out possibilities for change in one or more of four domains: external, personal, of practice, and of consequence. It represents a move away from previous linear modelling of teacher change (Guskey, 1986), suggesting there are multiple and cyclic growth pathways. It aligns with an increasingly popular view of change as professional growth, acknowledging teachers as active and reflective learners, socially situated within a learning environment (Clarke & Hollingsworth, 2002). The model was employed to describe interaction between domains, the mediating processes of enactment (putting a new

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idea, belief or practice into action) and reflection, and the resultant (professional) growth. The term reflection was viewed in the same vein as Dewey (1910), that is, "active, persistent and careful consideration" (p. 6). Clarke and Hollingsworth (2002) suggested change may occur in one domain of a teacher's world but this may not lead to change in other domains. A 'change sequence' is represented when two or more of the identified domains are connected by reflective or enactive links. This may be momentary experimentation, not necessarily sustained. A 'growth network' on the other hand represents considered and long-lasting change in cognition and/or behaviour.

The External Domain represents information sources or stimuli outside a teachers' day-to-day context. The other three domains can be described as belonging to the teacher in the context of their daily work, that is: teachers' professional experimentation, teachers' knowledge and beliefs, and teachers' salient outcomes. In this research, the main source of stimulus in the External Domain was teaching the *Some of the Parts* unit (Britannica, 2006). In the personal domain, the Mathematical Knowledge for Teaching model (MKT) (Hill, Ball & Schilling, 2008) was used to label the kinds of knowledge present in the practice and reflections of the participating teachers while implementing the innovative curriculum unit.

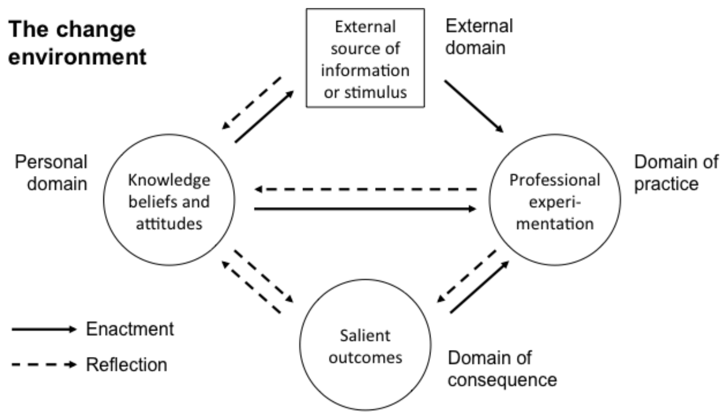


*Figure 1.* The Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002).

Many researchers have used the IMPTG to identify pathways of change as a result of professional learning (Lebak, 2015; Wongsopawiro, Zwart, & van Driel, 2017; Zwart, Wubbels, Bergen, & Bolhuis, 2007). Most of these studies involved science and mathematics high school teachers.

Characteristics of the IMPTG model have been both narrowed and reinterpreted by researchers to aid analysis. Lebak (2015) used the IMPTG to model factors mediating change in beliefs and practice of a high school science teacher in a year-long video-supported reflection process. Recognising the complexity involved in studying the relationship between beliefs and enacted practice, analysis using the IMPTG model involved only the attribute of beliefs in the Personal Domain. Changes in the participating teacher's knowledge of his students' capabilities were evident in the discussion but did not form part of the modelling; they were viewed only in relation to the teachers' beliefs about what students could do. Justi and van Driel (2006) reinterpreted Clarke and Hollingsworth's (2002) definitions of change and growth in their analysis of beginning science teacher's knowledge of scientific models and modelling. Due to the time constraints of the research period, they used the criterion of complexity to identify the difference between “superficial change” (p. 443) and growth rather than how long the change was maintained.

Zwart et al. (2007) adjusted the IMPTG model in four ways. Two of these were definitional, and two structural. The researchers broadened the concept of reflection to suit their understanding of the term to incorporate the intention of such a process, and reconsidered the Person Domain as an integrated whole rather than the individual attributes of knowledge, beliefs and attitudes. In a more pragmatic vein, Zwart et al. divided the External Domain to reflect the specific professional learning introduced into the research (reciprocal peer coaching, and other generally available sources of information), and delineated the preparation and implementation of lessons in the Domain of Practice. Wongsopawiro et al. (2017) adapted the External Domain and Domain of Practice in a similar way. Unlike Zwart et al., however, they highlighted four PCK elements in the Personal Domain to better reflect change in PCK.

Reflection is acknowledged as an important internal process when studying the progression of teacher change (Darling-Hammond, 2005; Mewborn, 1999; Sowder, 2007). Research using the IMPTG has identified patterns in change that suggest focused and structured reflection on students’ learning was an important catalyst for PCK development (Wongsopawiro et al., 2017) and that reflection occurred more often than enactment as the first mediating process for change (Zwart et al., 2007). Considering its pivotal influence on changes in teacher knowledge and as a stimulus to engage teachers in the change process, greater insight into the influence of reflection on teacher cognition and behaviour would be beneficial. The current IMPTG structure has some limitations in this regard. While successfully representing change between domains it fails to demonstrate change within a domain. Considering the emphasis in reform-oriented teacher professional learning on developing teacher knowledge and beliefs, such adaptation to the model may be assistive.

## Methodology

This case study research involved an experienced male and female teacher at a single New South Wales government primary school site. Mark taught Year 5 and Debbi taught Year 6 (pseudonyms). Both volunteered to be participants in the research. Each teacher implemented the four-week fractions unit called *Some of the Parts* (Brittanica, 2006). Based on the principles of Realistic Mathematics Education (RME; see, e.g., Streefland, 1991), this unit progressively introduced ‘models of’ realistic contexts to provide ‘models for’ student thinking, including fraction bars, double number lines and the ratio table. The teacher support guide provided details about the underlying mathematics of each section within the unit, how to implement the tasks and the associated modelling, outlined possible student responses and ways to assess student understanding. During the unit, students were encouraged to conjecture, explain and justify their reasoning, thereby promoting conceptual understanding through “reinvention” of mathematics (Gravemeijer, 1999). These features led to the unit being considered innovative.

To gain a broad understanding of how each teacher designed and implemented lessons in their normal routine, both Mark and Debbi were observed for three pre-intervention lessons. The Copur-Gencturk (2015) classroom observation record assisted in recording these aspects of each lesson, as well as the mathematical discourse and sense-making promoted, and the classroom culture. In this pre-intervention phase, both Mark and Debbi completed two questionnaires developed as part of the Teacher Education and Development Study in Mathematics (TEDS-M) (Tatto, et al., 2008). The first questionnaire assessed their mathematical and pedagogical content knowledge and the second questionnaire their level of agreement with statements relating to teachers' beliefs about learning mathematics, mathematics achievement, and the nature of mathematics. Background forms generated data about personal mathematics history and professional development experiences.

The innovative curriculum trail period was four weeks, with four lessons planned for each week. Meetings were held with each teacher in the term preceding implementation to assist with the familiarisation of the unit's structure, the underlying philosophy of RME and the models promoted. Both Mark and Debbi were given their own copy of the teachers' guide and student response book to read over the two-week holiday break. In the first week of the following term, time was put aside for each teacher to clarify any questions before the trial started. Semi-structured interviews designed to prompt the teacher to reflect on how the lesson went, how it matched their intentions, moments they felt were significant, decision-making junctures, what they had learned, and what they believed the students had learned were held after lessons in all phases of the research. An extended reflective interview was held at the end of the research period.

### *Data Analysis*

Making sense of the data in this study drew upon both direct interpretation and categorical aggregation, attaching meaning to small collections of impressions within a single episode, then searching for patterns and relationships (Stake, 1995). Constant comparison began with initial observations, incidents at interviews, notes made through direct observation of lessons or documents. These incidents were compared with others both within and across sets of data (Merriam, 1998). Consistent refinement addressed the large quantity of data generated and allowed questions arising to be asked *during* the field experience as well as after its completion. The search for patterns and themes in this research started with open coding. After locating themes and assigning initial codes, data were condensed and organised into preliminary categories via axial coding.

## Results and Discussion

Following brief background on the teachers, most of this section focuses on the specific modelling of growth and change of each teacher and how an adapted version of the IMTPG assisted with this.

Both Mark and Debbi had taught for around 40 years; both said they loved teaching mathematics. Mark had only taught either Year 5 or 6 apart from three years in lower primary grades. He had tutored mathematics to Year 12 level to "keep his mind active" and thought there was great benefit in spending time doing complex mathematics. Mark felt there was "nothing really that kids can throw at me that I can't answer off the bat" (31.7.15), indicating how confident he felt in responding to problems and explaining the underlying mathematics while in the act of teaching. Mark's belief about his role of instructor and explainer in the classroom was tightly held; a position that was well understood by his students. Debbi had taught her current grade for more than 10 years. On her background survey she reported to be highly confident both in teaching mathematics in general, and in catering for the needs of higher achieving students. Debbi indicated she would like to be a specialist mathematics teacher in the primary setting in the future. Interestingly, both Mark and Debbi scored noticeably higher on their PCK percentile score than their MCK score on the TEDS-M assessment. A third of the difficulties Debbi encountered in this assessment related to extended reasoning, suggesting that explanations of mathematical ideas may be challenging for her.

Mark and Debbi had very different responses to the innovative curriculum trial. Mark adopted a growth perspective in relation to his knowledge and beliefs about the teaching of fractions. Implementing *Some of the Parts* tasks challenged Mark's knowledge of teaching difficult concepts like equivalence, and his long-standing beliefs about the most effective way to do this. The changes Mark observed in the engagement of his students and their ability to solve complex fraction problems challenged his knowledge of how students interacted with content. At times Mark found the tasks and ensuing changes in his classroom confronting but he trusted the expertise of the unit writers and was willing to persist. Debbi was concerned about the applicability of the unit from the beginning of the research trial. She felt it was not current or challenging enough for her higher achieving students, demonstrating a lack of trust in its progressive modelling approach. Debbi used only some of the realistic tasks and the associated models. Her often stated concerns that the tasks did not challenge her 'top students' resulted in disparate presentation of lessons. Such prioritising of one group of students over the rest of her class resulted in limited interaction with the underlying RME philosophy and most of the models presented. Growth evident in Debbi's knowledge of how to use ratio tables to promote understanding of proportional reasoning was also driven by her focus on the extension of higher achieving students.

Modelling Mark and Debbi's pathways of change using the IMPTG assisted analysis of the categories of knowledge and beliefs affected by the introduction of innovative curriculum into the classroom setting. In this modelling it became evident that the results of the research could be better represented. Participating teachers had made changes within the Personal Domain, in particular an internal relationship between teacher's knowledge, beliefs and attitudes. In some instances there were changes in both knowledge and beliefs, in others there were changes in knowledge but no reported changes in beliefs. One teacher changed attitudes as a result of changes in knowledge and beliefs; the other teacher's early attitudes towards the innovative unit dominated the change process. The mediating process for each of these options was reflection. While facilitating analysis in one domain or from one domain to another, the current structure of the IMPTG has not anticipated modelling of change *within* in a domain. If the IMPTG is considered a model of possibilities, this anticipatory status suggests that it can also function to represent lack of change or growth. An interesting opportunity, then, is created to compare why change may have occurred in one domain and not another. An expansion of the structure of the Personal Domain might allow greater representation of such an occurrence. As this research aimed to look closely at changes in the knowledge and beliefs of teachers implementing innovative curriculum, such structural inclusions have potential to be helpful in the data analysis phase.

### *Representation of Changes in a Refined Structure*

In this section I outline two examples from the data generated in this study that demonstrate change within an IMPTG domain, one for Mark (Fig. 2) and one for Debbi (Fig. 3). These examples contribute to my argument for refining the structure of the IMPTG. Codes reflecting the current IMPTG domains are used in the following examples, that is: ED (External Domain), DoP (Domain of Practice), and DC (Domain of Consequence). Codes for the adapted version appear as PD-K (Personal Domain - Knowledge), PD-B (Personal Domain – Beliefs) and PD-A (Personal Domain- Attitudes). The mediating processes are also outlined.

| Domain Relationships | Mediating processes | Description |
|---|---|---|
| **ED to DoP** | Enactment | Using the innovative curriculum introduced Mark to models he had not used to teach fractions including fraction bars, the ratio table, and double number lines. |
| **DP to DC** | Reflection | As he used the models, Mark reflected on how much he was able to hear students' understanding and the reasoning they were able to demonstrate. |
| **DC to DoP** | Enactment | Mark followed the curriculum's presentation of such models with fidelity. |
| **DP to PD-K** | Reflection | Using a range of models to represent big ideas like equivalence caused Mark to reflect on the knowledge he had and was gaining in relation to teaching fractions. |
| **PD-K to PD-B** | Reflection | In Mark's reflections about instructional advantages of using such models (knowledge of content and students, knowledge of content and teaching), he stated his new belief: that this was a better way to teach fractions than he had used previously in his career. |
| **PD-B to PD-K** | Reflection | This change in beliefs about teaching fractions through hands-on activities and models promoted reflection on Mark's new knowledge of curriculum options and his intention to use them again. |
| **PD-K to DC** | Reflection | Changes in Mark's knowledge and beliefs about using models to teach fractions encouraged further reflection on the salience of such knowledge, and the benefits for his students. |

*Figure 2.* Mark's IMPTG pathway of change in relation to using models to teach fractions.

The reflection that occurred from Mark's change in knowledge about the instructional advantages of using the RME modelling to change in belief that this was a better way *for him* was an important result in this research. It demonstrated that reflection on new knowledge had changed his beliefs, not action or further reflection on aspects outside his Personal Domain.

In the case of Debbi, change within the Personal Domain is reflected by intensification of what is known (knowledge of curriculum), and what is believed (what 'lazy teaching' looks like). The reflection while immediate was not fleeting; it had been considered for a long time and was being activated by an external stimulus (*Some of the Parts*).

This example represents 'lack of change,' and reinforcement of current thoughts and beliefs. Cognition is activated but knowledge, beliefs and/or attitudes are not changed in this process. This mapping extends the current possibilities for which the IMPTG can be engaged. Such resistance is not unusual in the process of change, but a vehicle needs to be present to map it. Without the proposed refinement in the structure of the Personal Domain shown in Figure 4, mapping of Debbi's initial reaction to the unit would have been restricted, and it is this initial reaction that affected much of the enactment that followed.

In making these structural refinements I present my assumptions about the terms knowledge, beliefs and attitudes. Thompson (1992) distinguished between knowledge and beliefs in two ways: conviction and consensuality. Beliefs can be held with different levels

| Domain Relationships | Mediating processes | Description |
|---|---|---|
| **ED to PD-K** | Reflection | Debbi was introduced to the *Some of the Parts* unit as part of her orientation to the innovative curriculum trial. Looking through the unit, Debbi reflected on her personal knowledge of curriculum "units like this" (11.6.15) in England. |
| **PD-K to PD-B** | Reflection | Recalling this knowledge, and looking further through the unit caused Debbi to reflect on her beliefs about the best way to teach mathematics; her belief intensified the longer |

| | | |
|---|---|---|
| | | she looked at the teachers' manual and students' workbook. |
| **PD-B to PD-A** | Reflection | Debbi believed the *Some of the Parts* unit would not be effective in extending her higher achieving students, leading to rejection of many of the activities in the unit even before they had been trialled. Debbi voiced immediate concerns about its appropriateness for her students, describing such units as "lazy teaching" (11.6.15). Voicing this belief changed Debbi's initially positive attitude to being part of a research trial. |
| **PD-A to DoP** | Enactment | This early negative attitude affected the degree to which Debbi was prepared to trial the curriculum in her classroom and her willingness to experiment with the models presented. There was little reflection from the DoP back to the PD as this negative attitude was so pervasive. |

*Figure 3.* Debbi's IMPTG change pathway in relation to using the *Some of the Parts* unit.

of conviction but knowledge is not. Knowledge is consensual (there is general agreement about ways to judge its validity) whereas beliefs are subjectively held understandings thought to be true. Attitudes are less cognitive than beliefs and felt more intensely. They are considered harder to change than beliefs (Phillip, 2007).

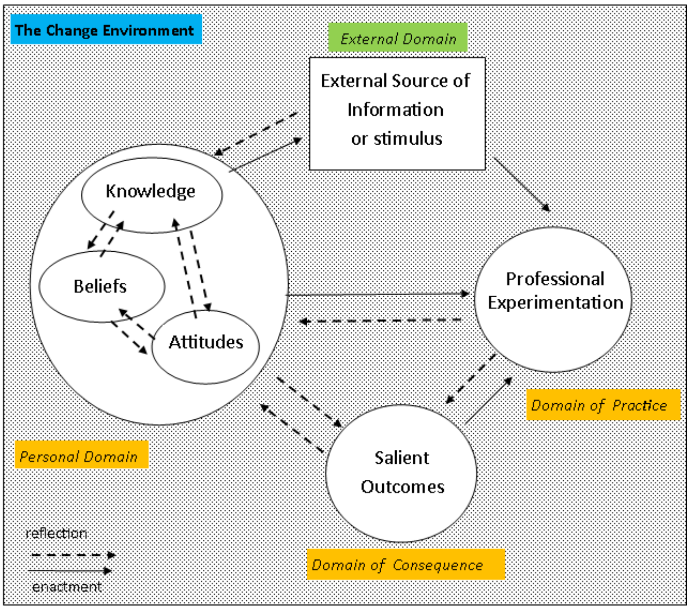


*Figure 4.* Proposed refinement of IMTPG model's Personal Domain.

## Conclusion

Empirical identification of patterns in teacher growth are needed to identify how professional learning initiatives like innovative curriculum work in particular contexts. While there were only two teachers involved in this study, the proposed structural refinement of the IMPTG expanded the extent to which data generated in this study could be analysed. Mapping change and 'lack of change', and the associated pathways may provide professional learning providers with information about the aspects of a teacher's Personal Domain that require challenge and support. I acknowledge of course that further examples are needed to assess the validity of my proposed enhancements of the model.

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