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Elaborating a model of teacher professional growth

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Abstract

This paper details a model of teacher professional growth and relates the model to the research data on which the model is empirically founded. A key feature of the model is its inclusion of four analytic domains in close correspondence to those employed by Guskey (*Educational Researcher* 15(5), 1986) and others, but the model proposed in this paper identifies the specific mechanisms by which change in one domain is associated with change in another. The interconnected, non-linear structure of the model enabled the identification of particular "change sequences" and "growth networks", giving recognition to the idiosyncratic and individual nature of teacher professional growth. One major value of a change model grounded in empirical data lies in its capacity to stimulate speculation, research and development regarding possible change mechanisms as yet unexplored and unexploited. In its current form, this model offers a powerful framework to support the analyses of those studying teacher change (or growth) and the planning of those responsible for teacher professional development.

Keywords: Teacher learning; Teacher change; Professional development; Change model

The optimization of the outcomes of a process is facilitated by the understanding of that process. If we are to facilitate the professional development of teachers, we must understand the process by which teachers grow professionally and the conditions that support and promote that growth. In this paper, professional growth is represented as an inevitable and continuing process of learning. By acknowledging professional growth as a form of learning, we become inheritors of a substantial body of learning theory and research. The application of contemporary learning theory to the development of programs to support teacher professional growth has been ironically infrequent. In particular, models of teacher professional development have not matched the complexity of the process we seek to promote. In this paper, we provide the details of an empirically grounded model of professional growth that incorporates key features of contemporary learning theory. The model described here both explains existing research data on teacher professional development and suggests key considerations for those responsible for the development of in-service and pre-service programs for teachers.

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1. Teacher change

A substantial literature exists on "teacher change" (see, for example, Doyle, 1990; Guskey, 1985; Johnson, 1996a). This literature permits various readings of the term "teacher change" and Clarke and Hollingsworth (1994) identified a number of alternative perspectives. In that paper we suggested that the notion of "teacher change" was open to multiple interpretations, and that each interpretation could be associated with a particular perspective on teacher professional development. We described six perspectives on teacher change:

- Change as training—change is something that is done to teachers; that is, teachers are "changed".
- Change as adaptation—teachers "change" in response to something; they adapt their practices to changed conditions.
- Change as personal development—teachers "seek to change" in an attempt to improve their performance or develop additional skills or strategies.
- Change as local reform—teachers "change something" for reasons of personal growth.
- Change as systemic restructuring—teachers enact the "change policies" of the system.
- Change as growth or learning—teachers "change inevitably through professional activity"; teachers are themselves learners who work in a learning community.

It should be noted that these alternative perspectives on change are not mutually exclusive, and that many are in fact interrelated. We would suggest that the central focus of current professional development efforts most closely aligns with the "change as growth or learning" perspective. Within this perspective, change is identified with learning, and it is regarded as a natural and expected component of the professional activity of teachers and schools.

Historically, teacher change has been directly linked with planned professional development activities (Clarke & Hollingsworth, 1994). Professional development became a major enterprise in education during the post-depression era (Howey & Vaughan, 1983). At that time it was based on a training paradigm that implied a deficit in teacher skills and knowledge (Guskey, 1986). Most professional development consisted of "one-shot" workshops aimed at teacher mastery of prescribed skills and knowledge. Professional development attempts based on this deficit model have been criticized throughout the literature. Researchers including Guskey (1986), Howey and Joyce (1978), McLaughlin and Marsh (1978), and Wood and Thompson (1980) have highlighted the ineffectiveness of professional development programs that have an overemphasis on this deficit approach. Others, including Fullan and Stiegelbauer (1991), Johnson (1989), and Lovitt and Clarke (1988), have provided convincing evidence of the failure of "one-shot" professional development approaches.

The clear ineffectiveness of attempts to effect teacher change through professional development programs based on the deficit-training-mastery model has provided the impetus for much research related to the process of change and professional development in recent years. A significant outcome of this research has been the shift in focus from earlier conceptions of change as something that is done to teachers (that is, change as an event with teachers as relatively passive participants), to change as a complex process that involves learning (Fullan & Stiegelbauer, 1991; Guskey, 1986; Hall & Loucks, 1977; Johnson, 1989, 1993, 1996a, b; Teacher Professional Growth Consortium, 1994). The key shift is one of agency: from programs that change teachers to teachers as active learners shaping their professional growth through reflective participation in professional development programs and in practice.

The notion of ongoing and life-long professional learning for teachers has been emphasized by several authors including Fullan and Stiegelbauer (1991), Jackson (1974), Johnson (1993, 1996a, b), Schon (1983, 1987), and Stephens, Lovitt, Clarke, and Romberg (1989). Jackson (1974) referred to a "professional growth approach" to professional development, where "the motive for learning more about teaching is not to repair a personal inadequacy as a teacher, but to seek greater fulfillment as a practitioner of the art" (p. 26). Similarly, Schon (1983) emphasized the

importance of ongoing, critical reflection in teaching, in his notion of teachers as "reflective practitioners" (Schon, 1983).

More recently, Johnson (1996a) presented a case for reconceptualizing teacher professional development as "opportunities for learning" to enable it to be "embedded into the ongoing work of the school" (p. 12). Recognition of the need to contextualize teaching and teacher development has led to the advocacy of approaches to professional development that employ cases, and more recently video cases (Clarke & Hollingsworth, 2000), as a means to situate the professional development of teachers in realistic contexts. This contextualization of teaching is also found in proposals for the "authentic" assessment of teaching (Darling-Hammond & Snyder, 2000).

While authors use different terms to describe changing conceptions of teacher change, it appears that fundamental to "new" perspectives on teacher change and teacher professional development that have learning as their core are views of "teachers as learners" and "schools as learning communities". Models of the process of teacher change (or growth) have been progressively refined over the last decade or so. This evolution is described in the next section.

2. Modeling professional growth

Researchers such as Fullan (1982) recognized that many professional development programs fail to consider the process of teacher change. Such programs often attempted to change teachers' beliefs and attitudes, with the expectation that changes in beliefs and attitudes will lead to changes in classroom practices and behaviors. This perspective took improved outcomes for students as the ultimate goal of teacher professional development. This represents a plausible and legitimate educational agenda, but it provides a misleading model of teacher professional development. What is being modeled in Fig. 1 is the implicit purpose of many teacher in-service programs: specifically, the causal chain on which such programs are based.

In discussing such programs, Guskey (1986) pointed out the flaws in this view of change and provided an alternative model (see Fig. 2). He stated that significant changes in beliefs and attitudes are likely to take place only after changes in student learning outcomes are evident, that is, once teachers have "field-tested" change proposals in classrooms and experienced first hand change in student learning outcomes.

Clarke (1988), while retaining the sequence of Guskey's elements, suggested that the model could be more usefully viewed as cyclic with multiple entry points. Whilst Guskey's model has provided useful insight into some aspects of teacher change, it can also be criticized for representing teacher change as a strictly linear process (Clarke & Peter, 1993).

Cobb, Wood, and Yackel (1990) described a process similar to Guskey's, where the importance of the need for teachers to attempt change in relation to the classroom context was emphasized. However they also proposed the importance of creating "cognitive conflict" in teachers' minds.

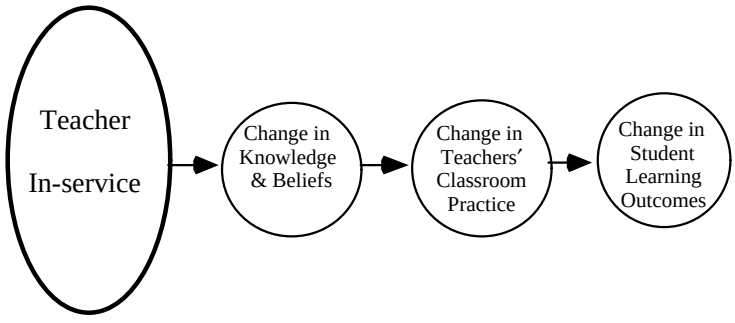

Fig. 1. An implicit model of the purpose of teacher professional development.

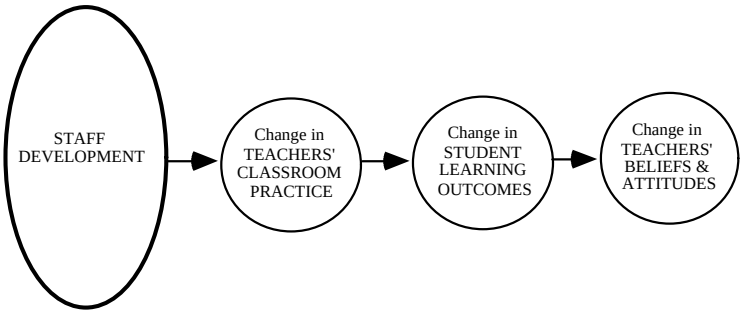

Fig. 2. Guskey's model of the process of teacher change. (Guskey, 1986, p. 7).

Cobb and his colleagues stated that challenging teachers' approaches prior to them attempting to modify their classroom practice could be an effective motivator for change.

A further explanation of teacher change has been described by Johnson and Owen (1986). They suggested that teachers involved in change move through a number of identifiable stages, including recognition (of their existing repertoire), refinement, re-examination, renovation and renewal (where the nature, extent and use of their repertoire are re-evaluated and additions are planned). This process, which at first glance appears like Guskey's model to be linear, would involve a continuous interplay between beliefs and practice similar to that suggested by Cobb et al. (1990).

Lappan and her colleagues (Lappan et al., 1988) made use of a model developed by Lewin (see Blanchard & Zigarmi, 1981) to design a 2 year study of change in middle-school mathematics. Lewin's model recognized three phases of teacher change: unfreezing (where the intent is to motivate and prepare teachers for change), changing (where new patterns of behavior are learned), and refreezing (where new behavior is integrated into teachers' repertoires).

A further model of the teacher change process was developed by Clarke and Peter (1993), and later revised by an international research group interested in teacher professional growth as the Interconnected Model of Teacher Professional Growth (Teacher Professional Growth Consortium, 1994). It is the further elaboration and empirical grounding of this model that provides the focus of this paper. The Interconnected Model (as shown in Fig. 3) suggests that change occurs through the mediating processes of "reflection" and "enactment", in four distinct domains which encompass the teacher's world: the personal domain (teacher knowledge, beliefs and attitudes), the domain of practice (professional experimentation), the domain of consequence (salient outcomes), and the external domain (sources of information, stimulus or support). The four domains are analogous (but not identical) to the four domains identified by Guskey (1986). The mediating processes of reflection and enaction are represented in the model as arrows linking the domains. This model recognizes the complexity of professional growth through the identification of multiple growth pathways between the domains. Its non-linear nature, and the fact that it recognizes professional growth as an inevitable and continuing process of learning, distinguishes this model from others identified in the research literature. This model also identifies the mediating processes of reflection and enactment as the mechanisms by which change in one domain leads to change in another. Any processes of professional growth represented in the model occur within the constraints and affordances of the enveloping change environment (Hollingsworth, 1999).

In recognition of the relevance of the model to educational and other professional settings in addition to classrooms, the domain of practice is conceived as encompassing all forms of professional experimentation, rather than just classroom experimentation. In the discussion that follows,

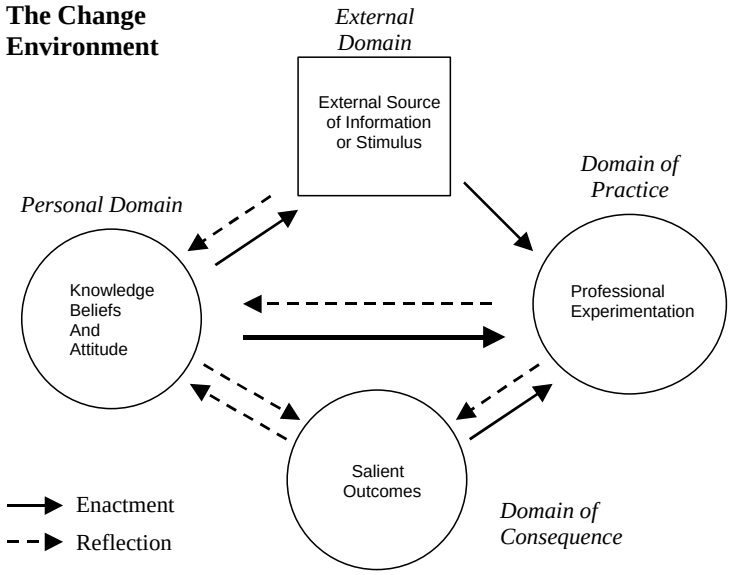

Fig. 3. The interconnected model of professional growth.

however, much of the professional experimentation reported took place in the classroom.

There are two types of domains represented in the Interconnected Model. The external domain is distinguished from the other domains by its location outside the teacher's personal world. In combination, the domain of practice, the personal domain and the domain of consequence constitute the individual teacher's professional world of practice, encompassing the teacher's professional actions, the inferred consequences of those actions, and the knowledge and beliefs that prompted and responded to those actions.

The model locates "change" in any of the four domains. The type of change will reflect the specific domain. For example, experimentation with a new teaching strategy would reside in the domain of practice, new knowledge or a new belief would reside in the personal domain, and a changed perception of salient outcomes related to classroom practice would reside in the domain of consequence.

Change in one domain is translated into change in another through the mediating processes of "reflection" and "enaction". The term "enaction" was chosen to distinguish the translation of a belief or a pedagogical model into action from simply "acting", on the grounds that acting occurs in the domain of practice, and each action represents the enactment of something a teacher knows, believes or has experienced.

3. The empirical foundations of the model

In elaborating the empirical foundations of the model, we have chosen to group together the four change domains: external source of information or stimulus (the external domain), teacher knowledge, beliefs and attitudes (the personal domain), professional experimentation (the domain of practice), and salient outcomes (the domain of consequence). For the purpose of explicating the model, we distinguish these four change domains from the change environment, and from the mediating mechanisms of enaction and reflection. By illustrating each component of the model with empirical data we hope to both explain the model and demonstrate its viability.

3.1. The studies

Three Australian studies provide the data used to provide the empirical foundation of the model.

(i) *The ARTISM study*: This study was conducted and reported by Clarke, Carlin, and Peter (1992) and consisted of a longitudinal investigation over 18 months of the professional growth of 18 mathematics teachers from three Catholic boys schools in suburban Melbourne. The teachers were participating in an extended professional development program (Active and Reflective Teaching In Secondary Mathematics). More detailed reports of this study can be found in Carlin, Clarke, and Peter (1992), Clarke et al. (1992), Clarke and Peter (1993), Peter, Clarke, and Carlin (1992a); and Peter, Clarke, Carlin, and Harmes (1992b).

(ii) *The EMIC study*: Hollingsworth (1999) conducted a longitudinal study of primary school teachers involved in a Victorian mathematics professional development program—Exploring Mathematics In Classrooms (EMIC). The professional growth of six teacher participants in one EMIC course was examined over a period of 18 months. The teachers selected were from four different schools located in the southern metropolitan region of Melbourne.

(iii) *The negotiation of meaning project*: This 4-year project was directed by Clarke and involved the collection of classroom video data of 55 high school mathematics and science lessons at grade levels 7–10. The videotape data were supplemented by post-lesson video-stimulated recall student and teacher interviews. Reports of this project can be found in Clarke (1998, 2001), Clarke and Helme (1997), Clarke and Kessel (1995), Helme and Clarke (1998), and Helme, Clarke, and Kessel (1996).

Since it is our purpose to explicate the Interconnected Model rather than to report the findings of these three studies specifically, data are used selectively to illustrate particular facets of the model.

3.2. The practice of teaching

In the case study reported in Clarke et al. (1992) a single high school mathematics teacher, Robert, was interviewed regularly over an 18 month period that included his participation in the ARTISM professional development program (six in-service sessions spread over 8 months, with "school visits" by the in-service leaders between sessions). Robert was an experienced and successful teacher of mathematics, nearing retirement, and a reluctant participant in the in-service sessions. He saw no need to modify the teaching practices that he felt had proved successful over a lengthy teaching career.

After the first in-service session the teacher was observed for one lesson employing a "conventional" teaching approach (chalkboard introduction, individual seatwork, explanation to the whole class). In interview, Robert assessed the lesson in these terms: "It [conventional instruction] works although some students were not very motivated." Robert persisted with conventional methods even after a second in-service session. However, 1 month after commencing the program, he introduced investigative group work for the first time. In the lesson observed, the students worked in pairs, then formed groups of six to discuss their findings and report back to the class (the importance of arguing mathematically was stressed). This strategy had been explicitly modeled in the first in-service session one month earlier. In an interview conducted after this lesson, Robert reported "Excellent involvement by the students. They were keen to succeed, new ideas were brought forward, no-one fell asleep. There were no control problems as work had to be correct [assessed through the reporting process] before moving on." This use of group work represented a radical departure from the teacher's normal practice.

One week later, a lesson was observed in which Robert brought a bicycle into the classroom for the purpose of providing a real world referent for a discussion of ratio. Student work was structured by an assignment sheet to be completed over several lessons with ten points to be assessed and a self-evaluation protocol. Consistent with a model introduced in the in-service program, the students worked in groups of four, rotating group leaders (all group members were assigned specific functions). Time was set aside in class for group reflection and general recording of the results of the students' investigations of ratio. Some days later Robert reported in interview, "The start was difficult and students needed some prompting and

repetition of what would be evaluated. But from the second day onwards the group dynamics were unstoppable. New ideas kept rolling in. Students asked for appropriate formulas, but also developed their own ideas of working out distances and speed. All students participated and came up with investigations according to their abilities and interests… It seems that the class is taking over responsibility for their own learning.''

From that point onwards, the teacher's classroom practice was characterized by continued experimentation with group work, investigative projects, and innovative assessment techniques. Towards the end of the study Robert was to express regret that he had not encountered these new approaches earlier in his teaching career.

The abridged case study above provides several useful examples of change in the four ''change domains'' of the Interconnected Model. It must be stressed that each is a change domain. It is change in external stimuli, change in practice, change in salient outcomes, and change in knowledge or beliefs that constitutes the domain, not information, practice, outcomes, or knowledge per se. Specific examples of these changes are given below.

(i) *External source of information or stimulus* (*the external domain*): In the case outlined above, the ARTISM program provided both new information and new stimulus for the teacher studied. The teaching strategies modeled in the in-service sessions and the value attached to student-constructed mathematics represented external changes in the experiences available to the teacher. It is important to note that there are many alternative external sources of information available to teachers in addition to in-service sessions: professional publications and conversations with colleagues are both important external sources of new information and stimulus.

(ii) *Professional experimentation* (*the domain of practice*): The use of collaborative group work, of extended mathematical investigations prompted by a task specifically linked to a real world context, and the use of student self-assessment were all forms of professional experimentation for this teacher. Each represented a change in practice.

(iii) *Teacher knowledge*, *beliefs and attitudes* (*the personal domain*): Change in teacher beliefs and attitudes were evident in the increasing value that the teacher attached to the new teaching strategies that represented in themselves new pedagogical knowledge for that teacher.

(iv) *Salient outcomes* (*the domain of consequence*): The teacher attended to more than just student learning outcomes (as suggested in the models displayed in Figs. 1 and 2). The outcomes that were salient to this teacher's practice included teacher control and student motivation, as well as student development of new mathematical ideas. Change in the domain of consequence is firmly tied to the teacher's existing value system and to the inferences the teacher draws from the practices of the classroom. For one teacher an increase in student–student talk may be construed as a positive outcome of a new teaching strategy; for another teacher the same overt phenomenon may be interpreted as a sign of loss of control and an indication of the failure of the new strategy.

3.3. Mediating processes

What were the mechanisms whereby change in one of the above dimensions triggered change in another? We propose that only two mediating processes are required to account for such change effects: Enaction and Reflection.

(i) *Enaction*: The mechanism we are proposing here is not simply ''acting''. We are distinguishing the putting into action of a new idea or a new belief or a newly encountered practice from simply acting. In terms of the example above, the teacher enacted a new form of pedagogical practice modeled in the in-service session (linking the external domain to the domain of practice; Arrow 1 in Fig. 4). Equally, the teacher's increasing use of investigative work represented the enaction of a newly developed belief in student ability to develop important mathematical knowledge when working in collaborative groups (linking the personal domain to the domain of practice; Arrow 2). By drawing the conclusion that, contrary to expectations, the increase in student–student interaction was not associated with a loss in class control, the teacher was encouraged to persist with his classroom experimentation (linking the domain of consequence to the domain of practice; Arrow 3).

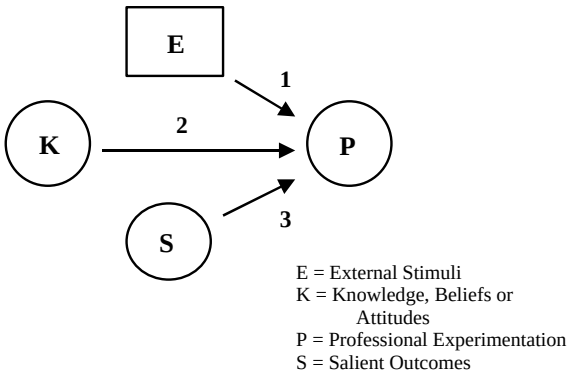

Fig. 4. Enactive links.

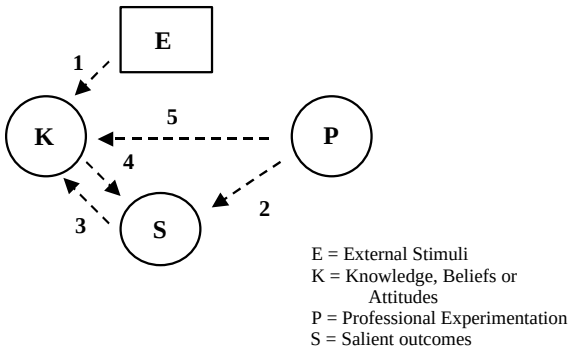

Fig. 5. Some reflective links.

(ii) *Reflection*: We employ the term "reflection" in much the way that Dewey did, as "active, persistent and careful consideration" (see Dewey, 1910, p. 6). This teacher had much to reflect upon. Initially, Robert reflected on the new experiences provided by the in-service session, but this did not lead to change in beliefs, until he came to actually experiment with the advocated strategies in his classroom. That is, the potential reflective link between the external domain and the personal domain was not realized in terms of beliefs, but since Robert clearly acquired knowledge of some new teaching strategies (which were subsequently put into practice), there was evidence of a reflective link between the external domain and the personal domain in terms of a change in knowledge (Arrow 1 in Fig. 5). Having experimented, and reflected on that experimentation, and interpreting the events of the classroom in terms of outcomes that he valued, the teacher drew conclusions as to the consequent changes in those salient outcomes (the reflective link between the domain of practice and the domain of consequence; Arrow 2). The nature of the inferences drawn depends entirely upon the value system of the teacher. The significance of the designation "Salient Outcomes" lies in the need to acknowledge that individuals (teachers) value and consequently attend to different things (they consider different things salient). From the evidence of the case study, this teacher reflected on the increase in student motivation and the maintenance of class control and revised his knowledge, beliefs and attitudes accordingly (providing a reflective link between the domain of consequence and the personal domain; Arrow 3). There are two other postulated reflective links within the model. One relates to changes in the teacher's beliefs that lead to a re-evaluation of changes in the domain of consequence. A simple example is the growing acceptance by the teacher of the value of student–student interaction, such that the increased student–student interaction initially only tolerated became a valued outcome (a reflective link between the beliefs in the personal domain and the salient outcomes in the domain of consequence; Arrow 4). The final reflective link was not evident in the case study conducted by Clarke et al., but was documented in the study conducted by Hollingsworth. This link relates to teacher reflection on changed practice, not in terms of the changes in salient outcomes but solely in terms of the fidelity of implementation of a new practice and the new knowledge related to the classroom deployment of that new practice (the reflective link between the domain of practice and the personal domain; Arrow 5). This last link is discussed more fully in relation to Fig. 11.

3.4. The change environment

In the case under discussion, the professional growth of the teacher was made possible by particular elements in the change environment. As a staff member of a particular school, Robert had the opportunity (taken however reluctantly) to participate in a professional development program

requested and funded by the participating schools. As a member of a school community that was participating in the professional development program, he had a community of colleagues with whom he could share the consequences of his experimentation, and whose experiences he could also share. Such characteristics of the change environment acted to facilitate (afford) the documented changes in the teacher's practice. The teacher's seniority and consequent anticipation of retirement acted to constrain any inclination to experiment with new practices. Similarly, the value attached by the teacher and the school to class control (student discipline) acted to dissuade (constrain) Robert from embarking on any classroom experimentation that might threaten that control. Opportunities to participate in such professional development programs, school subscription to professional journals, administrative encouragement of teachers to experiment with innovative teaching strategies, the encouragement of collegial discussion and the structural provision of opportunities to share and reflect on each other's practice are all facets of the change environment that act to afford or constrain teacher growth and, specifically, the change that might occur in any one of the change domains in the Interconnected Model.

3.5. Links to learning theory

Whether we adopt a cognitive or a situative perspective on learning (Clarke, 2001; Cobb & Bowers, 1999; Greeno, 1997), our modeling of teacher growth must conform to some coherent theory of learning. Given the professional context in which teaching practice is perceived to occur, a situative perspective with its associations of apprenticeship offers an appealing theory of teacher learning and consequently of teacher change or growth. From such a perspective, teacher growth is constituted through the evolving practices of the teacher, which are iteratively refined through a process of enaction and reflection, as outlined above. These teacher practices represent an individual teacher's personalized enactment of the activities (and knowledge and beliefs) by which the community of teachers is constituted as a community of practice (Wenger, 1998).

Alternatively, if we focus our attention not on teacher practice but on teacher knowledge (Shulman, 1987), then teacher growth becomes a process of the construction of a variety of knowledge types (content knowledge, pedagogical knowledge, and pedagogical content knowledge) by individual teachers in response to their participation in the experiences provided by the professional development program and through their participation in the classroom.

Is it necessary for us to resolve the differences between these two perspectives in order to locate the Interconnected Model in terms of contemporary learning theory? In a sense, we have already done so. The Interconnected Model can be interpreted as consistent with either the cognitive or the situative perspective, dependent upon whether we take teacher growth as being the development of knowledge or of practice. This is not a dichotomous choice. Indeed, any dichotomization of knowledge and practice as competing objects of learning should be seen as problematic. The consistency of the model with both interpretations illustrates the complementarity of these two perspectives on learning as much as it demonstrates the conformity of the model to a coherent theory of learning (Clarke, 2001; Cobb & Bowers, 1999).

One challenge for theorists has always been to account for the demonstrable diversity of individuals' knowings within the evident commonalities of action associated with participation in a common social setting. Various theoretical positions have been constructed from which to resolve this tension. A focus on learning as a form of incrementally increasing, but differentiated, participation in an existing body of social practice has provided one useful lens (Lave & Wenger, 1991). This identification of learning with social practice is an important advance from notions of learning as simply occurring in social settings. Specifically, "learning is an integral part of generative social practice in the lived-in world" (Lave & Wenger, 1991, p. 35). The social "situatedness" of learning can then enter the equation through consideration of the extent to which features of the social setting

constrain or afford particular practices associated with learning and thereby constrain or afford the learning itself (Greeno, Collins, & Resnick, 1996, Chapter 2), delineating socially enacted tolerances within which individual idiosyncrasy can develop.

This is the description of learning that we find in closest accord with the Interconnected Model. Such a description gives, in our opinion, due recognition to situated practice and to the development of individual practice and individual theories of practice within an environment that both constrains and affords such individual variation. The two mediating processes, enaction and reflection, usefully connect to practice and to cognition and identify both activities as mediators of change.

3.6. Interconnections

Both reflection and enaction can take various forms. The reflective connection between the domain of practice and the domain of consequence typically has the character of teacher inference or construal. For example, teacher experimentation involving increased student talk may be interpreted by one teacher as a change in classroom noise level, and by another teacher as a change in student engagement. Since the same overt social behavior is open to such disparate interpretation, it is the interpreted change, rather than any observable change that is crucial to subsequent change in teacher knowledge and beliefs. Teacher interpreted change is the only consequence of teacher experimentation that is "of consequence" either to the teacher or to the researcher seeking to explain changes in teacher knowledge and beliefs. An empirical example of differences in the interpretive acts of teachers and students is helpful at this point. The following example is taken from the Negotiation of Meaning Project (Clarke, 2001). In this study, the teacher was asked to provide commentary on the videotape of a lesson she had taught. The videotape used a split-screen format to show both the teacher and a student group simultaneously. The teacher was asked to comment on those things that she felt were "of significance." One student was singled out for comment.

> You see Joanne was just looking around the ceiling etc., like that and I am sure she was off with the birdies.

In fact, the teacher, Mrs. Brown, made several references to Joanne's lack of attentiveness in her reconstruction of two consecutive lessons being studied. It was clear from the videotape that her interactions with Joanne were predicated on this typification of Joanne as an inattentive student who required close monitoring. Yet the videotape data also showed Joanne asking perceptive questions, displaying significant interest in the content, and persistently pursuing issues in which she became interested.

Interestingly, when the student, Joanne, was interviewed after each of the two lessons and asked to provide comment on the videotape she made these observations:

After Lesson One:

> J: Well, if, if we ask Mrs. Brown she tells us, she kind of tells us as though "why don't you already know this?" in, in that kind of tone. As though, you know, you do this, you do this, and you do that, why don't you know it. And we just, um. That's just how we feel I suppose, um.

After Lesson Two:

> J: It's funny 'cause when I was um, like I was just looking there and it looks like um, and it looks as though I'm not listening at all but I, I was listening to everything that she'd say.
>
> I: Oh!
>
> J: And I was thinking, "Gee, that's why she gets probably gets annoyed 'cause she thinks I'm not listening" but I find that I can't listen when I'm sitting there doing nothing just listening, I have to sit there going like this [imitates position on videotape, sitting over paper, pen in hand looking down at desk],

This excerpt serves to illustrate, among other things, the manner in which the practices of the classroom are co-constructed through the actions and the inferences of the participants. The teacher's behavior towards Joanne was predicated

on a typification grounded in her observation of Joanne in class. Joanne's negative attitude to the teacher was similarly grounded. The practice of that classroom included elements constituted through Mrs. Brown's and Joanne's reciprocal interpretations of each other's actions and their consequent actions. Elsewhere (Clarke, 2001) it is argued that classroom practice cannot be adequately understood without the integration of the practices and constructed meanings of both teacher and learner. In terms of our present discussion, however, it is the teacher's interpretive acts and the change phenomena that the teacher considered salient that are important if our goal is to model and explain teacher growth.

Changes in teacher beliefs regarding the efficacy of new practices are mediated by the teacher's inferences linking the new practices to salient outcomes. These salient outcomes will inevitably reflect the teacher's existing conception of the goals of instruction, and of acceptable classroom practice; that is, the teacher's knowledge and beliefs. It must be stressed that, while the model has more general application, in the context in which we are discussing it, this is a model of teacher growth. Fig. 6 offers an operationalization of each domain in a form that explicitly stresses the focus on the teacher.

The model as outlined serves at least three functions:

Analytical tool—the model has been used with considerable success as a tool for the categorization of teacher change data: in terms of data specific to each of the four change domains, in terms of the empirical identification of the processes by which change in one domain is associated with change in another, and, possibly most importantly, in the identification of structural patterns in teacher professional growth. These are discussed at some length in the next section.

Predictive tool—the model poses the possibility of particular change sequences and growth networks, not necessarily evident in the data, whose possibility can be either empirically investigated or practically promoted in experimental studies. This speculative capacity within the model also includes the suggestion of mechanisms by which teacher change might be promoted and possible avenues, as yet unexploited, for teacher professional development.

Interrogatory tool—the model facilitates the framing of specific theoretical and practical

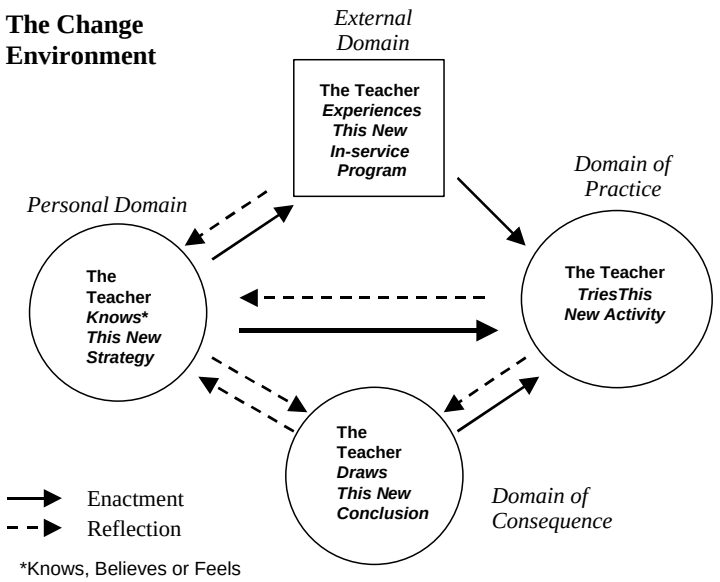

Fig. 6. Interpreting the interconnected model of professional growth (Entries in each domain are illustrative examples).

questions, such as: "What are the possible pathways leading to change in teacher knowledge, beliefs or attitudes?" or "What is the role played by the teacher's existing theoretical framework in the process by which the consequences of classroom experimentation are construed?" or, more specifically, "What are the outcomes of new practice which a particular teacher considers to be salient to their workplace or school context?" or "What factors in the school context constrain teachers' ability or inclination to reflect on the efficacy of their practice?"

In carrying out all three functions, the intention is to be neither prescriptive nor merely descriptive. The actions of those responsible for designing teacher professional development programs should be informed by each function.

4. Identifying specific patterns in teacher professional growth

In a model capable of accommodating (and suggesting) alternative pathways to professional growth, it becomes a matter of interest as to which forms of teacher change can be identified empirically and particularly in which sequences do we observe change occurring. While the study by Clarke et al. provided an empirical grounding for each of the proposed change domains and the connecting mediating processes, the more recent study by Hollingsworth gave more analytical attention to the order in which change was seen to occur. As a result of her analyses, Hollingsworth came to distinguish between Change Sequences and Growth Networks. These are discussed, with suitable empirical illustration, in the following sections.

4.1. Change sequences and growth networks

The process by which change occurs (as evidenced by empirical data) can be represented using the Interconnected Model by denoting particular "change sequences". A change sequence consists of two or more domains together with the reflective or enactive links connecting these domains, where empirical data supports both the occurrence of change in each domain and their causal connection. Change in one domain may not lead to change in another. Where it does, we employ the term "change sequence." Such change may be fleeting, a single instance of experimentation, quickly relinquished. In our analysis, the term "growth" is reserved for more lasting change. This does not preclude a changed practice or belief from being further adapted or refined. Indeed, the adoption of a growth perspective conceives of change as on-going. Where data have demonstrated the occurrence of change that is more than momentary, then this more lasting change is taken to signify professional growth. A change sequence associated with such professional growth is termed a "growth network".

Hollingsworth (1999) found that all of the teachers in her study "changed" certain aspects of their practice or ideas. This was evidenced by the various strategies and activities explored by the teachers, and the ideas they reported. Often the teachers explored similar kinds of strategies and activities, in particular those presented in the EMIC professional development program. For example, all six teachers involved in the study explored the use of small groups and pairs in mathematics lessons. The use of these student groupings was emphasized in the EMIC program.

In Hollingsworth's study, any occasion when change in one domain was demonstrably linked to change in another domain was taken to constitute a change sequence. The teachers' experimentation with a new teaching strategy introduced during EMIC was one of the most simple and most common change sequences, in which change in the external domain was linked through enaction to change in the domain of practice (Fig. 7a). Following such changes in practice, some teachers reflected solely on the quality of their implementation of that new practice (Fig. 7b). Other teachers reflected on the outcomes of their changed practice (Fig. 7c). Each of these three patterns of change is what we have termed a "change sequence."

For some teachers in Hollingsworth's study, change sequences such as those in Fig. 7 went no further. In order to identify empirically grounded growth networks, Hollingsworth required explicit evidence of lasting change in practice or in teacher

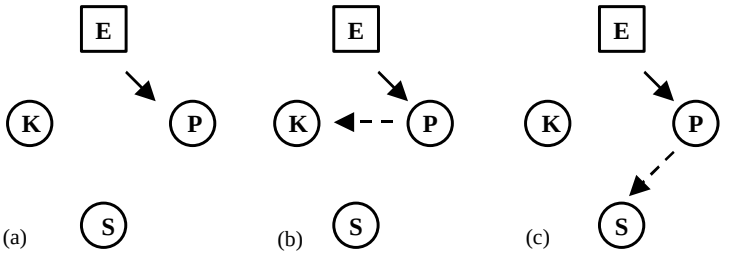

Fig. 7. Change sequences (E = external domain; P = professional experimentation; S = salient outcomes; K = knowledge, beliefs and attitudes).

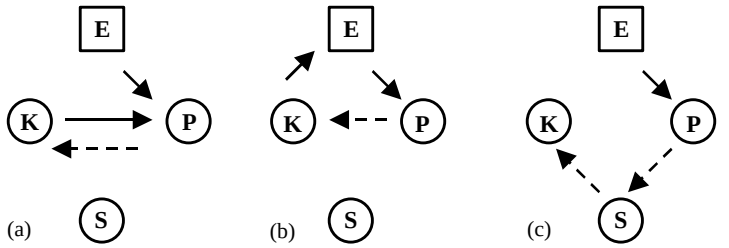

Fig. 8. Growth Networks (E = external domain; P = professional experimentation; S = salient outcomes; K = knowledge, beliefs and attitudes).

knowledge or beliefs. Such lasting change can be illustrated in the specific case of Alan.

> [Now] I use groups and pairs and things like that rather than just this is how you do it, putting thirty problems up on the board and saying open your books and go for it. So a lot of it's different… Just a whole lot of things to make maths more interesting.
>
> [On-going refinement of practice, Fig. 8a]

> It's just that I'm always looking for practical means, far more than I used to, and interesting approaches to use that the children will enjoy and benefit from. So it's not all teacher directed. There's more self-discovery and sharing.
>
> [Continually seeking new strategies, Fig. 8b]

> Well, when I first spoke to you about this I was always extremely formal, my maths teaching was always really formal. Obviously I've learnt that there are better ways and more interesting ways to teach maths.
>
> [Long-term change to knowledge and beliefs, Fig. 8c]

Figs. 7 and 8 illustrate the distinction we are drawing between change sequences and growth networks. All teacher development programs have teacher change as their goal. We would suggest that teacher growth is a much more useful and appropriate goal. The Interconnected Model makes it clear that many change sequences are possible through teacher participation in in-service programs or by other means. Not all such sequences lead to lasting teacher growth. By drawing this distinction we are able to pose the question, "How do we create the conditions required (i) to stimulate change sequences, and (ii) to foster the transformation of these change sequences into growth networks." Unless questions such as this can be addressed in our research, our evaluations of teacher professional development programs may mistake short-term change for long-term growth.

4.2. Accommodating previous models

The Interconnected Model incorporates all previous linear models. It would be a serious error

to see these previous models as necessarily in competition. Data have been collected, in studies conducted by Clarke, Peter, and Hollingsworth (variously cited here), consistent with several possible linear models. What is needed is a model capable of encompassing all of these legitimate alternative "growth networks" and also of suggesting others. The Interconnected Model has this capacity. For instance, Fig. 9 illustrates the early "naïve" linear model (corresponding to Fig. 1) in which student learning outcomes were seen as the goal of teacher professional development.

As a further example, one teacher explored a new teaching strategy, reflected on the consequences of that exploration, and decided that two notable outcomes were improved student learning and increased satisfaction with respect to her teaching. This led to a change in belief regarding the value of the strategy, and consequently the inclusion of the strategy as a regular part of the teacher's practice, and the on-going refinement of that practice (Peter et al., 1992a). This is considered an example of teacher growth. Fig. 10 displays the entire growth network associated with the teacher's growth in this case. Arrow 1 represents the teacher's initial exploration (or enaction) of the strategy they were exposed to at an in-service activity. Arrow 2 represents the teacher's interpretation (upon reflection) as to what constituted the outcomes of that exploration. Arrow 3 represents the teacher's evaluative reflection on the salient outcomes, which led to a change in belief, and, Arrow 4 represents the application of the new belief (via enactment) as a regular feature of the teacher's practice, to be further refined through the teacher's on-going experimentation and consequent reflection.

It is interesting to note that Arrows 1, 2 and 3, together with the domains they connect, mirror Guskey's original linear model (Guskey, 1986). The Growth Network displayed in Fig. 10 could also be interpreted as modeling the first cycle of the process of action research in which a practitioner makes informed modifications to practice, monitors the consequences of the new practice, reflects on the significance of those consequences, makes further modifications to practice, and so ad infinitum. The Interconnected Model suggests that the spiral of action research as undertaken by many teacher researchers can be seen as the formalization of a learning process intrinsic to teacher professional growth.

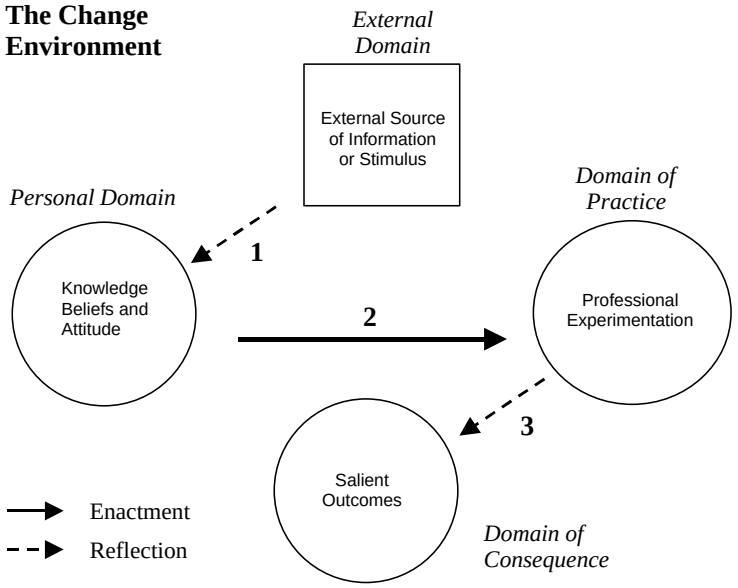

Fig. 9. Sample growth network 1 ("Naïve Linear Model").

4.3. Empirically derived structural patterns

In Fig. 10, Arrows 2, 3 and 4 offer a model of on-going teacher professional growth in the absence of in-service activity. Clarke and Peter (1993) argued that any model of teacher change had to account for the demonstrable occurrence of teacher professional growth independent of participation in in-service activities. That is, teachers engage in professional experimentation in all aspects of their professional activity, reflect on the consequences of that experimentation and initiate further modifications or refinements of their practice. Every day teachers encounter situations that require such adaptive practice. Some adaptations are temporary, others lead to long-term modifications to practice, that is, to professional growth. The capability to model this process (no part of previous models, which took in-service participation as the prerequisite catalyst of teacher change) is a major strength of the Interconnected Model.

Research undertaken by Hollingsworth (1999) identified a further growth network illustrated in Fig. 11. Contrary to the notion of change proceeding along a predetermined linear path (for example, Guskey, 1986), it appears that teacher change often involves multiple and cyclic movements between the analytical domains of the teacher's world. Fig. 11 represents a cycle of alternate enaction and reflection between the domain of practice and the personal domain (represented by arrows 2, 3, 4, 5, 6 and 7) prior to any reflection associated with consequences (represented by arrow 8), and to any subsequent change in beliefs (arrow 9). This makes the important point that at times teachers may postpone the consideration of outcomes and only change their beliefs following extensive refinement and perfection of an instructional technique. Data collected by Hollingsworth (1999), such as Alan's interview excerpts quoted above, are consistent with this growth network.

Data accumulated from the Clarke/Peter and Hollingsworth studies support the existence of multiple growth networks. It is possible that some growth networks are more prevalent than others. For example, a sequence analogous to Guskey's (1986) linear model (given the reinterpretation of the particular change domains) was clearly evident in the data from both studies. It is also possible that individual teachers have an inclination in

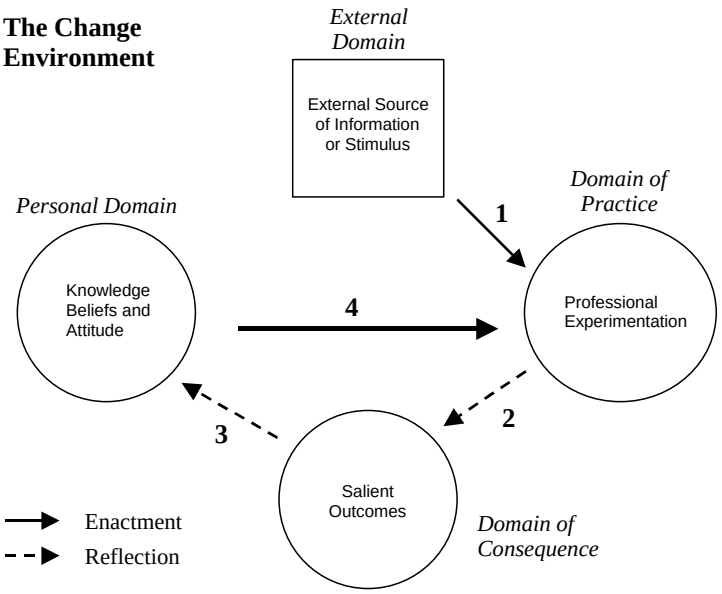

Fig. 10. Sample growth network 2: incorporating "Guskey" (arrows 1, 2, 3) and "Clarke/Peter" (arrows 2, 3, 4, and repeat).

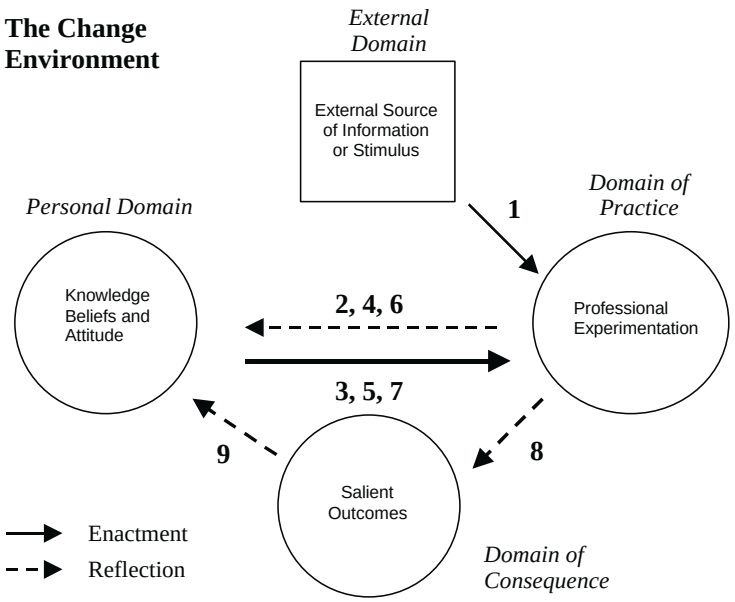

Fig. 11. Sample growth network 3 (“Hollingsworth”).

favor of particular change sequences and growth networks. Such preferences would constitute a form of professional ‘learning style’. Data collected to date have not demonstrated any such individual inclinations—rather, each of the teachers studied have exhibited professional growth through a variety of growth networks. Nonetheless, the finding that teacher professional growth can occur through a variety of such networks suggests that professional development programs should be deliberately designed to offer participants the opportunity to enact change in a variety of forms and change sequences consistent with individual inclinations. In advocating this more responsive approach to professional development, we align ourselves with contemporary recognition of the need to accommodate a variety of learning styles in our classrooms.

5. The role of the change environment

The context in which teachers work (the Change Environment) can have a substantial impact on their professional growth. The school context can impinge on a teacher’s professional growth at every stage of the professional development process: access to opportunities for professional development; restriction or support for particular types of participation; encouragement or discouragement to experiment with new teaching techniques; and, administrative restrictions or support in the long-term application of new ideas. This is illustrated in Fig. 12.

5.1. An environment conducive to change

Throughout Hollingsworth’s study, Alan, for example, made positive and consistent references to the school context in which he was working. In responses to structured interviews and in informal discussions, he referred to several different elements of his school environment that appeared to support him as he was involved in the process of professional development. These included: the school staff and, in particular, the EMIC tutor; the resources and equipment available in the school; the mathematics ethos of the school; and the professional development culture evident in the school. Table 1 displays comments made by Alan that illustrate how he valued each of these supportive elements.

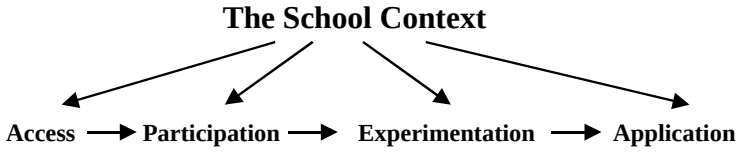

Fig. 12. Influence of the school context.

It was clear that the school environment in which Alan worked had a significant influence on his professional growth. When Alan first arrived at his school, his mathematics teaching style was traditional in orientation, his teaching and assessment strategies repertoires were very limited, and it appeared unlikely that he would actively seek professional development in mathematics. However once his enthusiasm had been aroused through his participation in EMIC, the conditions that existed in the school were both supportive and encouraging of Alan's development. The following comment made by Alan highlights his positive view of his school environment.

> I think the teaching of maths at this school is pretty good. I think we're lucky, we've got a great resource, we've got a fantastic [maths] room, there's always things that we can use, there's always someone there that we can ask questions of. Any changes necessary? I don't think so.

5.2. A different school environment

For some other teachers in Hollingsworth's study, the absence of particular conditions supportive of change appeared to cause some difficulties. One teacher, Cath, considered that at her school there was a lack of coordination and leadership with respect to mathematics, little collegial activity, and no obvious commitment to professional development in the mathematics area. While Cath was obviously concerned about this situation, it did not appear to constrain her involvement in the EMIC program in any way.

Even though Cath demonstrated confidence with respect to her ability to teach mathematics well, and enthusiasm to learn more about mathematics teaching, it seemed that she "missed" the active support of colleagues in her school. Early in the study, Cath highlighted what she considered to be a lack of interest in, and support for, mathematics in her school. In particular, Cath felt that the teaching of mathematics in the school needed to be supported by someone with a "passion" for the subject.

> Unless you have got somebody who really has a passion for that subject and really pushes it forward in front of everybody all the time and keeps it going… it's difficult.

Cath noted a distinct lack of support from the coordinator at her school with respect to participation in EMIC.

> I did mention to the maths coordinator that I thought EMIC would be fantastic, and the comment was "I don't have time for that. I'm only interested in the grade [my class]". So that's fairly hard when you don't have that support.

Cath and one other staff member from her school attended the EMIC course, however it appeared that they did not often communicate with one another about the ideas presented in the program, or any other aspects associated with the course.

Throughout the period of the study, Cath made several references to the difficulties associated with having few staff members from one school attending professional development activities. She considered that a coordinated approach to professional development throughout the school was needed.

> When people do EMIC, I think it's a good idea if it was possible for the whole staff to do it. Because I think that's what you need. You need a coordinated approach where everybody at

Table 1
Elements of Alan's school environment that appeared conducive to change

School environment elements	Related comments made by Alan
Staff and EMIC tutor	There's people. I've got Gail across the road [corridor] … and there's Tanya [EMIC tutor] downstairs. … There are five people I work fairly closely with. (Alan, Interview 1, p. 3) I've got a resource person here [Tanya] that I can go to anytime I need to. (Alan, Interview 3, p. 3) There's a lot of sharing here, it happens all the time. Alan, Interview 3, p. 3) There's always someone there that we can ask questions of. (Alan, Interview 3, p. 5)
Resources and equipment	It's terrific me being here because I can just race up the stairs whenever I want to and grab what I need. It's all there, and it's well set out. (Alan, Interview 2, p. 4) I think we're lucky. We've got a great resource [Tanya], we've got a fantastic room, there's always things that we can use, there's always someone there that we can ask questions of. (Alan, Interview 3, p. 5)
Mathematics ethos	I think our school is up to date … . People are happy following the EMIC approach. I mean it's all happening here. (Alan, Interview 2, p. 5) From what I can see everyone is doing real life maths and using the EMIC approach as much as possible. (Alan, Interview 3, p. 5) I think the teaching of maths at this school is pretty good. … Any changes necessary? I don't think so. (Alan, Interview 3, p. 5)
Professional development culture	Everybody else in the school has been EMICed. … So everyone's up to date. (Alan, Interview 2, p. 4) Tanya even runs special nights here for the staff. (Alan, Interview 2, p. 4) We have heaps of things here. We have FASPA, FAMPA, Key Group [Victorian professional development activities]. There's always something happening here. (Alan, Interview 3, p. 2)

that particular time has done EMIC and then they know what you're on about. I think it's very difficult when you've [only] got two teachers [involved].

I think that these things [professional development activities] are more meaningful if the school does them as a whole, because then you bring back to the whole school what you learn. Rather than have one person from here or three from there. I think it doesn't have that flow through.

It appeared that Cath felt no support from other staff members when she tried to share information she had obtained from the program with them. She suggested that those staff members not directly involved in professional development do not have the same commitment to it.

That's the problem too when only a few people are doing it at once, it's feeding back information to the rest of the staff. Because people think, "oh here's something else". Unless you do it all together and get involved you get, "here's something else we have to think about".

In general, Cath demonstrated enthusiasm for, and interest in, participating in the EMIC program. However it would seem from her comments, that factors associated with her school environment had a negative impact on her professional growth.

The Interconnected Model, as shown in Fig. 3 and subsequent figures, incorporates the change environment explicitly. The significance of the constraints and affordances offered by the change environment (or school context) are powerfully summarized by the teacher, quoted by Desforges and Cockburn (1987): "I don't see the point of all these in-service sessions. I already know how to teach better than I possibly can." Change in every domain and the effect of every mediating process are facilitated or retarded by the affordances and constraints of the work-place context of each teacher (or other professional). Existing research has suggested some contextual factors which appear to act to promote or hinder professional growth (for example, Clarke, 1997). The identification of such factors must inform the design of future professional development.

6. Implications and future applications

The structure of the Interconnected Model has significant implications for future teacher professional development programs (and wider implications for professional development in general). The increasing complexity of teaching (Darling-Hammond, 1997) requires a corresponding sophistication in models of both teaching and of teacher professional growth. Recognition of the complexity of professional growth in a form which models possible growth networks allows the designers of in-service programs and other professional development enterprises to anticipate and encourage all avenues to professional growth.

In the Interconnected Model, the identification of key change domains and mediating processes and the possible relationships between these within the model highlights the particular elements that might most usefully form the components of an effective professional development program. In particular, the interconnected, non-linear structure of the model enabled the identification of particular "change sequences" and "growth networks" in the data relating to individual teachers. Unlike more prescriptive models, the alternate pathways in the Interconnected Model allow us to give recognition to the idiosyncratic and individual nature of teacher professional growth.

Steffe has consistently placed "the mathematics of children" at the center of classroom mathematics activity (Steffe, 1991; Steffe & Thompson, 2000, p. 205, 206). By an analogous argument, we would place "the pedagogy of teachers" (that is, the theories and practices developed by teachers) at the heart of our promotion of the professional growth of teachers. We must accord the same dignity and status to teachers' developing practices that we exhort them to accord to developing student practices. The Interconnected Model of Professional (Teacher) Growth takes teacher change to be a learning process and suggests the possible mechanisms by which this learning might occur. The non-linear structure of the model provides recognition of the situated and personal nature, not just of teacher practice, but of teacher growth: an individual amalgam of practice, meanings, and context. Our support for the process of teacher growth must offer teachers every opportunity to learn in the fashion that each teacher finds most useful. We and our research colleagues have found particular value in the capacity of the model to stimulate speculation, research and development regarding possible change mechanisms as yet unexplored and unexploited. If our professional development programs are to recognize the individuality of every teacher's learning and practice, then we must employ a model of teacher growth that does not constrain teacher learning by characterizing it in a prescriptive linear fashion, but anticipates the possibility of multiple change sequences and a variety of possible teacher growth networks.

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