

Conceptualizing Teacher Professional Learning

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This article adopts a complexity theory framework to review the literature on teachers' professional development practices, the generative systems of these practices, and the impact that learning experiences have on their knowledge and changes in classroom practices. The review brings together multiple strands of literature on teacher professional development, teaching and learning, teacher change, and organizational learning. In doing so, it illustrates that process–product logic has dominated the literature on teacher professional learning and that this has limited explanatory ability. The review demonstrates the ways the elements of three subsystems (the teacher, the school, and the learning activity) interact and combine in different ways and with varying intensities to influence teacher learning. The limitations of studies focusing on specific elements or subsystems are highlighted. The article concludes that to understand teacher learning scholars must adopt methodological practices that focus on explanatory causality and the reciprocal influences of all three subsystems.

KEYWORDS: teacher learning, teacher professional development, teacher change, learning orientation, complex systems.

The importance of improving schools, increasing teacher quality, and improving the quality of student learning has led to a concentrated concern with professional development of teachers as one important way of achieving these goals. Despite this importance, much of the research on professional development has yielded disappointing results with teacher professional learning activities often being characterized as ineffective (Hanushek, 2005; Sykes, 1996). Borko (2004), D. Clarke and Hollingsworth (2002), and Timperley and Alton-Lee (2008) have all argued in previous reviews of this research that the problem stems, in part, from researchers employing simplistic conceptualizations of teacher professional learning that fail to consider how learning is embedded in professional lives and working conditions.¹ These previous reviews have demonstrated that the available literature fails to explain how teachers learn from professional development

(Borko, 2004, p. 3) and the conditions that support and promote this learning (D. Clarke & Hollingsworth, 2002, p. 947). The extant literature also does not build on the work of researchers who have shown teaching and learning to be contextually situated (e.g., Anderson, Greeno, Reder, & Simon, 2000; Ball, 1997; Borko & Putnam, 1997; Cobb & Bowers, 1999; Greeno, Collins, & Resnick, 1996; Lave & Wenger, 1991; Leinhardt, 1988). Thus, although there have been significant calls for a more complex conceptualization of teacher professional learning, our analysis of the extant literature suggests that the majority of writings on the topic continue to focus on specific activities, processes, or programs in isolation from the complex teaching and learning environments in which teachers live. Here, we build on and extend the work of those who advocate a more dynamic understanding of teacher professional learning in an attempt to conceptualize this complex process in ways that provide a foundation for future empirical work.

To develop this complex conceptualization of teacher professional learning, we bring together multiple, fragmented strands of literature from teacher professional development, teaching and learning, organizational learning, and teacher change that have tended to remain separate. In so doing, we rely on a complexity theory orientation that helps to identify systems both within and across these different strands of research and the ways these systems intersect and recursively interact, resulting in the emergence of teacher professional learning. In the following sections we provide both a discussion of this conceptual framing and the subsequent methods used. These sections are followed by sections focusing on each of the systems of influence on teacher learning we have identified in the literature: the teacher, the school, and the learning activities or tasks.

Complexity, Explanatory Causality, and the Conceptual Implications for Understanding Teacher Professional Learning

The impetus for this article comes from frustrations we experienced when conducting an earlier systematic review of professional development literature for the Training and Development Agency for Schools in England that focused specifically on research demonstrating effects on teachers and their students (McCormick et al., 2008).² First, as Nuthall and Alton-Lee (1993) identified with similar teaching and learning research, significant findings in these professional development studies often do not replicate, and findings from some studies conflict with findings from other studies because of a methodological preference for process-product designs. Related to this, despite a seeming consensus on the characteristics of professional development that lead to teacher learning and change (Desimone, 2009), we are still unable to predict teacher learning based on these characteristics. As a result of this review, we questioned why there are reports in this literature of teachers attending professional development with all the characteristics of effectiveness and yet learning or change does not occur. Conversely, we wondered, why are there reports that some teachers learn and change via activities that do not have the identified characteristics of effectiveness?

We believe the professional development effects literature has committed an epistemological fallacy by taking empirical relationships between forms of activity or task (e.g., being activity based), structures for learning (e.g., collaboration between teachers), location (e.g., situated in practice), and so on, and some measure of teacher change to *be* teacher learning. For the most part, this research is

based on the assumption that teacher professional development consists of a repertoire of activities and methods for learning and that teacher learning follows more or less directly from the frequency with which professional development programs use these specific activities, structures, and so on. That is, this literature views teacher learning through a serial (Doll, 1993), additive (Day, 1999) lens. And yet, regardless of how strong these relationships between forms of activity and teacher change may be, they do not address the ultimate causal question—*why?* (Marsh, 1982, p. 102).

Following from this preference for process–product approaches is also a reliance on an absence versus presence measurement of variables. That is, intensity and scale of variables are often lost in the aggregation required for correlating relationships between elements of teacher professional learning. Thus, in addition to considering teacher learning as serial, this research also tends to adopt a logic of reduction (Hoban, 2002). Nuthall and Alton-Lee (1993) have emphasized the need for the Goldilocks Principle when it comes to understandings of teaching and learning. They suggest that the relationships between variables are often curvilinear—too little and learning will not occur, too much and it is counterproductive or negative. The curvilinear nature of many elements of teacher learning has been demonstrated in Leberman and Grolnick's (1996) investigation of 16 education reform networks in the United States when they identified tensions and the need for balance between inside and outside knowledge, centralization and decentralization, and inclusivity and exclusivity of membership. The focus on the absence or presence via aggregate tendencies of certain characteristics of professional development (or of the teacher learners themselves, their environment, etc.) limits our ability to understand the way these mechanisms work in different intensities and at different scales in different contexts. Thus, one of our goals in this review is to shift the conceptual framing of teacher learning and professional development research from a cause-and-effect approach to a focus on causal explanation so that we understand under what conditions, why, and how teachers learn.

For this to occur, we believe that teacher learning must be conceptualized as a complex system rather than as an event (A. Clarke & Collins, 2007; Collins & Clarke, 2008; Curtis & Stollar, 2002; Davis & Sumara, 2006; Hoban, 2002; Marion, 1999; Weaver, 1948). Complex systems thinking assumes that there are various dynamics at work in social behavior and these interact and combine in different ways such that even the simplest decisions can have multiple causal pathways. For example, if we think about why someone may choose to have a cup of tea we can identify multiple mechanisms or systems at work including biological (thirst), normative (he or she lives in England), institutional (it is readily available), historical (he or she has always done so when writing), and so on. How these dynamics combine will vary for different people and even for the same person at different times of the day or in different contexts. Furthermore, the ways they combine and the circumstances in which they combine are patterned; there may be a large number of reasons for tea drinking, but the reasons are neither limitless nor tend to be random.

In the context of current research on professional development and teacher learning, misunderstanding the nature of teacher learning by underplaying the complexity of the problem leads to focus on the micro context (individual teachers or individual activities or programs) to the exclusion of influences from meso

(institutional) and macro (school system) contexts (e.g., Bore & Wright, 2009; Bottery & Wright, 1996). As a complex system, or what Blackman et al. (2006), Bore and Wright (2009), and Briggs (2007) refer to as a wicked problem, teacher learning becomes hard to define by aggregation and generalities because the nature of learning depends on the uniqueness of the context, person, and so on. As such, it is not necessarily amenable to generic principles of analysis and linear heuristics. Relationships between elements in the system vary in scale and intensity, come together in different combinations depending on the situation, are often reciprocal, and are always nested.

An important characteristic of the complexity of teacher learning is that it evolves as a nested system involving systems within systems (e.g., Stollar, Poth, Curtis, & Cohen, 2006). As such, drawing on useful conceptual insights of Davis and Sumara (2006, p. 90), teacher learning tends to be constituted simultaneously in the activity of autonomous entities (teachers), collectives (such as grade level and subject groups), and subsystems within grander unities (schools within school systems within sociopolitical educational contexts). These systems and subsystems associated with teacher learning are interdependent and reciprocally influential. As a result, to explain teacher professional learning, one must consider what sort of local knowledge, problems, routines, and aspirations shape and are shaped by individual practices and beliefs. How are these then framed by the other systems involved? Furthermore, all nested levels of complex systems are learning systems, where the system adopts new information and processes and in so doing transforms itself as it experiences the world (Davis & Sumara, 2005, p. 312). As Stollar et al. (2006, p. 183) argue, the complexity of schools and other educational agencies emerges through the reciprocal influences within and between systems so that learning and change in any particular part of the system can result in change in other parts (Curtis & Stollar, 2002). In this way, teacher learning is intimately connected to learning at other levels of the system. The point here is not that all levels must be taken into consideration for each and every aspect of teachers' professional learning, but that any attempt to understand teachers' professional learning at only a subsystem level must be understood as partial, incomplete, and biased.

Casting teacher learning as a complex system recognizes that this involves many processes, mechanisms, actions, and elements and that it is difficult to specify exact outcomes in every instance. Weaver (1948) identified a class of phenomena that were neither simple (involving a small number of variables and interactions allowing accurate predictions of all possible outcomes) nor complicated (involving multiple variables and interactions characterized by sufficient overall regularity to allow for predictions of an outcome within acceptable limits). He referred to this third set of phenomena as "organized complexity," what are referred to now as complex phenomena. Like complicated phenomena, complex phenomena involve multiple variables and interactions, but unlike complicated phenomena, the outcomes tend not to be predictable at the outset. Importantly, however, Weaver (1948) reported that outcomes do emerge, are not random, but reveal multiple patterns of outcome. Thus, we construe teacher learning as a complex system representing recursive interactions between systems and elements that coalesce in ways that are unpredictable but also highly patterned (A. Clarke & Collins, 2007, p. 161). Therefore, identifying emergent patterns of interaction within and between levels of activity that would constitute an explanatory theory of teacher learning

as a complex system requires variable-inclusive (as opposed to control) strategies of research, development, planning, and evaluation.

Many researchers have argued for more complex understandings of teaching or learning without necessarily adopting complexity theory to do so (see, e.g., Baird, 1992; Bickel & Hatrup, 1995; Biggs, 1993; Borko & Putnam, 1997; Calhoun & Joyce, 1998; Clandinin & Connelly, 1996; Cochran-Smith & Lytle, 1993; Day, 1999; Greeno, 1991, 1994; Leinhardt, 1988; Leinhardt, McCarthy Young, & Merriman, 1995; McLaughlin, 1993; Quartz, 1994; and others). In the mid to late 1980s and early 1990s, many authors were discussing teaching and learning as being situational, contextual, or ecological. However, coinciding with a rise in school accountability and the push in education research for scientificity in the late 1990s and 2000s (Lather, 2005), research on teaching and learning became more mechanistic and linear in response to the call for causal studies, effects, and the growth of linear statistical modeling. As a result, the conceptual growth on complex understandings made in the earlier period stalled but has more recently had a resurgence with the work of complexity theorists such as Davis (2004, 2008), Davis and Simmt (2003, 2006), Davis and Sumara (2006, 2007), Doll, Fleener, Trueit, and St. Julien (2005), Hoban (2002), Goldstone (2006), and others.

The situational, contextual, and ecological work of the earlier period was primarily focused on the complex practice of teaching or on the complexity of student learning. For example, Leinhardt et al. (1995) describe teaching practice “as a coherent whole” (p. 404) and explain that the “multiple, inter-related strands of teaching” (p. 405) cannot be separated into discrete skills, knowledge, or techniques. Furthermore, they argue that both teaching and learning involve movement in several directions simultaneously (p. 407), thus recognizing the multidirectional and multicausal processes at work. Similarly, in considering teacher learning specifically, Borko and Putnam (1997) identify multiple perspectives that can inform this learning, including the personal, the social, the situated, and the distributed notions of cognition. However, in identifying the multiple perspectives that can influence teacher learning, Borko and Putnam do not attempt to bring them together into a unitary conceptualization or whole. Rather, their discussion treats them as different lenses that can be used to understand learning from different perspectives. In thinking of them as separate lenses, however, they miss the interactions that occur between and among the different perspectives.

Thus, although the situational, contextual, and ecological literatures certainly understand teaching and learning as complex practices, they differ in substantial ways from how complexity theorists would characterize these concepts. For example, returning to Leinhardt et al. (1995), they discuss the components of teaching practice and the need to guide student teachers through actions, calling for systematic analysis of these processes (p. 405). In this regard, researchers such as Leinhardt and her colleagues who see teaching and learning as complex differ from complexity theorists because they think analytically in complex but systematic ways rather than in complex systems ways.

Another difference between today’s complexity theorists in education and those of the earlier period of complexity-like thinking is that the earlier researchers saw the contextualized nature of knowledge, teaching, and learning, whereas the complexivists see both contextualization and decontextualization at work. In the contextualized account, learners and their environments are seen as parts

of a single entity. How someone learns depends on the larger system in which he or she learns. Elements of the system (both individual learners and other system elements) cannot be understood independently. Rather, the interactions of the elements give rise to emergent behaviors that would not arise through independence. A key concern with a singular focus on contextualization is its inability to lead to generalizations (Goldstone, 2006). But complexity theorists have also identified some principles of complexity that can also be applied to different cases from seemingly unrelated domains (see, e.g., S. Johnson's, 2001, work on ants, brains, and cities). Thus, although teaching and learning are contextualized, complexity theorists also believe it to be decontextualized—patterns can be generalized across highly contextualized instances. Related to this, when complexity theorists think about learning, these two seemingly contradictory ideas—contextualization and decontextualization—are considered to be two aspects of a common process of conceptual reorganization (i.e., learning; Goldstone, 2006, p. 37). That is, teachers must recursively consider general principles and specific contexts to learn.

Given our understanding of complexity theory plus the issues identified with the reductionist epistemological positioning of much of the teacher learning literature, our conceptual framing rejects an invariant model of teacher learning that assumes that structures and sequences repeat themselves time after time in essentially the same form because such invariance ignores transformative processes and promotes premature simplification (Tilly, 2008). We adopt Marsh's (1982) position that there are many ways to produce teacher learning (p. 70). Some causes may be preconditions, others may be catalysts, others may influence the way learning is produced, and others may be able to directly affect learning, but they also may all work together to produce learning. Taking all these mechanisms and processes into account will help us not only to state the effect but to explain the effect. We therefore adopt a mechanism—a process logic of explanation that couples an understanding of systems with a search for initial conditions, sequences, and combinations of mechanisms that come together into processes that generate explainable but variable outcomes. We assume that in different combinations, circumstances, and sequences, the same causes that may produce teacher learning and change may also lead to intellectual stagnation and inertia. The invariable principle in our conceptualization is therefore variation (Tilly, 2008, p. 76).

Review Method

This conceptual framing of teacher learning has implications for conducting a review of the literature on teacher learning. As we have argued above, current methods and techniques that stress aggregation and identifying regularity have obfuscated the absence of theoretical explanation for teacher learning research, and we did not want our review methods to repeat this error. Because systematic reviews and meta-analyses take regularity as evidence of cause and effect, they reduce the “real” to empirical experience. Furthermore, the focus of these reviews on large-scale studies with strong associations privileges technique and method rather than the logic of causation. These forms of review, although procedurally rigorous, fail to provide insight into the generative mechanisms at work in the concrete worlds of teacher experience (Clegg, 2005, p. 423). We are not interested here in identifying a list of professional development processes or practices that result in teacher learning. Rather, our concern is on developing an explanation for

why teacher learning may or may not occur as a result of professional development activity.

In our review process, we focus on “elaborating” the identified relationships in the literature on teacher learning and teacher professional development to unpack how they have their effect. Our goal, though, is not to endlessly elaborate these relationships by considering more and more processes, moderators, and mediators at work. Rather, our goal is *verstehen*—to reach a point at which we have teased out the interconnected and overlapping processes that makes the learning of teachers plausible (Leat, 1972). To help develop and validate this understanding, we relied on “informant confirmation” (Boote & Beile, 2005; Ogawa & Malen, 1991). Our conceptualization of the literature was shared with, and corroborated by, various knowledgeable persons in an iterative fashion. The conceptualization was presented to multiple audiences—to the Training and Development Agency for Schools in England, to our colleagues in a faculty-wide presentation as part of a research symposium on Teaching and Learning, at the British Education Research Association Conference, at the American Educational Research Association Conference, and at an Effective Teachers Seminar in Scotland. After each occasion, we returned to the literature, adding additional ideas for inclusion in the conceptualization based on the feedback we had received. This iterative process of conceptualization has continued during the review process of this article, and the ideas presented here include suggestions made by anonymous *Review of Educational Research* reviewers and the journal editor.

In conducting our literature searches, we consulted databases containing abstracts of empirical and theoretical research. These databases included Australian Educational Index, British Educational Index, Educational Resources Information Center, Social Sciences Citation Index, SCOPUS, ProQuest, and PsycARTICLES. We also searched tables of contents from volumes of education-focused, peer-reviewed journals with an identified interest in professional development and teacher learning, including *Teaching and Teacher Education*, *Journal of Teacher Education*, *European Journal of Teacher Education*, *American Educational Research Journal*, the *Curriculum Journal*, and others. Relevant reviews of studies (e.g., Antonacopoulou, 2006; Borko, 2004; D. Clarke & Hollingsworth, 2002; Cordingley, Bell, Evans, & Firth, 2005a, 2005b; Desimone, 2009; Howes, Booth, Dyson, & Frankham, 2005; Lawless & Pellegrino, 2007; Nuthall, 2004; Seashore Louis & Leithwood, 1998; Timperley & Alton-Lee, 2008) as well as related handbook entries (e.g., Borko & Putnam, 1997; D. J. Clarke & Peter, 1993; Darling-Hammond & McLaughlin, 1999; Feiman-Neimser, 1985; Goddard, 2003; Greeno et al., 1996; Hallinger & Heck, 2002; Hawley & Valli, 1999; Richardson, 1996, 2003; Zack, 2000) were also considered both for what they contributed to the causal explanation and also as sources for additional articles.

In our procedures we did not intentionally pursue subject area research by searching in subject-specific journals or handbooks since different subjects have different patterns of reasoning and arrangements of concepts. Complexity theorists recognize the inability to read broadly and deeply across multiple fields and subject areas. As a result, they seek to reverse the trend toward increasing specialization (Goldstone, 2006). Therefore, we resisted a search procedure that would take us into increasingly specialized subject areas and journals in teaching, learning, and teacher learning. We chose instead to focus on pieces from the literature, some about a specific subject,

that identify principles and processes that apply to teacher learning across subject areas. In complexivist thinking, seemingly disparate phenomena that span orders of magnitude can be united within a complex system (Goldstone, 2006), and that is our goal in this review.

Articles, chapters, and books were excluded from the review if they presented only an evaluation of, or research on, a specific program or learning technique. For example, an article on the use of specific questioning practices by teacher learning mentors was excluded, as were articles on the impact of online resources for teachers. Nonempirical literature was excluded if it did not reference empirical literature. Thus, reviews of literature were included, but a piece by the Education Commission of the States addressing the importance of various aspects of teacher learning (including subject knowledge and specific learning contexts) by giving a sense of the strength of the evidence available failed to provide citation or description of the empirical work on which it relied and was therefore not included for review. Importantly, both empirical and nonempirical literatures were excluded if they did not attempt to explain how or why the processes of learning occurred. For example, a study demonstrating that teacher subject matter knowledge gained via professional development had an impact on student achievement was not included because the article failed to extend its investigation into why or how subject knowledge matters. These rules for exclusion significantly decreased the number of articles under consideration here. For example, in the search of the *Journal of Learning Sciences*, 73 articles were found for the search terms *teacher and learning*; 12 articles for teacher and professional and development were returned. However, after reading the abstracts and applying the above rules for exclusion, only 1 article was retained for review.

Once an article was selected for inclusion, the article was read by one of the authors and summarized as an “article note.” The notations made for each article included citation information, purpose of the article, level of measurement (teacher, group of teachers, school), summary of methods, outcomes or conclusions, any learning processes identified in the study, and then any mediators of these processes that were identified. Direct quotations from the article were included in the appropriate section of the notes to support the inferences being made and as a check on paraphrasing. These electronic notes were then sorted in different ways to consider themes, shapes, and organization of research ideas present in the overall literature. Thus, the process used mirrored qualitative data reduction and analysis techniques suggested by Miles and Huberman (1994). In instances where authors have multiple pieces on the same topic, multiple citations are included only if the pieces build or add explanatory ideas.

Our review of teacher learning and the resultant conceptualization we present here is therefore partial and contingent—partial in the sense that we are limited in our understanding of teacher learning by the literature considered but also contingent in that, as a complex system, teacher learning is transitory and changeable. As such, we would expect future researchers to add to, challenge, and change the connections that we propose here. Furthermore, through a sequence of evolving studies of teacher learning in different circumstances with different teachers, we would hope that further clarity would be obtained about the differences between the emergent patterns in teacher learning and what is specific and idiosyncratic to individual teachers or contexts. The applicability or generalizability of our review and

resultant conceptualization is thus an empirical question requiring further study or comparison of its accuracy against alternative explanatory models (Nuthall, 2004).

Our review identified three overlapping and recursive systems involved in teacher professional learning: the individual teacher, the school, and the activity. The individual teacher system encompasses their prior experiences, their orientation to, and beliefs about, learning, their prior knowledge, and how these are enacted in their classroom practice. School-level systems involve the contexts of the school that support teaching and learning, the collective orientations and beliefs about learning, the collective practices or norms of practice that exist in the school, and the collective capacity to realize shared learning goals. Finally, because we are interested in teacher professional learning, we include the systems of the learning activities, tasks, and practices in which teachers take part. It is to the systems of professional learning activity that we first turn in presenting the model. This is followed by sections that elaborate the system of the individual teacher, the systems of the school, and how all these autopoietic systems interact generatively for teacher professional learning to emerge.

Teacher Professional Learning Activity

The impetus for the large amount of attention given to teacher professional development by researchers and policymakers has often rested on a process-product conceptualization of causality: that effective professional development will improve teacher instructional practices, which will result in improved student learning.³ This position has been supported by policies in many countries that provide a definition of professional development to which activities engaged in by teachers should adhere—as is the case in England. The dominance of this straightforward equation has resulted in a significant research focus on processes and elements of “effective” professional development—that is, in identifying the features and forms of teacher learning activities that result in changes in teaching practice and, by extension, increases in student learning.

Twenty years ago, Carpenter, Fennema, Peterson, Chiang, and Loef (1989) studied the features of professional development associated with improved student learning by conducting a randomized experiment and found that teachers who participated in an extensive 80-hour program of cognitively guided instruction had students who outperformed the students of teachers who had participated in a brief 4-hour professional development program. This evidence of professional development effects has influenced a proliferation of research on professional development features, and a consensus on features associated with improved student learning has emerged (Desimone, 2009, p. 183).

Research on professional development has concluded that teachers need time to develop, absorb, discuss, and practice new knowledge (Garet, Porter, Andrew, & Desimone, 2001). As a result, most research has concluded that activities that effectively support teachers’ professional learning need to be sustained and intensive rather than brief and sporadic. Traditional learning formats such as one-time workshops and conferences, what Ball (1994) described as “style shows,” are less likely to lead to teacher change (Hawley & Valli, 1999). Thus, professional development that involves significant numbers of contact hours over a long period of time is typically associated with effectiveness (Guskey, 2000).

In addition to the element of time, researchers have focused on pedagogical features of professional development activities associated with effective teacher learning. This has led researchers to consider the types of materials teachers use while learning, the coherence of the learning activity to their daily work, and the pedagogical processes those teachers engage in while learning effectively (Birman, Desimone, Porter, & Garet, 2000; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Wayne, Yoon, Zhu, Cronen, & Garet, 2008). Teachers learn most effectively when activities require them to engage with materials of practice (Borko & Putnam, 1997; Greeno, 1991; Hawley & Valli, 1998; Putnam & Borko, 2000), when activity is school based and integrated into the daily work of teachers (Greeno, 1994; Hawley & Valli, 1999; Leinhardt, 1988; Wideen, Mayer-Smith, & Moon, 1998), and when the pedagogy of professional development is active and requires teachers to learn in ways that reflect how they should teach pupils (Borko & Putnam, 1997; Darling-Hammond & McLaughlin, 1999). Teachers are less likely to change practice as a result of learning activities that occur via presentation and the memorizing of new knowledge (Birman et al., 2000; Desimone et al., 2002; Garet, Porter, Desimone, et al., 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Wayne et al., 2008).

Professional development has been shown to be more effective in affecting teacher learning and teacher practice if teachers from the same school, department, or year level participate collectively (Birman et al., 2000; Desimone et al., 2002; Garet, Porter, Desimone, et al., 2001; Wayne et al., 2008). Cordingley et al. conducted two reviews of research that focused on the impact of collaborative professional development on teacher practice (Cordingley et al., 2005b) and student achievement (Cordingley et al., 2005a). In these reviews, they conclude that collaborative professional development produced changes in teacher practice, attitudes, belief, and student achievement. However, these reviews also highlight that few studies of individual professional development have measured the impact of the activity on these outcomes. Rather, the relationship between collaboration and changes in teacher behavior emerges as a correlational one in the research that focuses on professional development activities.

A separate literature has focused on collaboration resulting from the development of communities of practice. The work on these communities is primarily from a situated perspective and is more consistent with our complexity orientation. This research helps to explain how and why collaboration is important to teacher learning and change (Ball, 1997; Cochran-Smith & Lytle, 1999; Goldenburg & Gallimore, 1991; McLaughlin & Talbert, 1993; Richardson & Anders, 1994; Thomas, Wineburg, Grossman, Myhre, & Woolworth, 1998). It considers the interplay of individuals, communities of teachers, and specific contexts in trying to understand and improve teacher learning. When these elements come together and a learning community emerges, the participating teachers are more likely to discuss problems, strategies, and solutions. Change in teaching behavior then becomes an ongoing, collective responsibility rather than an individual one.

The research on collaboration in teacher professional activities is also a good example of how the application of the Goldilocks Principle (Nuthall & Alton-Lee, 1993) could improve the explanatory power of the research. Little (1982, 1990), Page (1988), and others have shown collaboration to be a double-edged sword. For example Little's research with teachers indicates that too much collaboration can

emphasize conformity to group norms at the expense of inventiveness and initiative. As a result, the predominant conclusion that increased collegiality will lead to improvement is unwarranted (Little, 1990, p. 509). To explain the role of collaboration in teacher learning, the intensity of collaboration becomes an important determinant—too much collaboration and learning are stifling, too little collaboration and teacher isolation inhibit growth, just enough collaboration and teachers receive the stimulation and support from colleagues necessary for change. How much collaboration is necessary for teachers to learn will also vary depending on both individual and organizational system influences. All teachers in a school may vary in the amount of collaboration necessary for change, and for teachers the amount of collaboration will vary as their specific systems of influence interact and change overtime. For the general principle—teacher collaboration enhances their learning—to hold, we must understand collaboration as a collection of specific patterns across individuals and schools that hold in a variety of situations.

Although a substantial literature exists about the ability of specific features of professional development to improve teacher practice and student learning, some researchers have begun to question this as causal knowledge. A recent review of this research by Lawless and Pellegrino (2007) concluded that although professional development opportunities have increased for teachers, our understanding of the features and content of quality professional development has not increased proportionately. Furthermore, Wayne et al. (2008) have also concluded that the evidence is weak and fails to address practical questions that would help in the design of effective learning activities (p. 469). These authors recognize that the current research on professional development features has identified effects on teachers' knowledge or practice, but the lack of replication of these effects across studies and the lack of consistency in these effects across contexts make the findings on these features less impactful than the research consensus would imply.

The work of D. Clarke and Hollingsworth (2002), D. J. Clarke and Peter (1993), and D. J. Clarke (1988) is also helpful in understanding why the correlational research on features of teacher professional development activity and change has been so disappointing. This work illustrates the cyclic nature of the learning and change process. Change can occur in one area of influence but may not lead to change in another. That is, teachers may change their beliefs but not their practices, may change their practices but not their beliefs, and ultimately may change their practice but not the learning outcomes of their students. For teacher learning or growth to occur, change must occur in multiple areas of influence (D. Clarke & Hollingsworth, 2002). Learning in one system must affect and be enacted and supported in another system. As a result, "effective" teacher learning requires multiple and cyclic movements between the systems of influence in teachers' worlds.

Thus, if the goal is to explain and predict effective teacher learning and teacher pedagogical change, we must first expand our causal assumptions about the features of professional development by recognizing that features may collectively work together in different ways under different circumstances in different contexts. Second, we must recognize the important role of variation in intensity of the features. Then, we must expand our causal assumptions beyond the features of the learning process or activity to consider the reciprocal relationships that exist between the system of activities in which teachers engage and the systems of influences that mediate and moderate these activities, teacher learning, and teacher

change. Our review of the literature suggests that two additional systems influence teacher learning and teacher change beyond features of the learning activity: the individual teacher and the school. It is to explaining teachers' orientations to learning systems and the impact on professional learning that we now turn.

The Influences of the Teacher on Professional Learning: Their Orientation to Learning System

Teachers bring both past experiences and beliefs to their teaching and learning. As Richardson (2003) has shown in her work with preservice teachers, the beliefs they bring to their work are shaped by the kind of teaching they have experienced as students (p. 2). Green (1971) has also argued that teaching involves the formation of beliefs, both in terms of *what* we believe and also *how* we believe it (p. 48). Thus, teaching is influenced by beliefs but also leads to the modification and formation of belief systems. This intersection of experience and belief creates a powerful combination that determines not only the instructional decisions that teachers make (Raths, 2001; Richardson, 1996) but also, we would argue, what they themselves are willing to learn.

The recognized importance of teacher beliefs as critical to teacher practice and change has resulted in a proliferation of studies investigating these connections. In Richardson's (1996) well-known work on preservice teacher belief, she identified three sources for teachers' pedagogical beliefs: personal experience, experience with school and instruction, and experience with formal knowledge (both subject and pedagogical). Likewise, for example, Powell and Birrell (1992) and Novak and Knowles (1992) demonstrate that beliefs are heavily grounded in past and present experiences. Based on past experiences (as both teachers and students), teachers bring to their teaching and learning attitudes, values, theories, and images in the guise of beliefs that affect their own decisions about learning.

Teachers also bring prior knowledge to their own learning. However, our assessment of the literature on knowledge for teachers and teaching indicates that there is little consensus both within and between subject fields about what teachers need to know or how they need to know it. Generally, the research indicates that more courses in a subject may not be what teachers need. For example, Begle (1979) and Monk (1994) demonstrate a weak relationship between subject courses taken by teachers and their students' performance on exams. Ball and Bass (2003) assert that the mathematical knowledge needed by teachers is neither more knowledge nor knowledge with greater depth than that of their students. Rather, they assert that the knowledge needed is qualitatively different. Likewise, Gregg and Leinhardt (1994) for geography and Zeidler (2002) for science have reached similar conclusions. Thus, there is now a consensus in the literature that a distinct rather than a generic body of knowledge is needed (Ball, Lubienski, & Mewborn, 2001).

The researchers who call for a distinct type of knowledge for teaching, following Shulman (1986), start by identifying separate but interacting domains of knowledge needed for teaching. The blending and interaction of these various types of knowledge into a unique form is thought of as pedagogical content knowledge (Ball, Thames, & Phelps, 2008; Gess-Newsome & Lederman, 1999). Calderhead's (1988) alternative model of knowledge use in teaching has numerous aspects of a complex system including interacting concepts, multidirectional

arrows, and recursive causality (e.g., between metacognitive processes and elements that affect knowledge use in the classroom). But Calderhead himself acknowledges that his model still represents subject knowledge as a single, discrete entity and is therefore an oversimplification (p. 62). Likewise, the transformative model of pedagogical content knowledge, as described by Gess-Newsome (1999), illustrates a complexity-like understanding of the role of knowledge in teacher learning. Different forms of knowledge are synthesized in the learning processes (subject, pedagogy, and context knowledge are identified by Gess-Newsome) into a unique form of knowledge. In this way, learning is emergent from the reciprocal interaction of the generative mechanisms of knowledge. As an example of this understanding of knowledge for teaching from complexity theorists, Davis and Simmt (2006) have identified multiple influences on knowledge including subject objects, curriculum structures, collective dynamics, and subjective understandings.

From a complexity theory perspective, the point to be made here is that teaching knowledge has many influences and also influences other components of teacher learning systems. Furthermore, a body of teaching knowledge resides neither in the knower nor outside the knower; rather, knowledge emerges from the recursive actions of knowers and other learning system elements. Thus, complexity theorists emphasize the simultaneity of the knower and the known. They view systems of knowledge produced (knowledge) as simultaneous to the knower (a knowledge producing system). One cannot exist without the other. Learning then is the ongoing transformations, simultaneously, of both the knower and knowledge. Learning is a continuous process through which both the learner and the knowledge to be learned is redefined in relation to one another. Thus, teacher learning is affected by prior knowledge that has many influences. As teachers learn, new knowledge emerges from the interaction of the teacher learning systems, and this new knowledge then recursively influences future learning and also what is to be known about teaching.

Thus, it is the interaction and intersection of knowledge, beliefs, practices, and experiences that constitute a teacher's individual orientation to learning system. But when does an orientation to learning serve as an impetus for change? K. F. Wheatley (2002) suggests that dissonance between personal expectations and sense of efficacy may open up the possibility for teacher learning to occur—self-doubt may cause reflection and may motivate teachers to learn. Likewise, Cobb, Wood, and Yackel (1990) discuss the importance of “cognitive conflict” in teachers' thinking. They suggest that this cognitive conflict—or challenges to teachers' approaches and thinking—could be a motivator for change. Ball (1988) too has argued that dissonance in teacher thinking is often required for teachers to unlearn much of what they believe, know, and know how to do in order to learn and adopt new practices. Complexity theorists refer to this dissonance as the “edge of chaos,” or the special balance point between chaos and order where creativity and change can occur (Marion, 1999; Waldrop, 1992, p. 12).

The Economic and Social Research Council-funded Learning How to Learn project in England (James et al., 2007; Pedder, 2006; Pedder, James, & MacBeath, 2005; Pedder & MacBeath, 2008) specifically considered how differences between practices and orientations to learning (defined as learning values in the study) created opportunities for teacher learning. In a survey of 1,212 primary and secondary

teachers in 32 schools in England, teachers were asked how often certain learning practices occurred (the practice scale) and how important teachers believed these practices were for creating opportunities for students to learn (the values scale). The analysis showed that differences in the gaps between teachers' own assessment of their values and practices were indicative of varying levels of inquiry, collaboration, valuing of learning, and critical and responsive learning.

The continuous and sometimes conflicting interplay between an individual teacher's practices, experiences, and knowledge and his or her beliefs within his or her orientation to learning system become important (Cobb et al., 1990). The dissonance between the ideal and the assessment of current capability that emerges from this cyclic interaction may result in a "change-provoking disequilibrium" (Woolfolk Hoy, Hoy, & Davis, 2009). However, Coburn (2001) has shown that if the dissonance among beliefs, practices, knowledge, and experience is too large, teachers may dismiss new ideas as inappropriate to their situations. Timperley and Alton-Lee (2008) concur that since the resolution of dissonance involves the reconstruction of current values, beliefs, and knowledge in ways consistent with change messages, dissonance may lead to rejection rather than adoption of new learning (p. 345). Therefore, as with all the elements in our systems influencing teacher learning, intensity matters.

Within our developing conceptualization of teacher learning, the relationship among the learning orientation system, learning activity, and changes in practice is reciprocally causative. Teachers have an orientation to learning system that consists of the interactions among their experiences, beliefs, knowledge, and practices. The dissonance that exists within their learning orientation system may serve as a catalyst to seek new learning and change. However, as teachers change, their orientation to learning system also changes.

The Interaction of the Learning Activity System and Teachers' Learning Orientation Systems

A teacher's orientation to learning has an extremely strong influence on how and what he or she learns. Smylie (1988), in a study of belief and in-service teacher learning, concluded from a path analysis study of 56 teachers' professional development processes that the perceptions and beliefs of teachers were the most significant predictors of change (p. 23). Unfortunately, the orientations brought to teaching and learning are not easily altered. In studies that have specifically attempted to change teacher orientations to learning via course work and learning activities, few have been successful (Ball, 1990; McDiarmid, 1992). Research studies demonstrate that teachers are more likely to embrace evidence supporting their existing orientations than evidence that contradicts them (Chinn & Brewer, 1993; Tillema, 2000). Thus, reported changes resulting from course work or short-term professional development activities may be more the result of the change measures used than "real" changes in teacher orientation (Richardson, 2003, p. 11).

The literature expects these orientations to change if teacher learning provides more and better,

- a. Field and classroom experiences (Atkins, 1998; Groulx, 2001; Hart & Rowley, 1996; Hodge, 1998; Linek, Nelson, & Sampson, 1999; Mason, 1997; Pigge & Marso, 1997; Quinn, 1997; Teicher, 1997);

- b. Opportunity for reflection (Carter, 1998; Harlin, 1999; Levin & Matthews, 1997; Maxson & Sindelar, 1998; Peterson, Cross, & Johnson, 2000);
- c. Opportunities for understanding oneself in a secure environment under challenging or novel circumstances (Crawford, 1998; Harper & Daane, 1998; V. G. Johnson & Landers-Macrine, 1998; Robin, Tellez, & Miles, 1998; Ropp, 1999; Sherry, 2000; Yildirim, 2000);
- d. Applied knowledge about teaching and learning (Abbott & Farris, 2000; Foegan, Epsin, & Allinder, 2001; Tatto, 1996; Vacc & Bright, 1999).

Despite the close identification of these elements with effective teacher learning and changes in teacher orientation, few of these studies empirically connected the specific learning activities to specific changes in teacher belief. Fewer still go further to connect the learning activity to change in learning orientation and change in subsequent teaching practice.

The empirical research that has considered the learning activity system elements associated with changes in teacher orientations tends to support the professional activity features identified in the previous section. Since teacher learning orientations are acquired via teaching practice and experience, it is difficult for learning activities that rely on the transmission of new knowledge to alter what has been acquired through action. Thus, teacher learning orientations are more likely to change when learning activities have a conceptual and practical coordination or coherence across programs and activities (Feiman-Nemser, McDiarmid, McInik, & Parker, 1989). Tillema (2000) demonstrated that reflection after practice had a positive effect on belief change, whereas reflection prior to practice did not result in belief change, resulting in unstable change of practice. It is interesting that because of the connection between belief change and experience, change in teachers' learning orientations appears easier to accomplish in in-service rather than preservice teacher learning.

As with the other elements in our systems influencing teacher learning, the activity system and the teacher orientation to learning system are interdependent and reciprocal. Teachers will tend to seek out learning activities that are consistent with their orientation to learning. However, should engagement in the learning activity lead to changes in knowledge, practice, or belief, the orientation to learning system will change. As the orientation to learning system changes, this may lead to teachers seeking different types of learning activities. However, all of these processes are nested within an organizational system, and it is to this system and its influences that we now turn.

The Influences of the School on Professional Learning: A School-Level Orientation to the Learning System

It is now well established that the norms of the school, its structures and practices, both enable and constrain teachers (Galloway, Parkhurst, Boswell, & Green, 1982; Mortimore, Sammons, Stoll, Lewis, & Ecob, 1990; Pollard, 1985; Rutter, Maugham, Mortimore, & Ouston, 1979; Woods, Jeffery, & Troman, 1997). For example, Hollingsworth's (1999) longitudinal study of primary mathematics teachers' professional development demonstrated that teachers encountered difficulties in implementing new practices in their classrooms because of unsupportive

conditions in their schools: a lack of coordination and leadership, little collegial activity, and no obvious commitment to professional development in mathematics. Given evidence on the role of schools in teacher learning, Pedder (2006) has argued that schools need to develop the processes and practices of learning organizations if they are to embody the conditions that optimize and sustain teacher learning (p. 175).

The conceptualization of a learning organization and the exact relationship between individual and organizational learning remain unresolved issues in the organizational literature (Antonacopoulou, 2006). Some researchers have asserted that organizations are more than just collections of individuals, but at the same time organizations cannot exist without a collection of individuals. Similarly, these researchers have concluded that organizational learning is more than just the sum of the learning of the individuals in the organization even though organizations can learn only through the experiences and actions of their members (Argyris & Schon, 1978). However, other researchers have critiqued the idea that organizations are more than collections of individuals, stating that this claim gives organizations anthropomorphic qualities (Kim, 1993). A compromise position presents organizational learning as a social process, which is affected by contextual factors such as organizational structure, information, and communication and control processes, but which in turn affect the way individuals learn (Hedberg, 1981; Pawlowsky, 2001; Simon, 1991).

Substantial research and writing on the characteristics of learning organizations have reached some consensus on the processes and practices that promote both organizational and individual learning. These include the following:

- Nurturing a learning environment across all levels of the school (Barth, 1986; Hopkins, West, & Ainscow, 1996; Senge, 1990);
- Using self-evaluation as a way of promoting learning (MacBeath, 1999; MacBeath & Mortimore, 2001; MacGilchrist, Myers, & Reed, 2004; Rosenholtz, Bassler, & Hoover-Dempsey, 1986);
- Examining core and implicit values, assumptions, and beliefs underpinning institutional practices via introspection and reflection (Argyris, 1993; Argyris & Schon, 1978; Deal, 1984; Huberman & Miles, 1984; Senge, 1990);
- Creating systems of knowledge management that leverage resources, core capabilities, and expertise of staff and pupils (Hargraeves, 1999; Leithwood, Leonard, & Sharratt, 1998; Marks, Louis, & Printy, 2000; Nickols, 2000; Nonaka & Takeuchi, 1995; Pedder, 2006; Rosenholtz et al., 1986; Zack, 2000).

However, the identification of these organizational factors and their impacts on teacher professional learning seem deceptively simple. As with many of the elements in the other systems influencing teacher learning, each factor is counterbalanced by an opposing one—autonomy and administrative direction, shared assumptions, and diversity of opinion are all necessary.

For example, schools can have both an internal and an external orientation to learning and improvement. Schools that are learning organizations have a

balanced reliance on external resources of knowledge and information and the internal resources and capacity within the school itself (Drucker, 1995; Hallinger, 1998; Hallinger & Heck, 2002). March (1996) identifies this distinction as “exploitation” and “exploration.” Senge (1990) identifies these as “adaptive” and “generative” modes of learning. Encompassing all this work is the acknowledgment that schools must spend as much (or some may argue more) time on internal development, execution, and capacity building as they do on searching and discovering new ideas. Getting the balance correct between the internal and external orientations to learning may be the difference between a school that continuously learns and one that continuously adopts new ideas without real effect. Likewise, we would surmise that this differentiation between an internal and external orientation to learning may also have implications for how teachers’ individual orientations to learning systems operate—that is, individual teachers may also need to balance an externally focused search for new ideas with internal reflection on teaching practice, beliefs, and values. This conclusion is supported by the contradictory research on collaboration (Cordingley et al., 2005a, 2005b; Little, 1982, 1990; Page, 1988), the research of Leiberman and Grolnick (1996) on the need for balance between inside and outside knowledge for teacher networks, Korthagen’s (1988) work on preservice teachers’ implicit theories of learning, and Schon’s (1983) work on the reflective practitioner.

Some of the most important school-level influences identified by research are school-level beliefs about learning. These beliefs influence both individual and collective behavior by creating norms of action (Sampson, Morenoff, & Earls, 1999). Coleman’s (1985, 1987, 1990) work on the social theory of normative control confirmed that a group of teachers will sanction an individual teacher’s practice when that practice violates group pedagogical beliefs. New or inexperienced teachers are especially vulnerable to constraining their practice to fit with collective pedagogical beliefs (Chester & Beaudin, 1996; Woolfolk Hoy & Burke-Spero, 2005). Thus, although individual teachers have their own beliefs and practices about teaching and learning, schools collectively also have beliefs and practices about teaching and learning that constitute what complexity theorists refer to as the “collective conceptual orientation” (Bowers & Nickerson, 2001).

In addition to collective pedagogical norms and practices, schools also have a collective awareness of their capacity for learning and growth. As Goddard (2003) has shown, teachers have beliefs, both individual and collective, about the conjoint capability of a school faculty (p. 184). According to Bandura (1997), an important feature of an organization’s operative culture is its beliefs about its efficacy to produce (p. 476). This collective sense of capacity then directly affects the diligence and resolve with which a school, and thereby its teachers, chooses to pursue goals.

Creating systems, supports, and norms that encourage both individual and organizational learning and getting the balance right between internal and external sources of learning are difficult for most schools. Pedder and MacBeath (2008) caution that schools struggle to develop systems and processes to support the sharing of knowledge and to use this knowledge to improve collective and individual practices. Similarly, much of the variation reported by Desimone et al. (2002) from the Eisenhower studies of professional development impact occurred between teachers within a school rather than between teachers in different schools. This suggests that schools lack a coherent and coordinated approach to teacher learning.

Argyris and Schon's (1996) work on "theories of action" illustrates that dissonance, as in the individual teacher learning system, serves as a catalyst for schools to attempt to change their environment in ways that better support learning. Their distinction between "espoused theories" (i.e., ideals) and "theories in use" (i.e., practices) illustrates the possibility that beliefs and practices at the school level may not align (p. 13). Dissonance or disequilibrium is a commonly recognized characteristic of complex systems (A. Clarke & Collins, 2007). Seashore Louis and Leithwood (1998) demonstrate in their work on organizational learning that for transformative processes to occur, disequilibrium is necessary (p. 277). Ilya Prigogine won the 1977 Nobel Prize in Chemistry for discovering that the generative potential of complex systems is the degree of disequilibrium inherent in the systems themselves. That is, complex systems need to be off balance to move forward. M. Wheatley (1999), in her analysis of large institutions as complex systems, notes that organizational equilibrium results in stasis and ultimately organizational stagnation (p. 76).

Thus, the school-level elements constituting the organizational orientation to learning system are similar to many of the elements found at the individual level—beliefs about learning, practices, and supports and practices for learning, a collective capacity for learning, and dissonance as a catalyst for change when practices and beliefs do not align. Likewise, the elements of the organizational orientation to learning also show evidence of reciprocity. That is, school practices can and do enable collective beliefs, whereas collective beliefs can also result in more enabling school-level practices and structures. In this way, the collective capacity of the school affects collective goals and enabling structures for organizational growth that affect, and are affected by, collective norms and practices. As the organizational learning literature indicates, however, this school-level system is constituted by and reflects its constituent members such that the school's orientation to learning both is influenced by and influences teacher orientations to learning.

Interactions Between the Individual- and School-Level Orientations to Learning

Our discussion has shown that the relationships between beliefs and practice enacted at the individual teacher level reenact themselves at the school level, creating joint or socially produced conditions for teacher learning—a school-level orientation to learning system. Thus, although individual teachers' decisions about professional learning may result from a confluence of instructional practices, pedagogical beliefs, prior knowledge, and past experiences, school-level decisions about professional learning may result similarly from the interaction of collective practices and beliefs about learning. These collective beliefs and decisions about school-level learning then heavily influence individual beliefs and decisions about learning. Furthermore, although an individual teacher's orientation may lead him or her to participate in professional learning activities, the access, support, and encouragement to participate are heavily determined by the school. Thus, our conceptualization suggests that we cannot understand teacher learning by investigating these influences on teacher learning in isolation from one another. To understand and explain why and how teachers learn, we must consider how a teacher's individual learning orientation system interacts with the school's learning orientation system and how both of these systems together affect the activities (and features

of activities) in which teachers participate and then are reciprocally affected by the changes that occur from participation in these activities. Although these different systems implicated in teacher learning have structural and elemental similarities, they cannot be collapsed or considered variations of the same thing. The dynamics of individual learning orientations may be similar to organizational learning orientations, but new possibilities arise and new emergent rules apply in each case. They interact and are mutually recursive but still maintain separate, emergent systems. The nonlinear structure of this conceptualization recognizes the concatenation of practices, learning orientations, and individual and collective learning contexts that must occur for teacher learning to take place. We believe that this conceptualization, although complex, better illustrates the multicausal and multidimensional nature of teacher learning, but it also has implications for how we investigate teachers' learning.

Research Implications of a Dynamic Model of Teacher Learning and Change

The research discussed in this article recognizes the overwhelmingly multicausal, multidimensional, and multicorrelational quality of teacher learning and its impact on instructional practices. Our proposed conceptualization moves us beyond a focus on the effects of professional development activity to consider the individual and school orientations to learning systems that mediate teacher learning and teacher change. The myriad of elements within and between these systems poses significant challenges for conducting causal studies of teacher professional learning.

This dynamic conceptualization of teacher learning assumes that there are many different ways of achieving the same learning effects. The specific sets of activities, systems, and supports for learning we use in one context, with one set of teachers, may be quite different from those that would be necessary to achieve the same end in another context with a different set of teachers. What should determine which set of activities, systems, structures, and so on are necessary for teacher learning to occur should depend on an understanding of the different ways that these elements interact with each other, with contexts, and with characteristics of individual teachers. Thus, the primary implication of the conceptualization we propose is the need for more research that can either verify or falsify our presumption of variation. Ultimately, we need more studies that investigate how the generative mechanisms of teacher learning appear in different combinations and sequences, with different weights, in different but concrete situations.

The presumption of variability in this conceptualization does not mean that patterns, regularity, and generalized understandings of teacher learning are not possible. Although we have argued that teacher learning varies by the teacher, by school context, and by the learning activities themselves, there are generalizations that we should be able to make about the way professional learning activities relate to teacher learning that are true across different teachers and different school contexts. Good teachers affect student learning by making a distinction between what is unique to a specific context and what is generalizable to other contexts and student groups. That is, they understand that teaching has both contextualized and decontextualized properties. An adequate explanatory theory of teacher learning should likewise be able to distinguish between those aspects of professional learning that are unique and those that are generalizable to other teachers and contexts of practice.

Nuthall and Alton-Lee's (1993) testing of a dynamic model of student learning should be an example of how causal explanation can be established for teacher learning. Their study illustrates the ways that generative mechanisms and processes of learning can be identified and then how different patterns emerge across cases and instances of learning. Although their method presupposes case study methodology, we do not believe that the need for the recognition of variation in future research on teacher learning makes any presumption of methods or methodology—these choices remain. As Tilly (2008) has shown in his seminal work on causal explanation, patterns of variation and regularity emerge from both small-scale and large-scale studies. Good explanatory theory should be verifiable at any scale of study because causal and generative mechanisms are fractal. Patterns at one level are very often similar to patterns at other levels. In fact, it is because of this fractal quality that causal mechanisms are verifiable. As Nuthall (2004) asserted later in his career, it should not matter what research paradigms are used as long as they provide the kind of information that is needed (p. 295). Research studies and research methods for understanding teacher learning and change should, therefore, be evaluated by how well they contribute to the knowledge base necessary for building an appropriate explanatory theory.

Nuthall and Alton-Lee (1993) demonstrated when testing their model of student learning that what each student experienced and learned was unique, even within the same classroom. They concluded that averaging findings across participants would have obscured the generative mechanisms at work. Thus, aggregation of data within and across studies of teacher learning must be carefully justified. Aggregating data may create unnecessary ambiguity and error in conceptualizing teacher learning by masking variation and assuming uniformity that does not exist in reality.

A further consideration resulting from our literature review is how to conceptualize and consider changes that result from teacher learning. In some of the previous models of teacher learning, change in belief leads to change in practice leads to change in students (Desimone, 2009). In others, change in practice leads to change in students that then leads to change in belief (Guskey, 1986, 2002). Disagreement thus exists about the order in which the change sequence occurs. Consistent with our complex systems conceptual framing, we would assert that this disagreement arises because some researchers have, in the first instance, considered change to be a linear process. This conceptualization is evidenced in this work not only in the diagrams and figures provided with unidimensional arrows but also with descriptions of change in belief or practice relying on terms such as *before* (Guskey, 2002) and *after* (Desimone, 2009).

We would contend that the disagreement about order has arisen because some researchers have seen these as separate, distinct processes. Huberman's (1983, 1995) and others' work on this topic has demonstrated the cyclic nature of the change process for teachers: Changes in beliefs lead to changes in practice that bring changes in student learning that bring further changes in practice that result in additional changes in belief and so on. The relationship between these processes is also reciprocal with changes in one being contingent on changes in another. Furthermore, our reading of the literature on these teacher learning outcomes indicates that change can begin at any point in the change process—via belief, practice, change in students, and so on (D. Clarke & Hollingsworth, 2002; D. J. Clarke,

1988; D. J. Clarke & Peter, 1993). One implication of our conceptualization of teacher learning is that for learning to occur, change may occur in all three areas, and, as a result, change in only one area may not constitute teacher learning.

Thus, our adoption of a complexity thinking perspective carries a number of methodological implications for the development of systems-informed research into teacher learning. From a complexity thinking perspective, the methodological emphasis of investigation is placed on the exploration of the patterned behavior arising from agents interacting locally according to their own principles, beliefs, and interests, in the absence of an overall blueprint or organizational master plan (e.g., A. Clarke & Collins, 2007; Davis & Sumara, 2006; Stacey, Griffin, & Staw, 2000). Notions of linear causality, law-like generalizations, attention to discrete elements within closed stable systems, and reductionist strategies of data collection and analysis aimed at the control and manipulation of selected variables are viewed as unhelpful to a holistic enquiry into dynamic learning systems. Instead, complexity-influenced research designs are shaped by assumptions of uncertainty and unpredictability, are shaped by an interest in understanding patterns of connectedness and networking between nested systems and subsystems, and are aimed at exploring the nature of process emergence over time through feedback and interactions between internal and external systems.

The methodological challenge from a complexity thinking perspective is to sustain a holistic interest in complex systems. Research designs need to illuminate multiple causalities, multiple perspectives, and multiple effects that constitute complex activity within and between complex systems and subsystems from the perspectives of interacting agents. We must also emphasize the importance of developing research strategies that aim at representing patterns of behavior at a level of generalization that allows for a useful balance between attending to both (a) the contextual specificity of systems and (b) their common affordances and patterns of evolution. This suggests the need for continued large- and small-scale empirical research combining both qualitative and quantitative modes of enquiry. To develop the conceptual and empirical basis necessary to test an explanatory theory of the complex systems of teacher learning, our focus must be on developing and continuously refining methods and methodologies aimed at identifying the edges of generalizability and variation that characterize the patterns of processes and interaction of these systems.

Notes

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¹Our use of the terms *teacher professional learning* and *teaching learning* instead of *professional development* is intentional. We believe the use of the term *professional development* has reinforced the focus on individual programs, activities, or individual

teachers in the research literature at the expense of context and the situatedness of teacher learning.

²The Training and Development Agency for Schools is the national agency charged with overseeing both initial teacher education and teacher professional development in England.

³We use the term *activity* to be consistent with the professional development effects literature reported in this section realizing that it fails to recognize, and is inconsistent with, the Vygotskian (1978) origins of the word.

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