

# Untangling the Relationship(s) Between Professional Development, Enactment, Student Learning and Teacher Learning Through Multiple Case Studies

Beth Kubitskey and Barry Fishman  
The University of Michigan  
[kubitske@umich.edu](mailto:kubitske@umich.edu) [fishman@umich.edu](mailto:fishman@umich.edu)

With the proliferation of educational reform policies and strategies, the need for high quality professional development (PD) has emerged as one of the most important areas for research in education, particularly in determining the relationship between PD and student learning outcomes (Borko, 2004). Although research has begun to focus on the defining characteristics of quality PD, little has been done to examine the specific factors involved in teacher learning from PD and its relationship to practice and student learning (Garet, Porter, Desimone, Birman, & Yoon, 2001b; Guskey, 2003; Kubitskey, Fishman, & Marx, 2003, 2004; Loucks-Horsley, 1997; Richardson, 2001). Teachers are influenced both by professional development and through reflecting on their own classroom practice (however informally), including evidence of their students' learning. While professional development is frequently designed to inform classroom practice, classroom practice is often the major influence on teacher learning related to the professional development. Professional development is intended to mediate teachers' practice; however the practice itself often becomes a mediating factor in how the professional development continues to impact the teacher. The sustainability of reform initiatives relies on teachers maintaining alignment with the intent of the initiative, even as they make adaptations to suit their local context. Thus understanding the relationship between teacher learning from professional development and the resulting practice is an important area for study. The purpose of this study is to examine the question: How does professional development impact teacher learning in the context of classroom practice?

## ***Background – What do we know about quality PD?***

The formal study of teacher learning from professional development began its crescendo 20 years ago and has made great progress in recent years. In her 2004 AERA Presidential Address, Borko (2004) encouraged a situated perspective to examine teacher learning from professional development. She located professional development within specific contexts, and showed mutual interactions between PD programs, facilitators, and teachers. She went on to describe the research on professional development as decomposable into three main phases. Phase one examines the relationship between PD programs and teachers, phase two includes the facilitators in the study and phase three looks at multiple programs in different contexts. Although these phases differ in their unit of analysis and focus, each contributes to our understanding of professional development, in particular what characteristics of professional development lend themselves to improved instruction, informing the design of quality professional development.

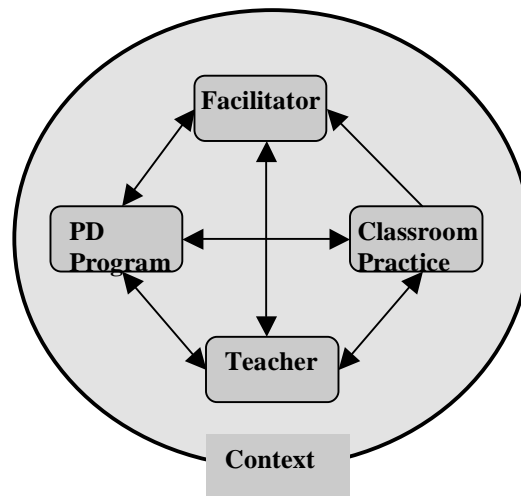
Richardson and Fenstermacher argue that "quality instruction" must be both good ("content taught accords with disciplinary standards of adequacy and completeness, and that the methods employed are age-appropriate, morally defensible, and undertaken with the intention of enhancing the learner's competence with respect to the content studied" (2000 p. 9)), and successful ("the learner actually acquires, to some reasonable level of proficiency, what the teacher is engaged in teaching" (2000 p. 10)). We suggest that quality professional development

should meet the same requirements. Thus quality professional development must be both good (includes content and pedagogy aligned with research) and successful (impacts enactment and ultimately student learning). The literature suggests the following four components of good professional development: plan, structure, community, and activities. The *planning* should begin with well-defined images of what the professional development is to be, allowing for continual assessment of the professional development in order to adapt and improve, incorporating an iterative design process that informs one professional development cycle to the next (Loucks-Horsley, Hewson, Love, & Stiles, 1998; Loucks-Horsley & Matsumoto, 1999). The *structure* should be internally consistent and contextualized around the needs of teachers in their classrooms, creating learner-centered environments (Garet, Porter, Desimone, Birman, & Yoon, 2001). The professional development participants should be a *community* of professional colleagues, for example teachers from the same grade, school and/or subject (Garet et al., 2001; Grossman, Wineburg, & Woolworth, 2001; Little, 2003; Loucks-Horsley et al., 1998). Recent research indicates that substantive pedagogical change requires extended effort on the order of 160 hours of engagement (Supovitz & Turner, 2000). Professional development that extends over a long period of time also allows for the creation of communities and for teacher participants to emerge and develop as leaders within the communities (Loucks-Horsley et al., 1998). Teachers need ample opportunity to learn content; both subject matter as well as pedagogical (Garet et al. 2001; Loucks-Horsley et al. 1998; Darling-Hammond & Ball, 1998). Good professional development should include *activities* that allow for active learning of content (Garet et al., 2001). Two examples are modeling activities teachers will enact with their own students and examining student work (Loucks-Horsley et al., 1998).

The successfulness of the professional development, however, is unique to each instance. The professional development literature (e.g. Guskey, 2002) and the training literature (e.g. Kirkpatrick, 1998) each suggest mechanisms for evaluating the effectiveness of professional development. Guskey (2002) suggests five different levels for evaluating the impact of professional development: (1) participants' initial reaction to the experience, (2) participants' learning, (3) organizational support and change, (4) participants' use of knowledge and skills, and (5) student learning outcomes. These are very similar to four levels suggested by Kirkpatrick (1998) for examining professional training programs for business: (1) reaction, (2) learning, (3) transfer and (4) impact. Either of these sets of criteria can be used to evaluate the success of the PD and can also inform the next iteration, which is a characteristic of good PD.

Where does this research lead us? Based on the literature, a potential quality professional development program is well planned over the long term using evaluations of past PD opportunities to inform future PD. The PD is structured around a specific need of participants, proximal to teacher practice and supplying usable information to teachers. The participants should either already be in a community or should have common ground for forming a community, such as teaching the same unit, teaching in the same school, etc. The PD should take place over an extended period of time, to promote the creation of a community of practice whose participants have common goals addressed by the PD. Finally, the PD activities themselves must offer opportunities for teachers to engage in inquiry of either content or pedagogy. The majority of research on PD is designed to either examine these characteristics of quality professional development or measure the level of quality professional development where teacher learning, and less frequently, student learning is the outcome measure. However, teachers also learn from practice. In fact, teachers value their learning from practice over other forms of professional development (Lieberman, 1995). As professional development adopts the

mandates of research and policy that requires professional development be “targeted” (U.S. Department of Education, 2001) and proximal to practice (Garet et al., 2001), the classroom practice becomes an integral component of the formal professional development context while also being a context unto itself. In addition to examining *what* and *how* teachers learn from professional development, in order to understand and support long term change in practice, we need to also look at *when* teachers learn from professional development and *how* teachers’ knowledge and beliefs change in the context of formal professional development *and* classroom practice. Thus we suggest the following model for professional development systems, where classroom practice becomes an explicit component of the formal professional development system, rather than an outcome or distinct context of its own (see Figure 1). Our modification adapts Borko’s (2004) model to include the classroom practice explicitly aligned with the professional development.



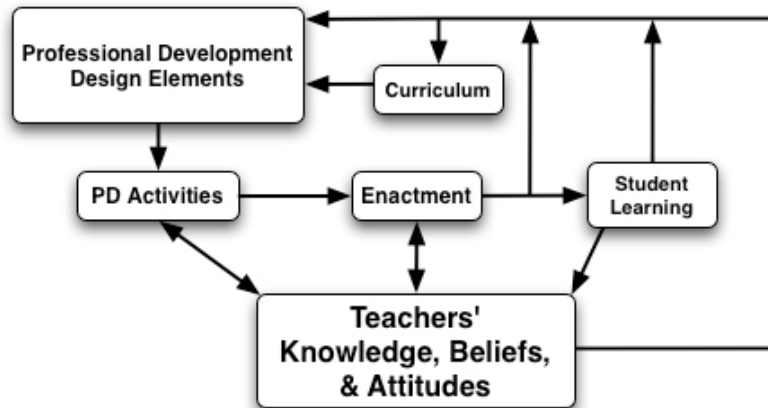
**Figure 1.** Modified from Borko’s (2004) elements of a professional development system.

This study expands upon the research base examining teacher learning from professional development by explicitly including classroom practice not as an outcome, but as a component of the professional development. Below we describe a teacher learning model which was the impetus for this study, and how using this model as a template for examining changes in teachers’ knowledge and beliefs over the course of a professional development/classroom practice cycle informs our understanding of teacher learning and professional development design. Through a series of case studies, we empirically examine what changes in teachers’ knowledge and beliefs occur, how they occur, and most importantly, when they occur in order to establish how and when teachers learn in a real-life application of “quality” professional development in the context of practice that it was designed to support.

### ***Theoretical Framework – A teacher learning model***

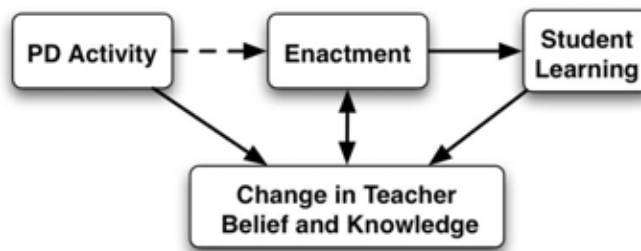
Beliefs and knowledge are informed through both formal instruction and experience; each contributing to teachers’ understanding of their field (Guskey & Sparks, 1996; Richardson,

2001; Richardson & et al., 1991). Teachers value practical knowledge from experience (Connelly, Clandinin, & He, 1997). In addition, teachers' beliefs and knowledge are informed by student learning (Evans, 1993; Franke, Carpenter, Fennema, Ansell, & Behrend, 1998; Loucks-Horsley, 1997). Finally, teachers learn from *effective* PD, which includes features such as creating community of learners, locating PD in proximity to practice, using instructional techniques that engage the teachers in active learning and examining student work (Garet et al., 2001; Guskey, 1994; Kubitskey et al., 2004; Loucks-Horsley, 1997; Loucks-Horsley & Matsumoto, 1999b; NSDC, 2001). To this end, we developed a model of teacher learning (see Figure 2) emphasizing the interactive nature of the formation of knowledge and beliefs with PD activities and classroom enactment (including evidence of student learning) and incorporating these understandings in PD design (Fishman, Marx, Best, & Tal, 2003).



**Figure 2:** Teacher Learning Model (modified from Fishman, Marx, Best, & Tal, 2003).

This study concentrates on factors that directly mediate teacher learning, focusing on PD activities, enactment, and student learning, their interrelationships and ultimate impact on changes in teachers' knowledge and beliefs (see Figure 3). This model suggests continuous, rather than episodic, learning. Thus, this model not only examines teacher learning from professional development in the context of practice, but begins to look at the sustainability of the influence of professional development on practice.



**Figure 3:** Influences on Teacher Learning.

To investigate the question of how professional development impacts teacher learning in the context of classroom practice, we address the following two sub-questions:

1. How does teachers' knowledge and beliefs change from professional development aligned with practice?

2. When does teachers' knowledge and beliefs change during professional development and practice?

## **Methods**

The study presented in this paper is part of a larger study examining the impact of professional development on teacher learning in the context of classroom practice. The larger study includes analyses of the professional development to support the assertion that this PD represents an example of "quality PD" as well as a statistical examination of shifts in knowledge and beliefs of a larger population of teachers. This paper focuses on the qualitative analysis using multiple-case study design to describe shifts in teachers' knowledge and beliefs.

## **Context**

The Center for Highly Interactive Classroom, Curricula and Computing in Education (hi-ce) creates inquiry-based curricula and learner-centered technology. Hi-ce develops and supplies professional development to support these activities. In particular, this study takes place in the context of one of hi-ce's projects, LeTUS (the Center for Learning Technologies in Urban Schools), which is a collaboration between the Detroit Public Schools, Chicago Public Schools, Northwestern University and University of Michigan designed to create technology-rich, inquiry-based, middle school science curricula. Hi-ce collaborates with the district to develop and disseminate technology and curricula for use by teachers and students in the district's middle schools, which involves extensive curriculum development (Singer, Marx, Krajcik, & Clay-Chambers, 2000), design and integration of technologies to support student and teacher learning (Marx, Blumenfeld, Krajcik, & Soloway, 1998), and broad-based professional development (Fishman, Best, Foster, & Marx, 2000). LeTUS has developed five units; one in the 6<sup>th</sup> grade, three in the 7<sup>th</sup> grade, and one in the 8<sup>th</sup> grade, used by approximately 80 teachers in Detroit from 20 middle schools in 2004. All teachers in LeTUS participate in a broad range of professional development activities, including intensive summer institutes, monthly Saturday workshops, periodic in-classroom support by peer teachers and graduate students, on-line materials, and graduate extension courses. LeTUS curriculum materials are designed to be educative (Ball & Cohen, 1996; Schneider & Krajcik, 2002), and are treated as another potential source of professional development. Of course, teachers select from among these professional development options; few if any teachers participate in all of them. Thus our data represent a situation commonly found in districts working on standards-based reform in science education, and our findings are therefore highly valid with respect to the design of real-world PD.

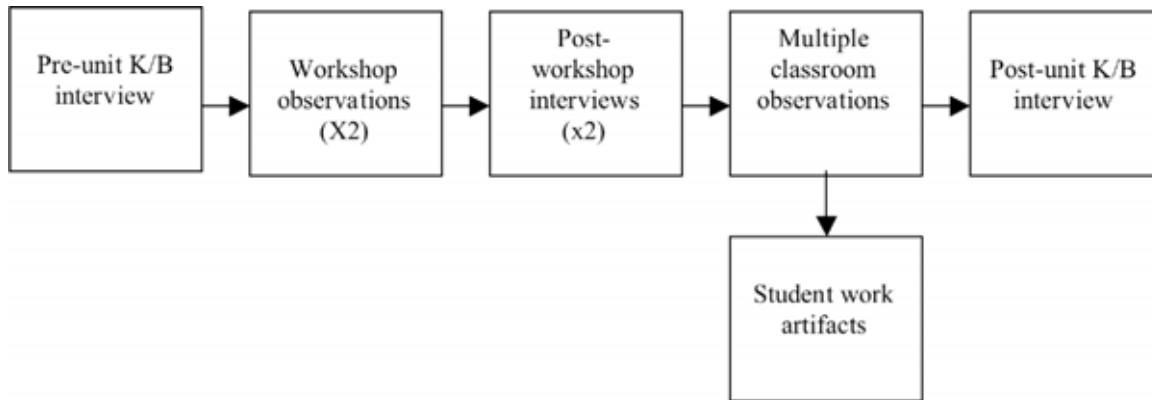
This paper examines professional development in the form of Saturday workshops and teacher learning and practice related to the Communicable Disease Unit (Hug & Center for Highly Interactive Computing in Education, 2002), which was taught mid-year in the 7<sup>th</sup> grade during the 2003-2004 academic year, the third year in which there has been formal professional development offered for the Communicable Disease Unit, and the fourth in which it has been enacted in the district (including an initial pilot enactment). The Communicable Disease Unit focuses on students interrogating the question "How can good friends make you sick?" and in so doing learning about the characteristics of the spread of disease, cells, bacteria and viruses through multiple opportunities to investigate with hands-on investigations, personal digital assistants, and computer simulations, as well as research projects. Thirty-one teachers enacted the Communicable Disease Unit in 2004. Participating teachers are nested within a larger

district-wide reform effort designed to incorporate the use of inquiry-based, technology-rich curricula throughout middle school science. One component of the Communicable Disease Unit is the use of concept maps as a way of fostering student understanding by allowing students to organize their ideas in a structured manner in addition to facilitating students into thinking in terms of concepts and their relationships, rather than simple examples. In addition, the authors of the unit intended the teacher to use concept maps as an assessment tool to gauge student understanding during the course of the unit. Concept maps are revisited throughout the unit, allowing students to edit and elaborate their ideas as their understandings become more sophisticated over the course of study. The authors of the curriculum adopted Novak's (1998) approach to concept mapping, which dictates that concept maps organize their quality concepts using hierarchy (from the most general at the top of the map, to the most specific and the bottom), linking words between concepts from level to level, and cross links between concepts on the same level. Anecdotal observations suggested teachers were not incorporating concept maps as intended. The pre-unit belief and knowledge interviews, as well as comments at the first workshop, support this observation. In order to assist teachers in their use of concept map as intended by the authors of the unit, lead teachers, with university assistance, designed workshops to specifically cover this area prior to teachers' anticipated use of concept map.

The workshop design incorporated the aforementioned characteristics of quality professional development. They were carefully planned to cover material deemed necessary by past observations and the curriculum unit (concept maps). They were part of a long-term professional development cycle specifically addressing curricula being used at the time of the professional development. The participants represented a community of practice, each teaching the same curriculum in a common school district. The lead teachers running the workshop adopted instructional strategies that included both opportunities for teachers to enact the activities as adults as well as how their students would. Lead teachers included ample opportunities for peer exchange between teachers as well as leading the group in examination of student work. All are characteristics of good professional development. The case studies below support the assertion that the professional development was also successful, and thus represents quality PD.

## **Data**

Teachers participated in two Saturday workshops designed to support their use of concept maps as an instructional strategy and then used concept maps in their classroom. Prior to the workshop, we interviewed the participating 7<sup>th</sup> grade teachers about their beliefs and knowledge about concept maps. We purposively selected a sub-sample of teachers to observe and follow-up with during their enactment of concept maps (see participants below). Those of the sub-sample who attended the Saturday workshops participated in interviews about what they learned from the workshops. We observed each of the sub-sampled teachers enacting lessons in the unit with concept maps, some on multiple occasions. In addition, we collected concept maps created by their students. Finally, at the end of the unit, we repeated the belief interview with the teachers (see Figure 4).



**Figure 4:** Data collected in this study.

## Participants

The participants were Detroit Public Schools teachers enacting the Communicable Disease Unit, *How Do Good Friends Make You Sick?* (Hug & Center for Highly Interactive Computing in Education, 2002) during winter, 2004. These teachers represented a cross-section of the population of middle school science teachers as a whole. Of the 23 interviewed during the pre-unit knowledge and belief interview, 65% volunteered to participate in LeTUS initially, while 35% felt compelled to participate by administrators or other teachers. The population of teachers was 52% African American female, 17.5% White female, 17.5% White male, and 13% African American Male. The teachers ranged in experience from over 30 years to first year teachers.

## Sampling

Twenty-three of the thirty-one teachers participated in the initial belief interview. Four teachers did not participate because they were involved in another research project and the remaining four were not available for interview.

We select a stratified purposive sample of 14 focus teachers to follow in classroom practice, representing a wide range of experience with concept maps, satisfaction with concept map instruction, experience with the unit, and workshop participation.

From the analysis of this data, we selected four teachers who represented a cross-section of change in knowledge and beliefs from the workshops, in addition to a brief description of one teacher who did not attend the workshops (see Table 1). To create a description of teacher learning as represented by change in beliefs and knowledge, we developed detailed case descriptions for these five teachers, developing a rich description of teacher learning for each.

**Table 1:** Teachers for case studies, summary of findings.

<b>Sample</b>	<b>Pre-unit Knowledge</b>	<b>Pre-unit Belief</b>	<b>Workshop attendance</b>	<b>Post-unit Knowledge</b>	<b>Post-unit Beliefs</b>
<b>Ms. Konig<sup>1</sup></b>	Did not align	Did not align	Yes	Aligned	Aligned
<b>Ms. Ubawa</b>	Did not align	Aligned	Yes	Aligned	Aligned
<b>Ms. Clarence</b>	Aligned	Did not align	Yes	Aligned	Aligned
<b>Ms. Lewis</b>	Did not align	Aligned	Yes	Aligned	Did not align
<b>Ms. Ford</b>	Did not align	Aligned	No	Some Aligned, others didn't	Aligned

## Analysis

A common method used to examine change in teacher beliefs and practice is ethnography (Emerson, Fretz, & Shaw, 1995) or grounded theory (Strauss & Corbin, 1990). Some argue this ethnographic narrative approach is the true way to capture the complex nature of the classrooms (e.g. Connelly & Clandinin, 1990), while others complain such an approach lacks the validity and generalizability necessary for rigorous study (Donmoyer, 1990). Yin argues that “typically these related methods (ethnography and grounded theory) deliberately avoid specifying any theoretical propositions at the outset of an inquiry,” (2003 p 28), as opposed to case study, which presupposes such theoretical propositions in the planning of the investigation. For this study we analyze each of the case-study teachers separately. Although the analysis of the cases is designed to elaborate on the theory of teacher learning discussed above, we employ some of the methods of grounded theory to examine teacher learning. We look for emerging themes across interviews and observations to create a description of the phenomena of teacher learning by identifying and distinguishing between causal conditions, context, intervening conditions, action strategies and consequences. From this analysis we create a rich description of the teacher learning over the time of the professional development and enactment for each teacher. We then look across these analyses to identify similarities and differences between cases as to what influences teacher learning throughout the practice. Thus, the learning of each teacher in the context of professional development in practice is discussed based on the analysis using a variation of a grounded theory technique. To describe each teacher’s enactment, we compare their knowledge and beliefs before the workshops, after the workshop and after the unit. We describe their practice, comparing it to the professional development and the curriculum unit. Finally, we analyze their students’ work and compare this with both the instructional practice as well as each teacher’s reflection on the student work during the post-unit interview.

In particular, we look towards teacher knowledge and beliefs about concept maps. As stated above, we accept Novak’s (1998) description of concept maps in that they are hierarchical (going from general at the top, towards more specific as you trace the map down) with linking words connecting the concept as one travels down the map, and cross links connecting terms on the same level. In addition, the concept maps focus on having the students examine concepts and ideas as opposed to examples. This is in contrast of a web-like structure with the main idea in the center with other concepts branching off that most of the teachers were accustomed to.

---

<sup>1</sup> All names are pseudonyms.

## **Findings**

In order to describe the findings, we first give a description of the codes that emerged from the analysis of the cases, to create a template for the case discussions. Next we share brief narrative descriptions of each of the cases. We then compare the analyses of the cases to address the questions: How does teachers' knowledge and beliefs change from professional development aligned with practice and when do teachers' knowledge and belief change during professional development and practice to ultimately examine how does professional development impact teacher learning in the context of classroom practice?

The first, Ms. Konig, is a teacher who represents the typical positive change in both knowledge and beliefs over the course of the unit. The second, Ms. Ubawa, represents a teacher that had a solid grounding in concept maps and extreme confidence in their use; however her knowledge did not initially completely align with either the unit or the PD. At the conclusion of the unit she showed a slight shift in knowledge and maintained her belief in her ability to teach using concept maps and their utility. Ms. Clarence, the third case, had a strong knowledge of concept map and a complete understanding of concept maps as intended by the unit; however she did not believe in their utility prior to the professional development and became an advocate by the end of the unit. The fourth case, Ms. Lewis, showed a positive shift in knowledge over the course of the professional development and enactment, however her confidence and belief about her own ability to teach concept maps decreased. Finally, Ms. Ford did not attend the workshops. However, her pre and post unit interviews and classroom observation suggested change in her knowledge of concept mapping nonetheless.

### **Prologue - the Codes**

The characteristics to describe each case emerged from the analysis. The fundamental characteristic from both the interviews and the observations is teacher content knowledge of concept maps. In this case, we examine content knowledge as it aligns with the unit, rather than defining a right or wrong. Pedagogical knowledge of concept maps emerged in two different forms. First, there was the pedagogical knowledge of teaching students how to create concept maps and second, the pedagogical knowledge for using concept maps as a means of assessment. The observations and post-workshop interviews both informed the former, while the interviews informed the latter. Pedagogical content knowledge was also two-fold. First, the pedagogical content knowledge for teaching students how to create concept maps (the focus of parts of the workshops) and the second was the pedagogical content knowledge of using concept maps as a means for fostering student understanding. Finally, through the interviews teachers expressed different levels of self-efficacy with respect to concept maps, both how comfortable they felt teaching them as well as how much they felt their students learned. These six emergent codes are used as a template for the discussion of each of the cases discussed below as well as the findings as we look across cases (see Table 2).

**Table 2:** Emergent Themes from Analyses of Cases.

Emergent theme	Definition	Measure
Content Knowledge Concept Maps (CK)	Characteristics of Concept Maps 1. Hierarchy 2. Clear concepts 3. Linking words 4. Cross links	Interviews and Observations
Pedagogical Knowledge for Teaching Concept Maps (PK-teaching)	General instructional techniques for teaching students how to create concept maps e.g. students critiquing each other's work, modeling with familiar concept, and supplying the students with a rubric.	Observations primarily Post-unit interviews
Pedagogical Knowledge for Using Concept Maps as Assessment (PK – assessing)	Using concept maps as a means for assessing student understanding, particularly examining if students understand the concepts and how they relate.	Interviews primarily
Pedagogical Content Knowledge for Teaching Concept Maps (PCK-teaching)	Techniques specific to teaching students the intricacies of creating concept maps e.g. reading sentences down the map, brainstorming terms and then grouping, and using the analogy “looks like a spider, not a caterpillar.”	Observations primarily
Pedagogical Content Knowledge – Using Concept Maps to Foster Student Understanding (PCK- student understanding)	How a teacher facilitates the students understanding of the concepts by assisting having them create concept maps. In particular allowing for multiple revisions with teacher feedback.	Interviews primarily
Beliefs – Self-efficacy (Self-efficacy)	The confidence teachers have with ability to teach concept maps and perception of the student learning.	Interviews

### Changed Both Knowledge and Beliefs

The first case represents a typical teacher's change in knowledge and beliefs. Ms. Konig is an African American female in her early 30's with 8 years teaching experience, participating in LeTUS for 3 years. This was her second year teaching the Communicable Disease Unit. Of the 31 teachers who administered student pre-tests for the 2003/2004 Communicable Disease Unit, the mean score of Ms. Konig's students ranked 16<sup>th</sup>. These students scored 13<sup>th</sup> out of the 28 teachers' students who completed the post-test of the unit, placing her students 8<sup>th</sup> of the 28 teachers in effect size, or in the 2<sup>nd</sup> quartile.

During the pre-unit interview Ms. Konig made it clear that she was neither satisfied with her own instruction of concept maps, nor her students' performance. She described concept maps as webs, and found assessing them virtually useless. “They used to do it (concept maps) like a web. This last time I did it (concept maps) was with linking words. And I think I still got the same thing (with and without linking words)” (pre-unit interview, 2004). Concept maps became a “check off if complete” assignment. She acknowledged that she was not good at teaching concept maps and looked forward to getting some tips on using concept maps at the workshop. “I don't think they (concept maps) went well because I don't think the kids, I don't

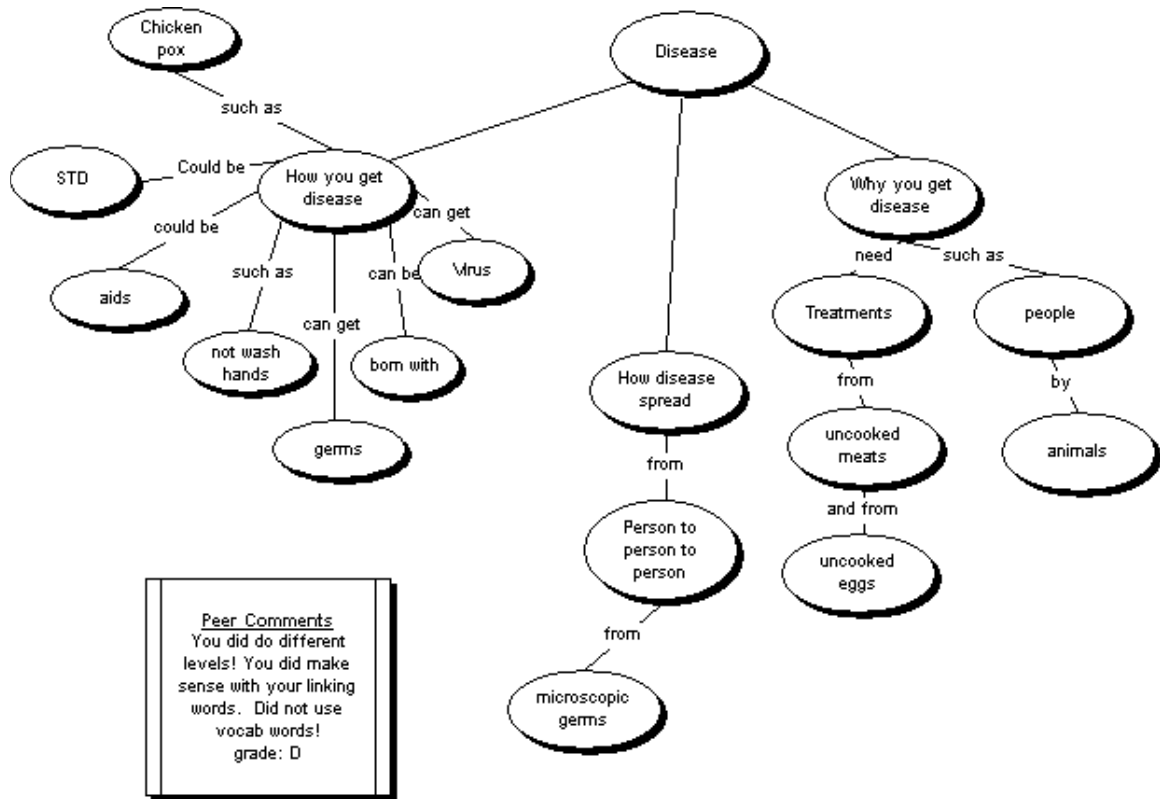
think my students benefit from it ... and I think it's my fault because I don't think I do a good job of teaching it" (pre-unit interview, 2004)

After the first workshop Ms. Konig felt motivated and had an increased belief in her own self-efficacy. Armed with an instructional approach, she was convinced she would be more successful than in the past.

I liked the changes that they made. Instead of making it look more like a web, making it look like hierarchy. Because I really didn't know how to grade my students on concept maps so I never did. I just gave them credit for doing it and then I really couldn't tell if they learned anything because it looked like a web. (post-workshop 1 interview, 2004)

Ms. Konig enacted the concept map lesson using the methods shared at the workshop. The workshop clearly influenced Ms. Konig's *content knowledge of concept maps* in that she adapted her definition of concept maps to include hierarchy. The workshop also influenced her *pedagogical knowledge for teaching concept maps* when Ms. Konig specifically used techniques from the workshop such as having the students brainstorm terms. In addition, the workshop informed the *pedagogical content knowledge for teaching concept mapping* by informing the type of term she used for the example concept, supplying her with a list of linking words, and having the students "read" sentences down the concept map thread. Thus *content knowledge of concept maps*, *pedagogical knowledge for teaching concept maps*, and *pedagogical content knowledge for teaching concept maps* were all influenced by the workshop. Despite the approach and support, the student maps still lacked clarity of hierarchy and linking words, and concepts were connected that didn't make sense. Ms. Konig was disappointed in the results, challenging her newfound self-efficacy.

The sharing of experiences and student work at the second workshop reinvigorated Ms. Konig and gave her explicit ideas how to address some of her dissatisfaction, including tips for peer assessment and rubrics for assessment. "I was just amazed that, you know, her [the lead teacher's] kids did so well, but it gave me some ideas and I took it back to my classroom and what I did was I used her concept maps that she gave us copies of, and I had the kids evaluate those concept maps" (post workshop 2 interview, 2004). She immediately incorporated some of the ideas in her classroom and was satisfied with the subsequent lesson. The resulting student maps in this enactment contained clear concepts and were hierarchical in nature, yet many of the links did not make sense and terms on the same level did not necessarily represent the same specificity. Only 25% of the maps incorporated linking words and cross links were not yet visited. The students' critiques of these maps as modeled by the second workshop showed the students were aware of the deficiency in linking words by their comment on each other's papers, but did not typically address the problem with linking the various concepts (see Figure 5).



**Figure 5.** Re-creation of student's concept map with linking words and peer comments- Konig.

The workshops directly informed Ms. Konig's *content knowledge of concept maps* and *pedagogical and pedagogical content knowledge for teaching concept mapping*. After the first workshop Ms. Konig felt motivated and had an increased belief in her own *self-efficacy*, armed with an instructional approach she was convinced would be more successful than in the past. After the first enactment, this newfound self-efficacy was challenged when the students did not work up to expectations. The sharing of experiences and student work at the second workshop reinvigorated Ms. Konig and gave her explicit ideas how to address some of her dissatisfaction. She was satisfied with the subsequent lesson. Despite the fact that Ms. Konig was not completely satisfied with the enactment as a whole (did not get the chance to use the concept maps for fostering student understanding to the extent intended by the unit), she still valued the usefulness of concept mapping and instead of substituting for some other instructional strategy, made plans as to how she might adapt concept mapping instruction the following year. She was aware of *pedagogical content knowledge for fostering student understanding* and would focus on improving on this in her next enactment of the unit. In addition the professional development provided a mechanism to assist in assessing student maps (*pedagogical knowledge – assessment*) and inform student revisions. Although not completely satisfied with the final student results, in the post-unit interview she believed in the advantages of doing the concept maps, was more confident in teaching them, and planned to continue their use the following year in a manner that aligned with the intent of the unit.

### Change in Knowledge

Ms. Ubawa is middle-aged African American female with many years of experience teaching science. Although she has taught previous LeTUS curricula, this was her first enactment of the Communicable Disease Unit. Ms. Ubawa volunteered to participate in LeTUS because several teachers in her school were already participating. Because of timing issues in her school, Ms. Ubawa was not able to complete the Communicable Disease Unit. Her students scored 9<sup>th</sup> of the 31 teachers who administered the pretest, however scored 26<sup>th</sup> out of the 28 teachers who administered the post-test, showing no significant gain. Despite the timing issue, Ms. Ubawa did have an opportunity to incorporate concept mapping into her practice.

In the pre-unit interview Ms. Ubawa shared that she was not only confident in teaching concept maps, but a strong advocate of their use. She stated that a previous class called her the “queen of concept maps.” Ms. Ubawa went into extreme depth when describing what she wanted the students to get out of concept mapping (how things are connected) and variations she has used, i.e. having the students draw pictures; however she never mentioned the hierarchy component, and described more of a web like structure. She demonstrated a *strong pedagogical knowledge of concept maps as assessment tools* and discussed their usefulness in helping students make connections between concepts (*pedagogical content knowledge concept maps – student understanding*), but she did not include a discussion of having students revisit concept maps.

Well one of the reasons I like to do them because I try to get (students) to see, as I say, how things link together. Like when you’re talking about cells ... and also it can link some of the main ideas of a concept together as well as a means for assessing their understanding. It helps me to get an idea whether or not they can link specific information with linking words, or if they’re just getting a general idea of what the topic or concept I’m trying to get is all about (pre-unit K/B interview, 2004).

She discussed multiple techniques surrounding the teaching of concept maps (*pedagogical and pedagogical content knowledge – teaching concept maps*), and even shared these at the workshop, although in one instance the ideas did not align with the unit.

Rather than change her content knowledge of concept maps, Ms. Ubawa claims she was merely reminded of hierarchy at the workshop, a reasonable assertion since the textbook she used included multiple representations of concept maps. She also valued the resources shared at the workshop, in particular a list of linking words for the students.

(The lead teacher) talked about hierarchy, which is good, I guess, when you’re starting out with the concept maps. I think the main thing is some of linking of terms, as long as the kids can understand the links and what, what goes with what....Sometimes they can, they can get more detail but I think if you use the linking words with each part that sometimes helps, helps kids. So I think that was a good, a good, a good information sheet she shared (referring to the supplied linking words) (post-workshop 1 interview, 2004).

Despite her experience and satisfaction with concept mapping in the past, she valued the information from the workshop.

Ms. Ubawa participated in and contributed to the second workshop, although her contributions did not always align with the intent of the unit. In particular she didn't think the semantics of the map were that important if you could see the logic behind the students thoughts. Despite her abundant previous experience with concept maps, Ms. Ubawa still took something away from the workshop. In particular, she noted in her post workshop interview that she appreciated the emphasis on cross links, although she stated she has used them she did not have a term for them. Although the concept was not new, the "new" terminology gave her a way of expressing it.

Her enactment was consistent with the workshop, incorporating specific approaches taught at the workshop, influencing both her *pedagogical and pedagogical content knowledge for teaching concept mapping* Her *content knowledge of concept maps* aligned with the unit, and she even posted on her board the components of a good concept maps directly from the workshop (see Figure 6).

<p>Hierarchy – concept from general to specific (broad to specific)</p> <p>Linking words – words or phrases to connect</p> <p>Concepts – appropriate relationships in a sentence, connected concepts make sense.</p> <p>Cross links – show interrelationships</p> <p>Examples – show an understanding of a concept on the map</p> <p>Form – should be neat and legible</p>
--

**Figure 6.** List of concept map characteristics from Ubawa's board.

Her *pedagogical knowledge for assessment* did not change, since she had a solid understanding prior to the workshop and felt confident in being able to interpret a variety of concept maps. The resulting group concept maps included clear concepts, hierarchy and linking words and were elaborate posters of multiple colors, incorporating her previous instructional practices to meet the needs of the unit (see Figure 7 for an example).

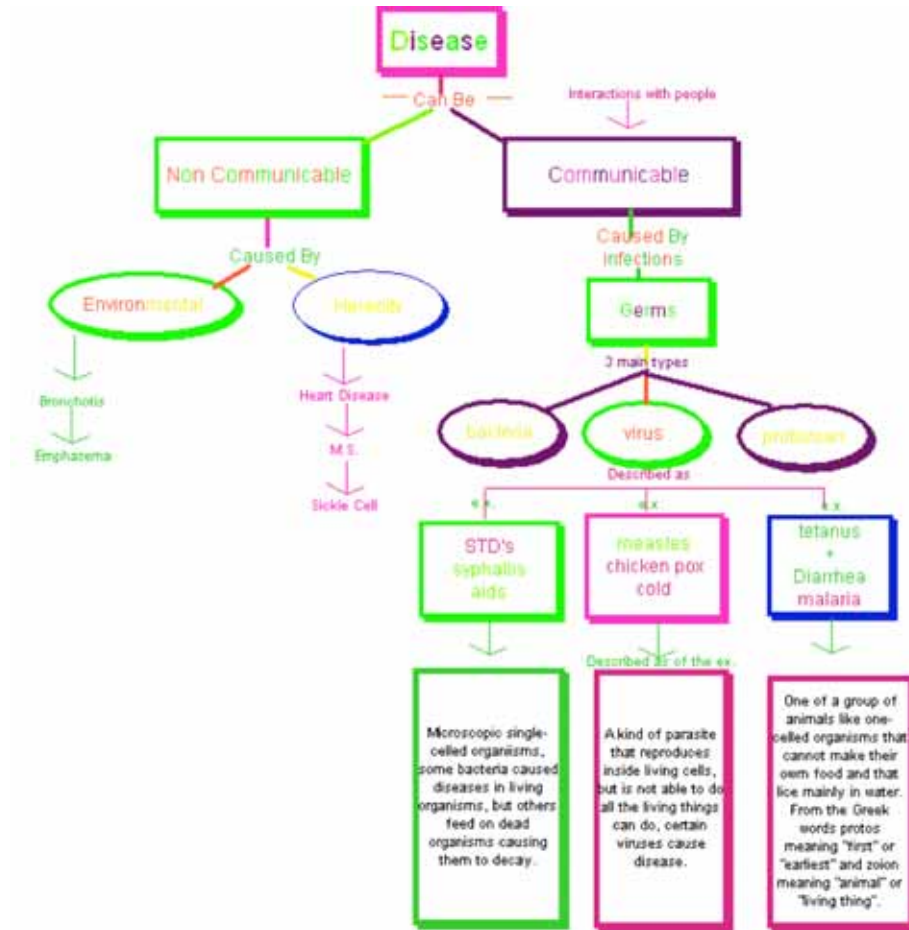


Figure 7. Re-creation of student work – concept map about disease – Ubawa.

Ms. Ubawa expanded her discussion of concept maps to include the idea of revision as a means for fostering student understanding, stating she had done it this way in the past, but never in this context (*pedagogical content knowledge of concept maps*). Therefore any change in knowledge seems to be related to more of “reminding” and “refining” rather than new knowledge. Despite this fact, Ms. Ubawa still acknowledged the workshops informing her instruction, and this is supported through observation. Ms. Ubawa remained confident in her instruction and satisfied with the concept mapping, although disappointed with the unit as a whole due to timing issues.

### Change in Beliefs - Positive

Ms. Clarence was a second year Teach for America teacher, nearing the end of her certification course work and was participating in her second year of LeTUS. She had used concept maps in classes as a student and during her previous enactment of the Communicable Disease Unit with her students. Her students scored 18<sup>th</sup> out of 31 teachers on the pre-test and improved to 10<sup>th</sup> out of 28 teachers on the post tests, placing her 3<sup>rd</sup> in effect size of the 28 teachers.

Ms. Clarence learned about concept maps in methods courses in college, had been instructed to create them as a student, and had used them in teaching. She felt they were basically a useless technique that theoretically would work, but in reality didn't.

(As a student): Well that part (hierarchy) I find annoying ... to create... but then it also helps you make sure that you've developed everything... Everything ends up down at the bottom with a specific. Honestly, I can't say that I would ever use a concept map for study.... So like in my own practice, I don't find concept maps for that (study) effective ... because I think that you just kind of learn how to do it in your notes rather than making a huge sheet with bubbles on it.

(As a teacher): Last year I used them (concept maps) pretty unsuccessfully. They (students) didn't really get the linking words done.... I think the linking words and I think that, I need to find a way for them to go back and change them. Because as they learn more they need to be modifying these things. And with a poster that's very difficult to do. And even with notes because so many of my students lose their notes.... I don't necessarily see it (concept maps) as a great final assessment. (pre-unit interview, 2004).

They may have been a meaning making opportunity for students, but she could not make heads or tails of the results. In addition, she did not like them as a student. She demonstrated a sophisticated *content knowledge*, *pedagogical knowledge of assessment* and *pedagogical content knowledge of student understanding* in the interview, but had a strongly negative *self-efficacy*.

After the first workshop Ms. Clarence expressed muted enthusiasm for the use of concept mapping.

I mean if you use the hierarchy it makes it a lot easier to see how you could actually see their ideas grow.... You know so that was cool and especially with the sentences, at least for myself, I understand them more. I don't know if I'll be able to get my students to do that really well though (post-unit interview, 2004).

She saw value in the *pedagogical and pedagogical content knowledge* for teaching students to create concept maps shared at the workshop and planned to utilize these in the class.

She enacted the concept map activity as instructed by the unit, adapting as suggested by the workshop and, although more satisfied than in the past, was not completely satisfied with the results and was struggling with how to make the activity more successful with her students. The resulting maps consistently demonstrated a student's attempted understanding of hierarchy, and the connections between concepts tended to make sense. Each of the maps included linking words and at least 3 levels (see Figure 8).

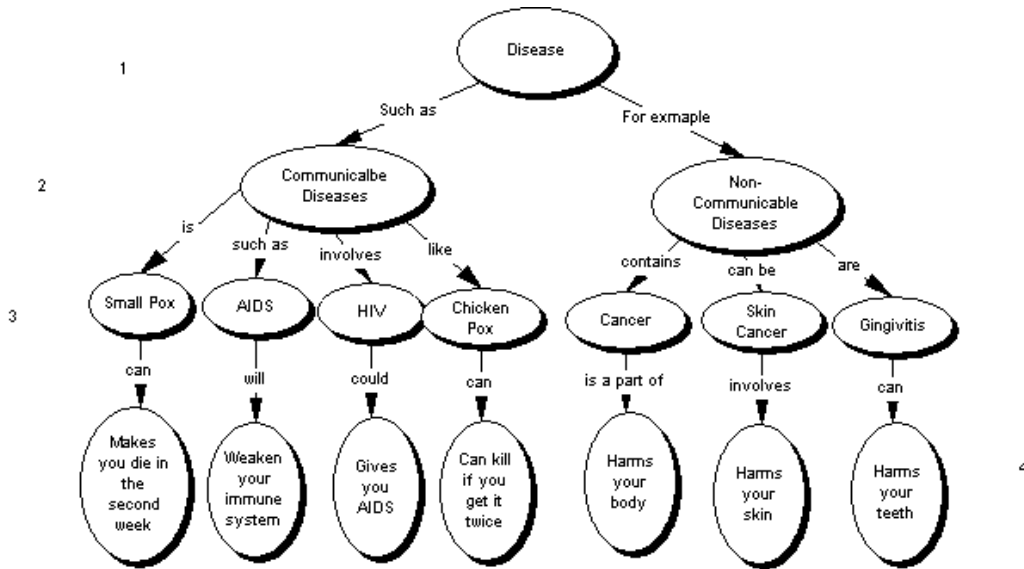


Figure 8: Re-creation of student work- concept map 1 - Clarence.

However, like Ms. Konig, many of the students create concept maps that looked hierarchical, but did not maintain the general to specific principle (see Figure 9).

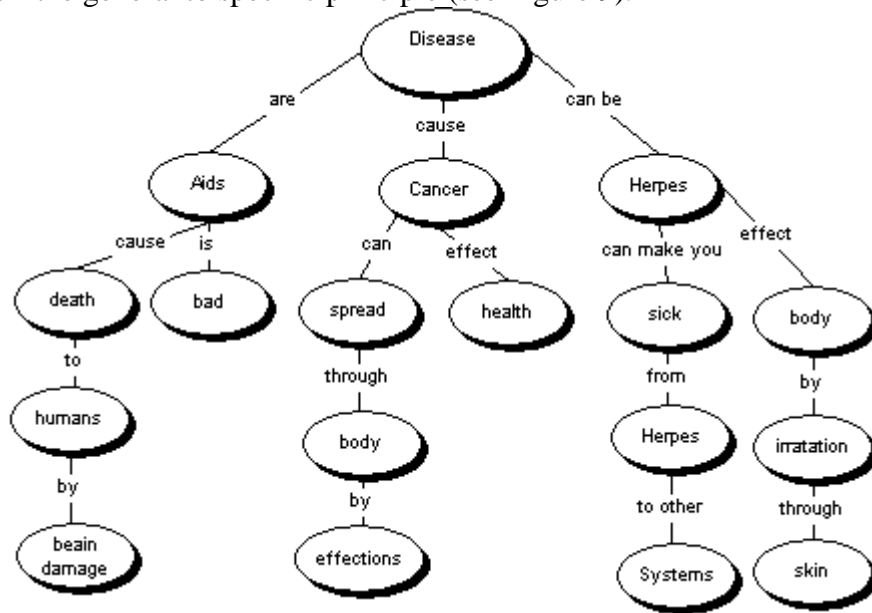


Figure 9. Re-creation of student concept map 1. Appears hierarchical, but content not general to specific - Clarence.

At the second workshop she saw other teachers were in the same situation, and appreciated the ideas offered as ways of having the students revise their concept maps. One suggested included having the students evaluate concept maps using the rubric from the curriculum (see Table 3). Ms. Clarence utilized techniques of having the students evaluate the concept maps with the supplied rubric demonstrating a change in pedagogical and pedagogical content knowledge for teaching concept maps.

**Table 3.** Analytical scoring rubric (for concept maps) from unit.

Scoring Key	4 = excellent, no flaws 3 = Good job, minor errors present. 2 = Good start, but many errors present. 1 = Little evidence of conceptual understanding	
		Score
Concepts	Concepts logically presented and relationships are appropriate.	1 2 3 4
Linking Words	Appropriate words or phrases connect the concepts	1 2 3 4
Hierarchy	Concepts flow from general to specific	1 2 3 4
Cross Links	Cross links display interrelationships.	1 2 3 4
Examples	Examples depict conceptual understanding	1 2 3 4
Form	Map is clear and legible	1 2 3 4

Students spent two days creating, evaluating a revising concept maps. The resulting maps satisfied Ms. Clarence (see Figure 10).

Upon completion of the unit, Ms. Clarence felt the concept mapping activity and the subsequent revision was successful. She felt these maps allowed her to assess students' misconceptions. In addition, she believed the students felt a sense of accomplishment when they revisited and revised their concept maps, noticing how much they had learned. She specifically attributed her success to the workshops, claiming that without them she would not have known how to make the concept maps useful. Her enthusiasm for concept maps extended to her professional life beyond the Communicable Disease Unit, when she chose to focus on her teaching of concept maps for her own master's thesis. Ms. Clarence had a solid pre-existing knowledge of *content knowledge of concept mapping, pedagogical knowledge of how concept maps were suppose to be used for assessment and pedagogical knowledge of how to use them for fostering understanding*. Despite this, she had a negative *self-efficacy* about teaching concept maps. The workshops supplied her with *pedagogical and pedagogical content knowledge for teaching concept maps*, and incorporating these into her practice dramatically improved her instruction and her sense of *self-efficacy*.

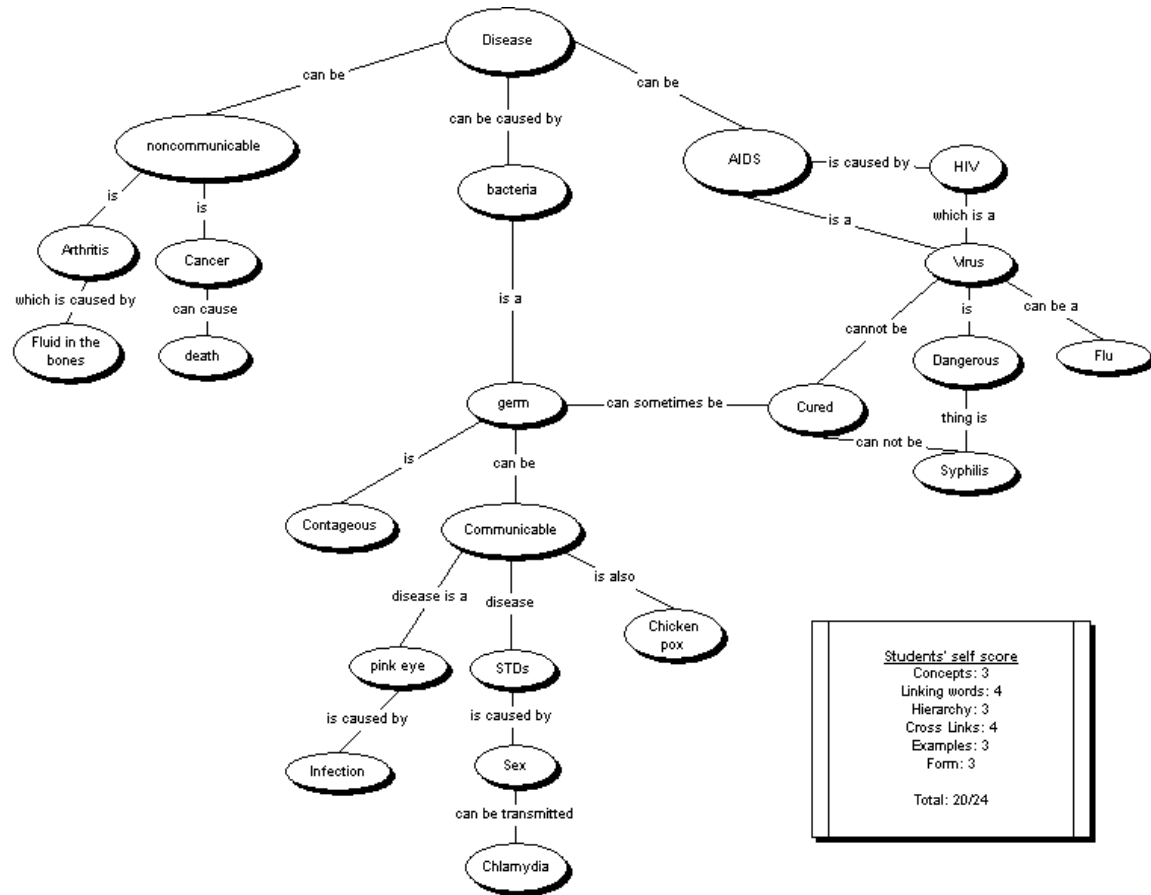


Figure 10. Re-creation of student concept map from second iteration - Clarence.

### Change in Beliefs – Negative

Ms. Lewis is an experienced LeTUS teacher, having participated in the program for over 5 years. She taught 7<sup>th</sup> and 8<sup>th</sup> grade, both of which have curricula that include concept mapping. She is a white middle-aged female with 6 years teaching experience, however this was her first year in a new school. Of all the students taking the pretest during the 2004-2005 school year, her students scored the lowest. However, her students improved to 18<sup>th</sup> out of the 28 teachers, making her effect size 5<sup>th</sup> out of the 28 teachers.

During the pre-unit interview, Ms. Lewis shared she had ample experience using concept maps while teaching LeTUS units. She was comfortable with teaching concept maps, but recognized that students often found them difficult. When discussing her students' Ms. Lewis shared her frustration.

Some kids really got it (concept maps) right away and other kids still would be putting things in a very random fashion. They might have the concepts but their spots that they put them to me were not as logical...But, I mean, sometimes it's pretty discouraging news (pre-unit interview, 2004).

She adopted the approach suggested in the curriculum unit for introducing concept maps, but did not include hierarchy either in her discussion about what a concept map looked like or what her

students created. Her idea of a concept map was more web-like in nature, and thus did not align with the content knowledge of concept maps as intended by the unit. She described her students as creating concept maps in the past that allowed them to organize their ideas, and said that they revisited the maps a few times, but she did not go into detail about the iterative nature of concept mapping. However, she did report more success in using concept maps in the Communicable Disease Unit rather than the 8<sup>th</sup> grade unit, which she attributed to the greater interest the students showed in diseases as opposed to forces (the 8<sup>th</sup> grade unit). She also had mixed feeling about the use of linking words, complaining that they sometimes made the concept maps more difficult.

There's a certain subjectivity to the kinds of linking words people use or don't use ... or if they have to link English or whatever. So I'm not sure that, I don't know if that helps with thinking about it, but sometimes it would (pre-unit interview, 2004).

For the most part she was confident in her teaching, and attributed some of the struggles of teaching the students to developmental and literacy issues, and thus she stated she chose not to include linking words often with her students.

The workshops introduced Ms. Lewis to the concept of hierarchy. She adopted this in the classroom, using the same introductory activity from the unit that she had used in the past, but including hierarchy. She made the strategic decision to not use linking words again because she thought they would only complicated the issue. Thus the workshops did not convince her of the value of linking words outweighing the instructional issues she had experienced and anticipated experiencing again. She was only able to revisit concept maps once, like most of the teachers, due to the timing issues. The resulting student maps consistently were hierarchical (except one) containing concepts, but no linking words or cross links (see Figure 11).

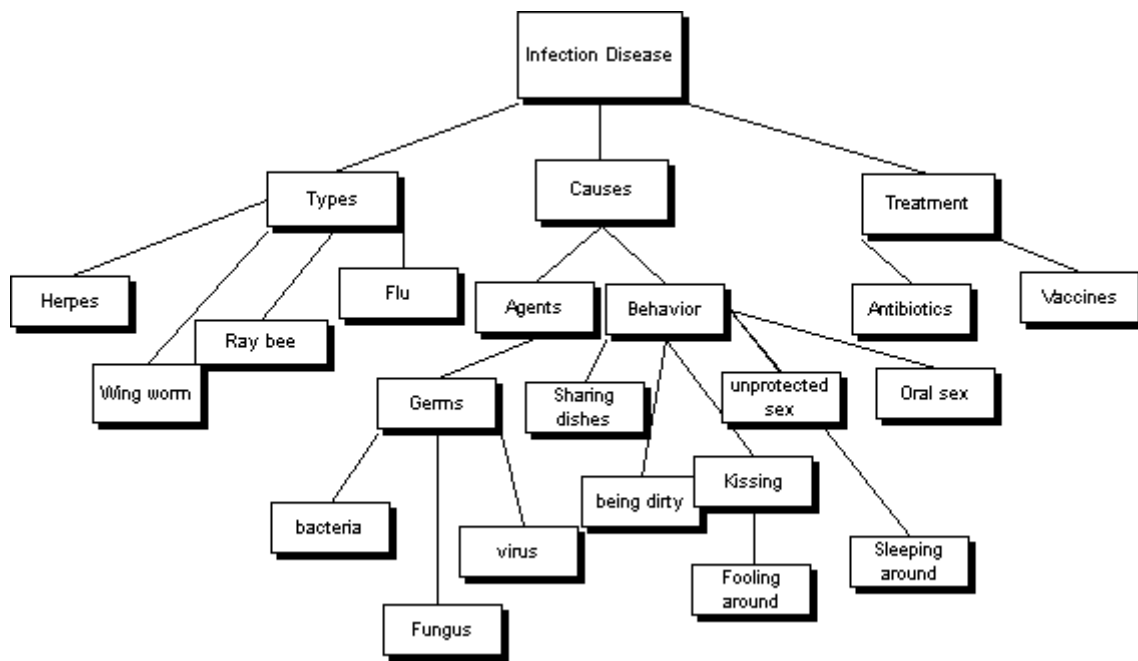


Figure 11. Re-creation of student's concept map - Lewis.

During the post-unit interview she explicitly stated she used concept maps as she had in the past, except incorporating the hierarchy. She felt less successful and found the students had a hard time understanding the hierarchy. Despite this, Ms. Lewis stated that she felt the hierarchy helped the students understand the concept more, and made the concept maps make more sense.

Well I like the idea of using a hierarchical format because I think the kids understand that a little bit better. But I think that it's still difficult to convey the idea to a lot of kids. It seems like right off the bat there are kids that think in this orderly fashion and there's ones that need to learn to do that and I think it's a little bit hard to walk through it in a large group situation. I think that they need to be, the ones that are having trouble getting it, need to be sort of walked through individually and, so it seemed like I either had very good ones, where the kids caught on right away, or I had ones that really just made no sense or else were just the copy of the starter that I gave them. So I was a little disappointed in that respect because I didn't think I saw a lot of individual growth but, like I say, we only did it twice (post-unit interview, 2004).

Despite her reflection that she did not feel as successful as in the past, she remained committed to the idea of hierarchy and planned to continue to incorporate it the following year, not only with the Communicable Disease Unit, but also with her 8<sup>th</sup> graders. She did not have the students use linking words as a strategic choice. She felt the hierarchy was tricky enough for them, and linking words added more confusion than they were worth.

We didn't do that (linking words) I was trying to go more with the idea of like a larger idea and then smaller idea to fit within the larger idea, type of thing. Because I feel like linking words are a lot dependant on kind of English usage type of thing. And maybe, I think, I feel like the more important ideas it should have larger concepts then you have sub-concepts and I'm not sure if linking words do that. (post-unit interview, 2004)

The workshops informed Ms. Lewis's *content knowledge of concept maps* with respect to hierarchy. She had previously known about linking words and chose not to use them all of the time. The workshop did not persuade her to change her theory about linking words. Students recreated concept maps rather than revise existing maps, although she acknowledged the problem with not revising maps in the post-unit interview, suggesting she had the *pedagogical content knowledge of fostering student understanding using concept maps*, just didn't get an opportunity to demonstrate it due to time constraints. She saw the potential for improved student learning and planned to incorporate concept maps in the future. The workshops failed to influence her beliefs about the value of linking words and thus did not impact her practice in that respect. She did not attribute the workshops to informing her instructional techniques for teaching concept maps (*pedagogical and pedagogical content knowledge for teaching concept mapping*.)

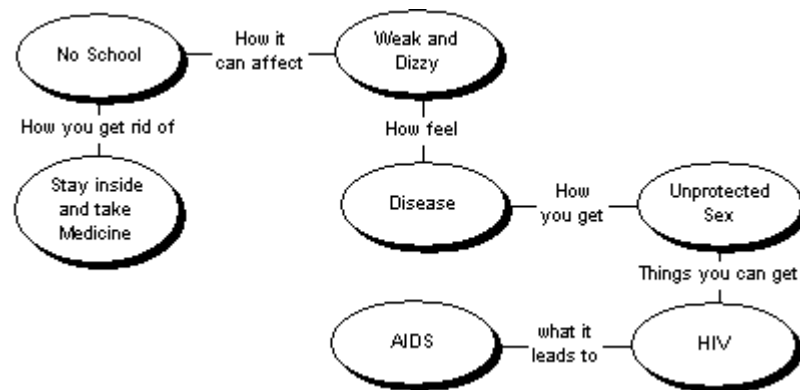
### **Change in Knowledge with No Workshop**

Ms. Ford, an African American woman in her early 30's, had never participated in LeTUS prior to the 2003-2004 school year, however is an experienced science teacher. All of the other 7<sup>th</sup> grade science teachers in her school utilized the LeTUS curricula and, along with

her principal, persuaded Ms. Ford to adopt LeTUS as well. Her students scored 10<sup>th</sup> out of the 31 teachers on their pre-test scores, and 11<sup>th</sup> out of 28 on the post-test scores, ending up 10<sup>th</sup> out of 28 in effect size. Ms. Ford attended workshops supporting another LeTUS curriculum that did not include concept maps. Ms. Ford did not attend any of the workshops designed to support this unit, although she was given the curriculum guide and shared a prep room and a common lunchtime with a teacher who attended the workshops (Ms. Konig). During lunch Ms. Konig and Ms. Ford would discuss their lesson for the day and share ideas. The observed discussions were practical in nature, sharing their plan and resources rather than discussions about pedagogy and instruction.

In the pre-unit interview Ms. Ford reported having some experience with concept mapping. Ms. Ford initially described concept maps as web like. “You know we’ll put a concept in the middle and then kind of brainstorm as to what we think a concept is. Kind of branch out from there” (pre-unit interview, 2004). She also focused on the advantage of concept maps as a means of encouraging cooperative learning in the classroom. She thought concept maps were helpful in letting her know if the children knew what she was talking about and saw their advantage as offering a means for students to come up with their own ideas and organize them, although primarily as a cooperative activity. “Well I guess it, it (concept maps) promotes co-operative learning. You know throughout the classroom. It helps them understand how to bring upon their own ideas without me having to give them the answers for everything.” (pre-unit interview, 2004). She saw the disadvantage of concept mapping is that they were time consuming. Her *content knowledge* of concept maps did not align with that of the unit. Her *pedagogical knowledge* for using concept maps as a means of assessment only slightly aligned with the unit in that she felt the concept maps gave her a way of evaluating student understanding, but she did not go into detail about students making connections between concepts etc. She did not mention revisions in her discussion of concept mapping, the *pedagogical content knowledge* of using concept maps as intended by the unit.

Ms. Ford introduced concept maps over a two-day period, like most of the observed teachers. However, unlike the other teachers, she began right with disease. She stressed the concept of hierarchy when giving the instruction, but the students’ concept maps still resembled webs or caterpillars with linking words phrases (see Figure 12).



**Figure 12.** Ms. Ford’s students’ example map.

Ms. Ford demonstrated *pedagogical knowledge for teaching concept maps*, by having the students create their own using a finite number of terms, and then had the students work in

groups to complete the maps. She used these maps to informally assess the students by checking off their work, but did not seem to use them as a formal assessment. Although in the pre-unit interview she did discuss concept maps as a useful way to help students make connections, and to see if what she was teaching was transferring, she did not elaborate on this *pedagogical knowledge of concept maps* further in the post-unit interview. She had the students brainstorm terms for the concept maps, a *pedagogical content knowledge* for teaching students to create the maps, but she also did not incorporate other techniques such as grouping the words, reading sentences down the maps etc. In the post-unit interview Ms. Ford described her use of concept maps, referring to both hierarchy and the need for revision. She did have the students go back and add to their concept maps, but she did not discuss the students actually changing what they already had. She did not have time to complete the unit, so did not complete all of the instructed revisions, a form of *pedagogical content knowledge of using concept maps* as a means for fostering student understanding. She lamented that the students got tired of returning to the concept maps, complaining they already did those. In discussing concept maps, Ms. Ford stated the only difference in the concept mapping she was doing in this unit as compared to her other experience was the length – returning and adding to the concept maps as the unit progressed. By the end she shared that she had students who had concept maps that were three pages long. Ms. Ford did not mention hierarchy in the initial interviews and, despite the fact that she mentioned hierarchy to the students at the onset of the lesson, the students did not adopt hierarchy and we did not observe Ms. Ford address this, or acknowledge it as an issue. Ms. Ford, through casual discussions with a fellow teacher and the curriculum unit, adopted the terminology and appeared to incorporate this into her instruction by including the terms "hierarchy" and "revision". Although she demonstrated a basic understanding of the *content knowledge of concept maps and the pedagogical content knowledge of concept mapping* with respect to fostering student understanding, upon more careful observation neither of these were adopted with the rigor as intended by the unit. Hierarchy was introduced, but neither enforced nor encouraged, resulting in students producing a variation of the common web. Rather than “revising” the maps and adding new information, Ms. Ford focused in adding new materials. In the case of hierarchy, this did not seem to bother Ms Ford, whereas in the case of revision, Ms. Ford did regret not having time to do a final revision. Yet it is unclear whether this final “revision” would have included revisions or merely having the students add more information. With the exception of the need for further revisions of the map, there was little difference in Ms. Ford’s *self-efficacy* with respect to concept maps in the pre and post unit interview, in both cases sounding confident.

### **Cross-Case Analysis**

How does teachers’ knowledge and beliefs change from professional development in the context of practice and when do these changes occur? Of the four teachers who attended the workshops, three initially did not demonstrate content knowledge of concept maps that aligned with the unit. Each of the three teachers described their own working definition of concept maps, thus if asked if they knew what a concept map was, they would answer "yes". However the concept maps they described were more web-like in nature. Participation in PD informed them of the “new” approach to concept mapping, the primary shift being the addition of hierarchy. In the cases of Ms. Konig and Ms. Lewis, this was new information, which both adopted. Thus their content knowledge of concept maps changed to include the hierarchical structure. Ms. Ubawa, on the other hand, merely was reminded of this definition. This

exemplifies the need for clarity when adopting an instructional strategy in reform-based instruction, and the need for professional development to ensure the teachers are defining the terms in the same manner as the curriculum developers. Even the lead teachers mentioned they liked this move on the part of the university to change concept mapping, when in fact it had always been written in the unit that way. Ms. Lewis already was convinced that linking words, an essential component of concept maps as defined by the unit, confused the issue too much, and she elected not to have her students use them, despite the discussion in the professional development about their usefulness and the multiple pedagogical approaches to teaching them presented by the lead teacher and shared by the participants. In this case, Ms. Lewis's negative experience in the past had a stronger influence on her instruction than the professional development. PD can influence teachers' content knowledge either by supplying new information or reminding them of past knowledge. However, if teachers do not believe the new information will improve their students' learning they may not adopt the reform (Turnbull, 2002).

Content knowledge of the instructional approach is not enough. Ms. Clarence was well versed in the content knowledge of concept mapping and could elaborate in greater depth than measured in this study. She had ample training in the creation of maps, but was still dissatisfied with their use. The initial professional development also included instructional techniques for teaching concept maps and the rationale for adopting these techniques, shared by both the lead teachers as well as other teachers in the workshop. Since only one teacher at the workshop said she used concept maps as intended by the unit (because she was part of another research study), much of the discussion amongst teachers involved adaptations of lessons they had used in the past. In addition to content knowledge, a necessary component of PD to facilitate teachers' adoption of given instructional strategies is to include explicit directions and hands on opportunities to explore, share and adapt pedagogical and pedagogical content knowledge designed to support enactment.

Ms. Konig and Ms. Clarence left the workshops armed with techniques to teach something they had previously felt unsuccessful at teaching and both expressed an increased sense of self-efficacy. Ms. Lewis and Ms. Ubawa were already relatively confident in their instruction. Ms. Lewis bought into the advantages of hierarchy as presented at the workshop, and planned to adopt it in her classroom. Ms. Ubawa stated she was merely reminded of this approach and also planned to use it in her classroom. Thus PD needs to attend to supporting teachers' self-efficacy and beliefs by convincing teachers of the advantages to using the information shared at the workshop, and supplying them with enough information to enact the activities in their classroom.

Ms. Konig, Ms. Lewis and Ms. Clarence each enacted the initial concept map activity prior to the second workshop, with Ms. Ubawa enacting shortly thereafter. Ms. Konig's and Ms. Clarence's increased sense of self-efficacy after the workshop was challenged after the first enactment. Each left the first workshop believing in this new approach with high expectations for their students. Upon completion of the initial activity, each expressed disappointment with the student work and was trying to think of ways to improve the situation. The practice challenged their new sense of self-efficacy and their belief in the success of the activity.

The second workshop included sharing of student work, going over assessment of maps, and sharing of ideas about student self- and peer-assessment. Although the revision component of concept maps was briefly discussed in the first workshop, the second workshop supplied specific pedagogical methods for these revisions. In addition, the second workshop included

presentation of a rubric designed to assess the concept maps, including techniques for evaluating not only the content, but also the structure. Both Ms. Konig and Ms. Clarence left this workshop and enacted the techniques of self and peer assessment, sharing the rubric supplied at the workshop with their students. The workshop refreshed as well as expanded on teacher knowledge of the nuanced understanding of the instructional strategy. Thus the second professional development supplied the tools the teachers needed to adapt the lesson, while maintaining the intent of the unit.

Ms. Lewis adapted her own instructional strategy by adding hierarchy. As stated above, she was not convinced of the need for linking words and made a strategic choice not to include them. Thus her enactment did not entirely align with the unit. She demonstrated less self-efficacy after making the instructional change to include hierarchy, however the professional development had successfully convinced her of the value of this approach and she remained committed to this “new” method.

Although Ms. Ubawa appeared to be pedagogically prepared for concept mapping, the workshop still impacted her enactment. Not only was she reminded of hierarchy, which she incorporated in her instruction, but she also used the same examples presented at the workshop in her enactment. The refresher PD proved a key impetus for adoption of the ideas in the reform, especially with experienced teachers who have participated in multiple professional development and had years of experience which might not align with that intended by the reform.

Finally, Ms. Ford, who did not attend either workshop, seemed to be impacted by the professional development indirectly through a combination of the written curriculum and the shared lunches with Ms. Konig. Her discussion of concept maps in the post-unit interview changed from the pre-unit interview to include the reference to hierarchy and revision, although not expanded upon as in the case of the other teachers. Observation of her practice initially suggested alignment with the unit, in that she directed her students to use hierarchy, and revisited the concept maps on multiple occasions. However, on more careful examination, she did not reinforce the hierarchical component of concept maps. The “revisions” seemed to be more “additions” to the concept maps. Thus what first appeared to be enactment as intended by the unit had the same misalignments suggested by the pre-unit interviews with the other teachers.

## **Discussion**

This analysis presents strong evidence that teachers learn from professional development, enactment, and evidence of their students' learning. Referring back to our teacher learning model (see Figures 2 and 3), professional development can supply teachers with new knowledge that can also influence their beliefs in the usefulness of the activity as well as their own self-efficacy with respect to enacting the activity. If the professional development convinces teachers of the value of adopting what the PD is teaching, teachers make the change in practice. Ideally, the professional development will assist the teacher in becoming more confident in the specific classroom practice it supports. Teachers who do not participate in formal professional development may pick up the language of the reform through conversation with other teachers; however, in this case the impact on practice was minimal. Professional development can change teachers practice by convincing them of the value of the change in instruction, although this study suggests this change is hard to achieve, as demonstrated by Ms. Lewis's hesitance to use linking words. This implies once a teacher decides a particular strategy is detrimental to instruction it is difficult to convince her otherwise. Change in teacher knowledge and beliefs

impacts their subsequent practice, which in turn influences their students' learning. The teachers' beliefs about their students' learning then mediate how the professional development might impact future practice. If the teacher does not see a positive change, he or she considers revisions. In order to maintain the integrity of the instructional practice intended by the professional development, future professional development should anticipate this need and include follow-up instruction. Failure to do so risks having the teacher believe the strategy is not successful and become recalcitrant.

These case studies suggest quality professional development planned to support a particular reform initiative need to include the following:

1. Careful consideration of the teachers' understanding of instructional techniques
2. Clearly defined content of instruction
3. Justification of the need for the content to facilitate teacher buy-in
4. Pedagogical and pedagogical content knowledge necessary for the enactment to support teachers' sense of self-efficacy
5. Follow-up with expanded information on instruction after initial enactment
6. Re-visiting previously taught material after the enactment, allowing for communal reflection as well as a means for mediating adaptations.

Quality professional development clearly can influence teachers' knowledge, by teaching teachers something entirely new, changing their previously existing understandings, or merely reminding them of something they already knew. To support adoption of these new understandings, professional development should attend to convincing teachers of their validity. However, the true test is in the classroom. Teachers' enactment and the resulting student learning are the ultimate measures of the success and/or failure of a given strategy. Various types of knowledge are informed through quality professional development and practice, ever increasing the teachers understanding. However, beliefs are in flux during this professional development/practice cycle. Thus, the professional development must attend to teachers' beliefs about the instructional approach, particularly their self-efficacy in order to maintain the integrity of the enactment of a reform initiative. Teachers by nature adapt their instruction based on the feedback from practice, and professional development needs to inform the adaptations for long-term sustainable impact.

### **Conclusion**

How does professional development impact teacher learning in the context of practice? PD both informs the practice and is mediated by the practice. If we accept the assertion that quality professional development has lasting impact on teaching, and characteristics of quality professional development include being long-term and proximal to be practice, then PD and practice are interlinked. Rather than representing two separate contexts for professional development, formal quality professional development opportunities such as workshops cannot be looked at in isolation from practice. Practice is part of the professional development, not just as an outcome variable, but also as a contributor. This study provides evidence of how teachers learn new knowledge from workshops and how this knowledge can transfer into practice, however the beliefs are fluctuating and influence the teacher planning and long-term practice. In order to be effective, professional development in long-term reform initiatives has to have long-

term impact on teacher practice. Rather than worry about which comes first, change in knowledge or change in beliefs, this study suggests a more fluid relationship between the two, echoing and providing empirical support for Richardson's arguments (2001). In either case, both need be attended to in professional development design.

### Future Work

This study looks at a very specific instructional technique and how to influence teachers in its use. A follow-up study to examine the long-term impact of the professional development at the focus of this study is planned as the teachers re-embark on another enactment of the same unit. In addition, future studies will examine other instructional techniques, possibly applications of technology, to see if the findings of this study are consistent across different domains and content. Finally, this study should be repeated with an examination of teacher subject matter knowledge. Although a sensitive topic to broach with professional teachers, the field is in desperate need of a thorough look at how to create subject matter focused professional development designed both to inform teachers as well as influence their instruction.

### References

- Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is—or might be—the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 25(9), 6-8.
- Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, 33(8), 3-15.
- Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry, *Educational Researcher* (Vol. 19, pp. 2-14).
- Connelly, F. M., Clandinin, D. J., & He, M. F. (1997). Teachers' personal practical knowledge on the professional knowledge landscape. *Teaching and Teacher Education*, 13(7), 665-674.
- Donmoyer, R. (1990). Generalizability and the single case study. In A. Peshkin (Ed.), *Qualitative inquiry into education: The continuing debate* (pp. 175-200). New York: Teachers College Press.
- Emerson, R.M., Fretz R.I., & Shaw, L.L. (1995) *Writing Ethnographic Fieldnotes*. Chicago, IL: The University of Chicago Press.
- Evans, C. S. (1993). When teachers look at student work. *Educational Leadership*, 50(5), 71.
- Fenstermacher, G. D., & Richardson, V. (2000). *On making determinations of quality in teaching*. Paper prepared for Board of Institutional Comparative Studies, National Academy of Science, Washington, D.C. Retrieved September 7, 2002, 2002, from the World Wide Web: [www-personal.umich.edu/%7Egfenster/teaqual14ss.pdf](http://www-personal.umich.edu/%7Egfenster/teaqual14ss.pdf)
- Fishman, B., Best, S., Foster, J., & Marx, R. W. (2000). Fostering teacher learning in systemic reform: A design proposal for developing professional development, *Annual Meeting of the National Association of Research in Science Teaching*. New Orleans, LA.
- Fishman, B., Marx, R., Best, S., & Tal, R. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education*, 19(6), 643-658.

- Franke, M. L., Carpenter, T., Fennema, E., Ansell, E., & Behrend, J. (1998). Understanding teachers' self-sustaining, generative change in the context of professional development. *Teaching and Teacher Education, 14*(1), 67-80.
- Garet, M., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001b). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.
- Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community, *Teachers College Record* (Vol. 103).
- Guskey, T. R. (1994). *Professional Development in Education: In Search of the Optimal Mix*. U.S.; Kentucky.
- Guskey, T. R. (2002). Does it make a difference? Evaluating professional development, *Educational Leadership* (Vol. 59, pp. 45-51).
- Guskey, T. R. (2003). What makes professional development effective? *Phi Delta Kappan, 84*(10), 748-750.
- Guskey, T. R., & Sparks, D. (1996). Exploring the relationship between staff development and improvements in student learning. *Journal of Staff Development, 17*(4), 34-38.
- Hug, B., & Center for Highly Interactive Computing in Education. (2002). How can good friends make you sick? Ann Arbor, MI: The University of Michigan.
- Kirkpatrick, D. L. (1998). *Evaluating training programs: The four levels* (2nd ed.). San Francisco, CA: Berrett-Koehler Publishers.
- Kubitskey, B., Fishman, B., & Marx, R. (2003). *The relationship between professional development and student learning: Exploring the link through design research*. Paper presented at the American Education Research Association, Chicago.
- Kubitskey, B., Fishman, B., & Marx, R. (2004). *Impact of professional development on a teacher and her students: A case study*. Paper presented at the American Education Research Association, San Diego, CA.
- Lieberman, A. (1995). Practices That Support Teacher Development. *Phi Delta Kappan, 76*(8), 591-596.
- Little, J. W. (2003). Inside teacher community: Representations of classroom practice, *Teachers College Record* (Vol. 105, pp. 913-945).
- Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing Professional Development for Teachers of Science and Mathematics*. Thousand Oaks, CA: Corwin Press.
- Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*(5), 258-271.
- Marx, R. W., Blumenfeld, P., Krajcik, J. S., & Soloway, E. (1998). New technologies for teacher professional development. *Teaching and Teacher Education, 14*(1), 33-52.
- Novak, J. D. (1998). *Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools*. Mahwah, NJ: Lawrence Erlbaum Associates, inc.
- NSDC. (2001). *National Staff Development Council's Standards for Staff Development 2001*. Michigan Department of Education. Retrieved 11-1-03, 2003, from the World Wide Web: [http://www.michigan.gov/mde/0,1607,7-140-5234\\_5703-36961--,00.html](http://www.michigan.gov/mde/0,1607,7-140-5234_5703-36961--,00.html)
- Richardson, V. (2001). Teacher change. In V. Richardson (Ed.), *Handbook of Research on Teaching* (4 ed.). Washington, D.C.: American Educational Research Association.

- Richardson, V., & et al. (1991). The relationship between teachers' beliefs and practices in reading comprehension instruction. *American Educational Research Journal*, 28(3), 559-586.
- Schneider, R. M., & Krajcik, J. (2002). Supporting science teacher learning: The role of educative curriculum materials. *Journal of Research in Science Teaching*, 13(3), 221-245.
- Singer, J., Marx, R. W., Krajcik, J. S., & Clay-Chambers, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, 35(3), 165-178.
- Strauss, A., & Corbin, J. (1990). Open Coding Definition of Terms, *Basics of qualitative research: Grounded theory procedures and techniques* (pp. 61-74). Thousand Oaks, CA: Sage Publication, inc.
- Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching*, 37(9), 963-980.
- Turnbull, B. (2002). Teacher Participation and Buy-In: Implications for School Reform Initiatives. *Learning Environments Research*, 5(3), 235-252.
- U.S. Department of Education. (2001). *No child left behind*. Retrieved, from the World Wide Web: <http://www.NoChildLeftBehind.gov/>
- Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed. Vol. 5). Thousand Oaks, CA: Sage.