Professional Development Design for Systemic Curriculum Change

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In an era of high stakes assessment and standards-based educational reform, the need for high quality professional development has emerged as one of the most important areas for research in education (American Association for the Advancement of Science, 1993; Borko, 2004; National Board for Professional Teaching Standards, 1998, 2001a, 2001b; National Council of Teachers of Mathematics, 1989; National Research Council, 1996; National Staff Development Council, 2001; U.S. Department of Education, 2001). Expecting teachers to embrace new instructional approaches without sufficient training and information on why such changes are necessary, or warranted, often result in inadequate adoption of the mandated curriculum (Cohen & Hill, 2001). With the increased emphasis on shifting instructional strategies to a more inquiry/constructivist approach, teachers need formal professional development to both buy-in to the changes as well as implement them. Although research has focused on the defining characteristics of quality professional development opportunities, little has been done to examine the specific factors involved in teacher learning from a professional development activity and its relationship to practice and student learning (Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2003; Kubitskey, Fishman, & Marx, 2003; Kubitskey, Fishman, & Marx, 2004; Loucks-Horsley, 1997; Richardson, 2001). The purpose of this paper is to empirically examine teacher learning from professional development and practice by answering the question: *How can we design long-term curriculum aligned professional development to best impact teacher learning in the context of classroom practice?*

Problem

Teachers are influenced both by formal professional development activities and through reflecting on their own classroom experience (however informally), influenced by their students' responses. Classroom practice is a major influence on teacher learning related to the formal professional development activity. Formal professional development activities are intended to mediate teachers' practice; however, the practice itself often becomes a mediating factor in how the formal professional development continues to impact teaching. 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 (Cohen & Hill, 2001). To design professional development that supports long term systemic change initiatives, it is important to understand the relationship between teacher learning from formal professional development and the resulting practice.

Looking at teacher learning from formal professional development episodes in isolation from practice proves problematic in that it limits our understanding to teachers' "knowing that" as opposed to "knowing how", an important distinction made by Ryles

(1949). Knowledge in action is another site for professional development (Clandinin & Connelly, 1996; Munby, Russell, & Martin, 2001), and thus learning that takes place during the practice informed by formal professional development proves an integral part of the teacher learning experience. Learning happens in a context and is extended over time. Teacher learning is continual and informed at many levels. Observing the impact of professional development, teacher behavior or student response on teacher learning each in isolation proves useful when looking for specific instances of transfer.   However, these must be examined in partnership to gain an understanding of the teacher learning process in context. In particular, we shift our focus from professional training during episodes of formal professional development to the long-term development of the teacher by attending to practice as a continuation of the professional development, rather than an outcome.

To identify what professional development might include to influence teacher learning in long-term curriculum aligned workshops to best influence teachers' practice, we examine the following questions about a successful professional development example:

1. What is the influence of a high quality, curriculum aligned, long-term, group workshops on teacher learning?
2. What is the influence of these workshops on teacher behavior?
3. What is the influence of teacher behavior on student response?
4. What is the impact of practice and student response on teacher learning?

We examine a particular topic (concept mapping) covered during workshops designed to support teachers' adoption of an inquiry-based middle school science curriculum. We measure teachers' shift in knowledge and beliefs about concept maps prior to the workshops through the enactment of the unit. Although we are selecting an instance in a specific unit, the study is nested within a long-term professional development cycle supporting teachers in curriculum instruction. These episodes allow us to tease out teacher learning from professional development (workshops and practice), using the concept maps as a tracer for measuring knowledge and beliefs. In particular, we focus on content knowledge of concept maps, using concept maps as assessment tools, instructional knowledge for teaching students how to create concept maps, and beliefs with respect to teacher self-capability of using concept maps. In so doing, we create a picture of the shifts in teacher knowledge and beliefs over the course of workshops and practice to inform professional development design.

Theoretical Framework

Quality Professional Development

Richardson and Fenstermacher argue that quality instruction is both good [1] and successful (2000). [2]   This approach provides a frame for looking at a special instance of instruction: professional development. Quality professional development (PD) is both good (including characteristics shown to be successful incorporating morally sound approaches to instruction) and successful (resulting in improved student learning).

Good Professional Development

The literature suggests the following components of "good" professional development. Good PD is well planned with clear goals, incorporating quality content and strategies (Loucks-Horsley & Matsumoto, 1999: Loucks-Horsley, Hewson, Love and Stiles, 1998). The PD is structured to align with the teacher practice, proximal to the practice and related to what the teacher is teaching (Garet, et al., (2001). The group of people participating in the PD includes participants of a common community, teaching a common curriculum or a common subject (Garet et al, 2001.; Loucks-Horsley et al, 1999). PD needs to be extended over time, and not an instant, to best impact teacher learning (Supovitz & Turner, 2000). Finally, the PD needs to includes activities teachers participate in, rather than get lectured about (Garet et al., 2001). However, quality PD needs to also be successful, resulting in improved student learning.

Successful Professional Development

Successful professional development is unique to each instance. Means for measuring the successfulness of professional development exist both in the education community (Guskey, 2002) and training literature (Kirkpatrick, 1998). Each has developed models of evaluation by getting feedback from the participants, impact on participants learning, measuring/observing the impact in practice, and seeing the results of participants practice, in this case student learning. Guskey presents this template to examine the successfulness of given professional development, focusing on the participants' reactions, the participants learning, organizational support, participants use of new knowledge and skills, and student learning. This is very similar to the Kirkpatrick model, which has been widely used in the professional business training literature as way to evaluate professional training. Kirkpatrick focuses on 4 phases of professional training, reaction, learning, transfer and impact. The learner reacts to the activity, learns

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[1] "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)

[2] "The learner actually acquires, to some reasonable level of proficiency, what the teacher is engaged in teaching" (2000 p 10).

something from the activity, transfers this learning to practice and this new learned practice results in positive outcome in production. Our professional development design model also incorporates characteristics that allow for the measurement of the successfulness of professional development using this same approach.

Table 1. Professional development measure of quality

Guskey (2002)	Kirkpatrick (1998)	Fishman et al (2003)
Teacher reaction	Teacher Reaction	Evaluation of PD
Learning	Learning	Evaluation of PD
Organizational support and change	N/A	(District adopted educative curriculum: context)
Use in classrooms	Transfer	Observation of classroom teaching
Student learning	Impact	Evaluation of student performance

Although our model for professional development design resembles an action research plan, it also addresses the issues of evaluation addressed by both Guskey and Kirkpatrick (Table 1).
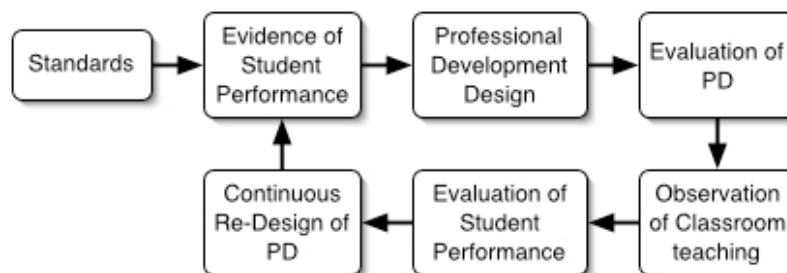
Figure 1. Professional Development Research Design Model (Fishman, Marx, Best, & Tal, 2003).

We incorporated characteristics of good professional development in our design motivated by evidence of student performance in meeting standards covered by the curriculum at the focus of the PD. We interviewed teachers after the PD activity to evaluate its reported effectiveness. We observed classroom teaching to examine the transfer of what was learned in the workshop to real world application. We studied student work resulting from this practice, as well as over all achievement from curriculum to inform the next PD enactment.

Our model allowed us to empirically examine the impact of PD on practice and student learning, measuring the successfulness of the PD. This professional development design model proved useful in developing and implementing long-term curriculum aligned professional development. Although this model has served us well as a research tool as well as a professional development design tool, we use the information from this model to create a more specific sustainable model to be adopted on a long-term basis.

Methods

Setting and Context

The Center for Highly Interactive Classrooms, Curricula and Computing in Education (hi-ce) created inquiry-based curricula and learner centered technology. Hi-ce

also developed and supplied professional development to support these activities (www.hice.org). In particular, this study takes place surrounding one of hi-ce's research projects, LeTUS (The Center for Learning Technology in Urban Schools), which is a collaboration between the Detroit Public Schools, Chicago Public Schools, Northwestern University and University of Michigan. LeTUS created and disseminated technology-rich, inquiry-based middle school science curricula. This involved extensive curriculum development (Singer, Marx, Krajcik, & Clay-Chambers, 2000), designed to integrate technology to support student and teacher learning (Marx, Blumenfeld, Krajcik, & Soloway, 1998) and included broad-based professional development (Fishman et al., 2003). LeTUS developed five units; one in the 6th grade, three in the 7th grade, and one in the 8th grade. Approximately 80 teachers in Detroit from 20 middle schools adopted LeTUS units in the 2003/2004 school year. LeTUS teachers participated 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. Teachers selected from among these professional development options, but few, if any, participated in all of them. This paper examines professional development in the form of Saturday workshops, and teacher learning and practice related to the Communicable Disease Unit (Hug and The Center for Learning Technologies in Urban Schools, 2002), which was taught mid-year in the 7th grade during the 2003-2004 academic year. As of 2002, responsibility for professional development shifted from the university to school district.

Curriculum and Activity

The Communicable Disease Unit focused on students interrogating the question "How can good friends make you sick?" to learn about the characteristics of the spread of disease, cells, bacteria and viruses. The unit incorporated concept mapping as a way of fostering student understanding as well as a means for assessment of student learning. In past years, informal observations suggested concept maps were often used infrequently or ineffectively by teachers during this unit's enactment. Later interviews confirmed this suspicion. For our study, concept maps serve as "tracers," allowing us to follow changes in teachers' beliefs, knowledge and practices in a more nuanced, focused manner. We are not primarily concerned with the *idea* of concept mapping as an instructional strategy, but rather the match between how it is presented for use in PD, and how that presentation translates into teacher learning and practice. The workshops informed teachers of the definition of concept maps as intended by the unit and assisted teachers in ways of using and teaching concept maps in the classroom.

Concept maps, as defined by the unit, included clear concepts, hierarchy, linking words and cross links, adopting Novak's model (1998). Novak defines concepts as "*a perceived regularity in events or objects, or records of events or objects, designated by a label*" and propositions that connect the concepts as "*statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected with other words to form a meaningful statement.*" (Novak). Hierarchy and linking words are two essential components of concept maps. Cross links

are propositions formed by linking concepts from different domains that have branched off the initial general topic.

Participants

Thirty-one Detroit Public School seventh grade science teachers adopted the Communicable Disease Unit in 2004. Eighteen teachers participated in the concept mapping portion of the first workshop. Of these, one had a student teacher and did not primarily teach the unit herself, three were participants in other studies, one did not want to be studied, and two were unavailable for the knowledge and belief interviews. We observed the remaining 11 teachers.

Professional Development

We assisted the lead teachers[3] who designed and ran the workshops in their planning of the workshops that incorporated concept mapping. The idea of hierarchy was also new to the lead teachers. During the first workshop, a lead teacher introduced concept maps first by contrasting the hierarchical form with the web-like concept maps. Seventeen of the 18 teachers volunteered that they used the web approach. The lead teacher reported to the teachers that she, too, created web-like maps with her students. The lead teacher then shared the four characteristics of concept maps as defined by Novak (1998) from the Communicable Disease Unit: (1) clear concepts, (2) hierarchy, (3) linking words and (4) cross links, using model teaching by having the teachers create a concept map using a common term. The lead teacher also supplied teachers with a list of linking words she copied from a science education textbook (Krajcik, Caerniak, Berger, & Berger, 2002). Teachers shared techniques they had used to create concept maps in the past during a peer exchange. The content of the workshop represented quality content as informed by the work of Novak on concept mapping (1998). The lead teacher also incorporated research-based instructional strategies of curriculum review with active engagement, peer exchange and model teaching (M. Garet et al., 2001; Kubitskey et al., 2004; Kubitskey, Fishman, & Marx, 2002; Loucks-Horsley, Hewson, Love, & Stiles, 1998).

During the second workshop the lead teacher asked other teachers to bring in examples of their students' work and used examples of her own students' work to foster a discussion about grading criteria for the concept maps. In addition, teachers participated in a peer exchange about their own success and failures, suggesting various strategies for improving and evaluating students' work. The lead teacher maintained the structure of Novak's model of concept maps as a guiding principle of the discussion, representing good content. She utilized peer exchange and examining student work (Little, Gearhart, Curry, & Kafka, 2003), both good instructional approaches.

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[3] Expert teachers from the school district, experienced with the unit, who taught the workshops.

Data

Prior to the workshop, we interviewed 7th grade teachers about their beliefs and knowledge on the subject of concept maps (pre-unit interview). We observed each of the two workshops dealing with concept maps. We interviewed those who attended the workshops about what they learned (post-workshop interview). We observed the teachers enacting concept maps, some on multiple occasions. We collected concept maps created by the students. Finally, at the end of the unit, we repeated the belief interview with the teachers (post-unit interview).

Interviews

The pre and post-unit interviews were designed to elicit teachers' knowledge and beliefs about concept maps using a focused interview format (Weise, 1994). The post-workshop interviews were designed to tease out teacher learning from the workshops using a more open-ended format (Weise, 1994). We interviewed teachers over the phone, recorded and later transcribed the interviews into text. The pre-unit interviews lasted, on average, 28 minutes (SD = 10). We repeated the interview with the teachers within a month of the end of teaching of the unit. These post-unit interviews lasted, on average, just over 14 minutes (SD=7) and did not include demographic information collected in the first interviews. We conducted open-ended interviews with teachers who attended each workshop about what they had learned. Eleven teachers attended the first workshop on February 14, 2004. Nine of these teachers were interviewed by phone for a post workshop interview prior to the second workshop (March 13, 2004). The two remaining teachers were unavailable for formal interviews during this time and interviews were later conducted in conjunction with the post-unit interviews. The interviews lasted an average of 14 minute (SD=8). Nine of the 11 focus teachers attended the second workshop on March 14, 2004. We interviewed eight of these teachers by phone over the month immediately following the second workshop. One teacher was unavailable until the post–unit interview, and thus the interviews were combined. The mean length of time of the interview was 15 minutes (SD=7). All interviews were transcribed.

Observations

Two types of observation contribute to this study: observation of the Saturday workshops and classroom observations. We recorded a running record into a Filemaker™ template, creating a new record with each shift in instructional strategy or content (Margerum-Leys, 2001). The resulting notes from the workshop observations included a description of the content of the instruction, the instructional strategy used by the leader, and the type of activity. We observed 11 focus teachers during the initial concept mapping lesson, which took approximately 2 class periods, resulting in 22 class-periods of classroom observations. Three teachers were observed when they revisited concept maps.

Student Response – Artifacts

We collected concept maps from the students to measure the outcome of the teachers' instructional practices. Some of the maps were created by groups, while others were created by individuals. Six teachers supplied individual student concept maps (Mean = 29.3, SD = 10.1, max = 48, min = 20), three teachers supplied group concept maps (Mean = 32.3, SD = 37.2, max = 75, min = 7), and one teacher had a mixture (N=78).

Analysis

Statistical

For the statistical analysis we took qualitative data of interviews, observations and student response and, adapting Chi's verbal analysis technique, translated the data into quantifiable terms (1997). Chi suggests that quantifying qualitative data is a way of measuring learning while reducing the subjectiveness of qualitative research. Chi describes an 8-step method for coding and analyzing verbal data, which informs the design of our data reduction and statistical analysis. We reduced the data by identifying parts of the interviews, observations and student work that had to do with concept mapping. We segmented the interviews by turn (shift from one speaker to another) and the observations by shift in content or teaching strategy. We developed a coding scheme identifying quotes from the interviews and observation of their practice where teachers are describing their knowledge and beliefs about concept mapping. In addition, we identified a list of instructional strategies shared at the workshop to look for in the teachers' practice. We operationalized the terms through the development of our likert-like scales describing teachers' content knowledge and beliefs about concept maps. We depicted the mapped formalism by examining the coded interviews and interpreted the patterns by conducting a Wilcoxon signed ranks test to determine statistical difference between the pre and post interviews. Finally, we repeated the analysis, but using case-study design (see Table 2).

Table 2. Descriptions of quantifying qualitative data by data type.

	Interviews		Observations		Student Work
1. Reducing	ID comments about concept maps		Limited to observations of concept maps		Student work from observed teachers
2. Segmenting	By turns		Shift in content or instructional strategy		Only concerned with concepts, hierarchy, linking words, cross links, form and structure.
	Belief and Knowledge	**Post Workshop**	**Workshop**	**Classroom**	**Content Knowledge**
3. Coding scheme	CK and instructional knowledge of Concept Maps. Satisfaction with instruction and student work.	CK and instruction knowledge for teaching Concept maps	Strategies and content. CK and instructional knowledge for teaching concept maps	CK and instructional knowledge for teaching concept maps.	CK of concept maps
4. Operationalizing	Characteristics of concept maps and assessment	Characteristics of concept maps. Instructional knowledge shared during workshop.	Characteristics of concept maps and instructional knowledge shared.	ID characteristics of concept maps and instructional knowledge shared at workshops.	Characteristics of concept maps.
5. Depicting mapped formalism	Rating CK and instructional knowledge of concept maps.	Rating CK, just identifying instructional knowledge.	Rating CK, just identifying instructional knowledge.	Rating CK, just identifying instructional knowledge.	Rating CK for each map, just whether present, no quality judgment.
6. Seeking pattern	Wilcoxon signed-rank test, Friedman test.				Bar graphs.
7. Interpreting pattern	Analysis of statistical findings and by observation.				
8. Repeating whole process	Qualitative Analysis				

Case Study

The statistical analysis identified shifts in knowledge and beliefs of teachers and alignment between what was taught at the workshop, teachers' practice and student response. We re-analyzed the same data used above in the statistical analysis using a case study design (Yin, 2003), the advantage of which is two-fold. First, the case-study analysis allowed us to triangulate findings with the statistical analysis. Second, the nature of the case study allowed us to look for distinct teachers' attributions for learning and compare across teachers. We used the quotes identified in the statistical analysis to identify to what teachers attribute their change in knowledge, change in beliefs and impact of workshop on practice. In addition, we reexamined the interviews and observations looking for emerging themes within and across teachers. Through this back and forth process we identified key components that stood out and recoded the

interviews. In particular we looked for teacher reference to interpretation of their practice after the enactment and the student reaction. We then looked across all teachers to create a cross-case synthesis by identifying specific instances of teacher learning as demonstrated by interview or action.

Findings

Professional Development Impacted Teachers' Knowledge

The workshops influenced teachers' knowledge and beliefs. In the case of knowledge, teachers demonstrated a significant shift in their understanding of concept maps based on a Wilcoxon signed-ranks test between the pre and post unit interviews ($p<.01$). Most teachers shifted from a web-like structure to the hierarchical structure intended by the unit.
The workshop informed the knowledge of the teacher in three ways. First, the *workshops supplied some teachers with completely new information (gained definition of concept mapping*). Two teachers had no reported classroom experience with concept maps or a working definition. One of these teachers stressed that, without the workshop, she would have adopted the web-like approach as discussed in the text book (Glencoe, 1995), and she didn't believe she would have been as successful.

> When they (lead teachers) showed the examples of the two types of the concept maps …the one in which just, you know, everything kind of came out like a spider web. I'm thinking that looks like something I'd make and I'm thinking, OK, you know, if the kids can do that, that's fine. But after listening and looking and watching and hearing some of the positives for the other concept map (hierarchical) I'm glad I was there and took notes…Because I would of had them (students) do the first one (web)…And really technically, like (the lead teacher) said, when they do that you really don't know what they know. They're just putting words down…but with the other concept map (hierarchical) there's some higher order thinking skills. You can basically look at it and get an idea of some basics that they know. (Anton, post ws 1 interview, 2004)

Second, *the workshops gave teachers tools for adapting their pre-existing knowledge (expanded previous definition to include hierarchy etc.).* Seven teachers had previous experience with concept maps, but defined them as webs; one teacher defined them as webs only and six teachers defined them as webs with linking words. Six of these seven teachers specifically attributed the first workshop with expanding their definition of concept maps to include hierarchical maps. A typical response when asked what was particularly helpful from the workshop included:

> Ideas like the part about the concept maps because I would have never thought about doing the hierarchy with the kids. (Merritt, post ws 1 interview, 2004)

Finally, *the workshop reminded other teachers of knowledge they had and encouraged teachers to adapt their practice accordingly.* The seventh teacher who was very experienced and confident with concept maps, but defined them as webs above, attributed the workshop with "reminding" her of the hierarchical structure of the maps and the second workshop supplying her with a term for "cross links," although she had used them in the past. Two teachers already included hierarchical maps with linking words in their definition of concept maps during the pre-unit interview, but one did not include cross links either before or after enactment. Thus, neither

teacher showed a statistical change in content knowledge of concept maps. However, these teachers reported using web-like maps with their students. Each teacher did express a change in the knowledge as they intended to use it in practice.

Professional Development Impacted Teachers' Beliefs

Teachers' Belief in their Capability Changed

From the pre-unit interview, most teachers were not satisfied with concept mapping. Two had no experience. Four were not satisfied with either their instruction or their students' performance with concept maps.

> 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. (Paki, pre-unit interview, 2004).

Three of the teachers were confident in their instruction, but not satisfied with the student work.

> For concept maps, you know, they're different forms and not only do I use the LeTUS approach but also I use my own background now as in the example that DPS uses in its textbook… And so I've integrated that in my teaching for many years…but I'm still not satisfied with the clarity and usefulness of concept mapping. The students have to really buy into this kind of mental organization. (Sahleh, pre-unit interview, 2004)

The two remaining teachers were both confident in their instruction and student work.

> I love concept maps... I've had a former class call me the concept map queen … I mean you know they (students) hated them. But they're used, they were used to them by the time they left, but I love concept maps…As a matter of fact I get carried away. I do boards; I have a huge one on my board now. (Moody, pre-unit interview, 2004)

After the workshops and enactment the beliefs significantly improved ($p < .05$). Seven of the 11 teachers were satisfied with their instruction and the resulting student work. Only two teachers remained disappointed in their student work, although were now comfortable with their own instructional approach. Both were experienced with the unit and concept mapping and were adapting their practice to include this new knowledge. Both modified their instruction after the second workshop as well, and were more satisfied after these adaptations. Parks was particularly disappointed with her student work and used this as an impetus for change.

> Well I think the thing that really stands out (from the second workshop) is the examples of the concept maps and, you know how you always think that your kids are, they just don't get it and then you see another group of kids and, you know you see some of the things or you see, see how they have taken something and they've made it a little bit better. (Parks, post Workshop 2 interview, 2004).

Both reported that they anticipated greater success in the future when they planned to start teaching concept mapping using their adaptations they made after the second workshop. Finally, Peterson was satisfied with neither her instruction, nor her students' performance.

> 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 in 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 can 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, there was only, we only did it twice. (Peterson, post-unit interview, 2004).

Peterson was the only teacher whose belief score decreased between the pre and post-unit interview. Despite this, she still remained convinced that hierarchy was a necessary component, but remained unconvinced that linking words were necessary (discussed below).

Teachers' Value of Using Concept Maps as an Assessment Tool Changed

There was no significant difference in teachers knowledge of concept maps as an assessment tool since most teachers had a general idea about how they were suppose to be used (p>.05). However, analysis of the case studies identified a shift in teachers' beliefs about the usefulness of concept maps as an assessment tool. Although teachers had a theoretical understanding of the usefulness of the concept maps from the pre-unit interview, only three teachers reported that they found them useful in their own practice for assessment. Most teachers did not find concept maps helpful in assessment.

> I liked the changes that they (workshop leaders) 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. (Paki, post-Workshop 1 interview, 2004)

Seven of the 11 teachers specifically noted that, armed with the new knowledge of the workshop, they felt the concept maps would be more useful as an assessment tool.

> I had problems with the concept maps before because the children literally…just linked stuff together. There is no flow to it and you've got to be careful because you might miss how they connected something and that could be a bad thing if the child is connecting concepts that don't make any, you know, there's no connection….I think doing hierarchy will be very interesting to see. I think it will give more structure to what the kids are doing. (Parks, post Workshop 1 interview, 2004)

Despite the fact that there was no statistically significant difference between the teachers' knowledge of concept maps as assessment tools, the case study suggests a change in teachers' anticipated successful use of the concept maps for assessment. This is an example of teachers initially having a basic knowledge of an assessment tool, but not being able to apply it in their practice. By adapting/clarifying the teacher definition of concept mapping during the workshop, couched in a discussion about why this change is needed and the added value of improved assessment, the workshop changed teachers' belief about the usefulness of concept maps as an assessment strategy.

Workshops Influenced Teachers' Buy-in

Analysis of the case studies also brought forth the importance of the workshop convincing the teachers of the value of adopting a particular technique or adapting their existing practice to better reflect the technique being taught. The lead teacher, by supplying a rationale for the decision to adopt Novak's model of concept mapping and nesting the discussion around improved student learning and assessment worked towards convincing the teachers to "buy-in" to the instructional technique.

Impact of the first workshop. We interviewed nine of the 11 teachers about their learning from the first workshop (2 were unavailable for interview prior to the second workshop). Eight teachers reported being convinced to incorporate hierarchical maps into their instruction and anticipated improved student learning.

> I think they (students) need that kind of scaffolding. I know they'll need it the first time we do it. You know to help them kind of think it through, to say oh OK, that's what I can put in there. The connecting words I think will help them so that was really helpful to me. (Massel, post Workshop 1, 2004)

Peterson and Merritt; however, intentionally did not initially adopt linking words, maintaining their belief that linking words made concept maps too complicated and distracted students. Peterson believed prior to the workshop that linking words were too literacy dependent and negatively impacted the usefulness of concept mapping. Peterson was not available for interview after the first workshop and did not attend the concept mapping portion of the second workshop. However, based on the post-unit interview and class observation, neither the workshop, nor the practice changed her mind. Merritt initially thought linking words were too difficult, but the practice challenged this belief as discussed below.

Impact of the second workshop. Teachers had various reactions to their practice prior to the second workshop. Nine of the initial 11 teachers attended the second workshop, and seven of these teachers were available for interview. Six of these seven had started concept mapping prior to the second workshop. Of these six teachers, four of the teachers explicitly reported being disappointed with their students' initial concept maps and thought the second workshop gave them ideas on how to adapt their practice. Thus, their belief in the usefulness of concept maps and their own confidence expressed after the post-workshop 1 interview was challenged by the practice. After presenting the teachers with student work, instructional approaches to improve student work, and a means for evaluating this work during Workshop 2, these teachers reported having ideas about how to adapt their practice that maintained the integrity of the unit and they believed would result in improved student learning.

> I had the kids evaluate those concept maps(supplied by the lead teacher)…If they thought they were good or bad. And they were like really, I was thinking to myself, that they were really critical of, you know finding something wrong because the first thing they want to know was those other students work. And I say yes, they're from another school. And so they went through it, that doesn't make sense. So I was kind of surprised that they knew more than they would put on their paper. (Paki, post Workshop1 interview, 2004).

The workshop gave the teachers concrete examples of successful student work that gave them hope that their students could do the same. It also gave teachers tools for adapting their practice to assist students in creating concept maps that would live up to their expectations. Thus, by supplying teachers with instructional tools to adapt their practice combined with the support of other teachers, the teachers maintained or renewed their belief in the potential usefulness of the hierarchical approach to concept maps and regained a confidence for adapting their instruction that maintained the integrity of the unit.

Teachers' Learning Impacted Teachers' Enactment

Workshop 1's Impact

Workshop 1 included redefining concept mapping for the teachers. Although only two teachers mentioned the hierarchical approach to concept mapping in the pre-unit interview, and even these two admitted to using web-like maps, all teachers were observed having their students create hierarchical maps after the workshop. Eight of the eleven teachers included linking words. Two of the three teachers chose not to use linking words, even though they were aware of them. Only three teachers were observed using cross links, however this is not unexpected since during the workshop the lead teacher suggested putting cross links off until later in the unit. The workshops also supplied teachers with instructional practices to assist them in their teaching students how to create concept maps. We observed four different types of influences of the workshop on practices.

Teachers adopted a new instructional practice. Both teachers new to concept mapping defined concept maps as hierarchical with their students, although one of these teachers did not include linking words. One teacher was new to teaching and working towards his certification, and thus everything he taught was new. He did not demonstrate remembering linking words either in his practice or interviews. The second teacher, Anton, had over 20 years of science experience. Her practice better resembled the approach shared at the workshop, including multiple instructional approaches shared at the workshop.

Teachers adapted their practice to incorporate new ideas. Four teachers maintained their original practice, adapting it to meet the new criterion of hierarchy. One teacher had her students initially continue to use an instructional technique she had learned in another workshop (dog bones, discussed below). Teachers modeled creating concept maps as taught at the workshop, but also continued to use them as quiz questions and a way of taking notes. The fourth teacher modified the structure of the concept maps as she taught them to the students, but did not initially supply the list of linking words, as suggested at the workshop.

Teacher adapted practice to incorporate knowledge they had previously chosen not to use. Both teachers were convinced to modify their instruction to have the students create the hierarchical maps. One teacher specifically said the workshops supplied her with the rationale for making such a choice, and the tools to do it, which directly impacted her teaching.

Teachers did not adapt their practice when the ideas contradicted their previous beliefs and the workshop did not provide compelling evidence to change their minds. In two cases, teachers did not intentionally include linking words because they thought linking words made the maps too complicated for the students. The workshop focused on convincing teachers to make the shift to hierarchical maps, which both of these teachers did. However, the workshops failed

to initially challenge their belief about linking words. (Note: One teacher changed her mind after practice, discussed below).

Workshop 2's Impact

Teachers learned how to adapt their practice, maintaining the integrity of the unit. The second workshop was informed by student work and teacher experience. The second workshop gave the teachers information about how to adapt their practice, maintaining the integrity of the unit, and gave the teachers more confidence in the approach and anticipated student work. Most teachers attributed this workshop with supplying them with information for adapting their practice. Parks, who was disappointed with her first attempt to adapt her practice, discussed below, specifically found examining the student work helpful.

> I like those three examples (of student work) that she (the lead teacher) gave us. And as a matter of fact what I did the next day I said you know maybe what we just need to be a little bit more focused because I had said I was going to follow it through until it was done. And I went in there and I put a very simple hierarchical concept map on the board, with no linking words and just disease and I said now you all decide what words you want to use and everything and lets see if we can't really get something very specific, you know down here but as you move up its very general…. And I would say for the most part they were able to handle that. So I know that they can do it. Its just that I have to find a better way of teaching it because I did use the dog bones and it was harder for them to do because there were other things that they had to do with the dog bones. (Parks, post Workshop 2 interview, 2004)

Paki was also disappointed with her first enactment. The sharing of experiences and student work at the second workshop reinvigorated Paki and gave her explicit ideas how to address some of her dissatisfaction, including tips for peer assessment and rubrics for assessment, which she then incorporated into her practice.

> 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 (Paki, post Workshop 2 interview, 2004).

Thus the focus of the second workshop was on building on teachers' instructional knowledge of concept maps since, at this point, most teachers had a working definition of concept maps that aligned with the unit. This analysis suggests the following three conclusions. Change in knowledge and sense of preparedness from the workshop impacts teachers' behavior. Practice can inform the next workshop. Workshops can influence teachers' modification in their instructional practice such that these modifications meet the needs of their students while maintaining the intent of the curriculum unit.

Teachers' Enactment Influenced Student Response

All teachers but one adapted or adopted a practice that explained to students a structure of concept maps that included hierarchy. The resulting student work can be broken into four categories. (1) Teachers adopted what was taught at the workshops with mixed results. (2) Teachers adapted their practice to align with what was taught at the workshop, resulting in

positive results. (3) Teachers adapted their practice without positive results. (4) Teachers adapted what was taught at the workshop to align with their pre-existing beliefs.

Teachers Adopted Workshop Approach

Anton had never used concept maps and presented the characteristics of concept maps, without cross links, modeled creating a map using a common term, and then had the students go through the same process to make a concept map from a reading. Anton's emphasis on hierarchy paid off with her students, all but 2 creating maps hierarchical in nature. Just less than half included linking words (rating of 4 or 5) (16/33). In addition, some students incorporated cross links on their own into the maps. Anton did not initially supply her students with a list of linking words, but later incorporated the list into her instruction. An example of the concept map that included cross links is in Figure 2.
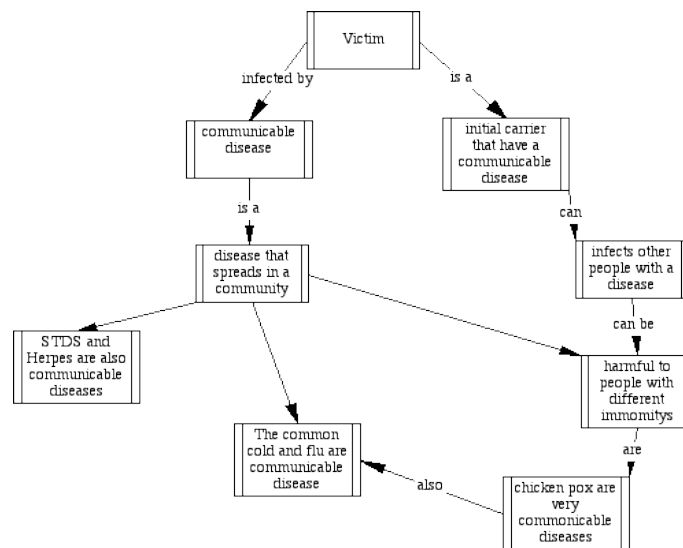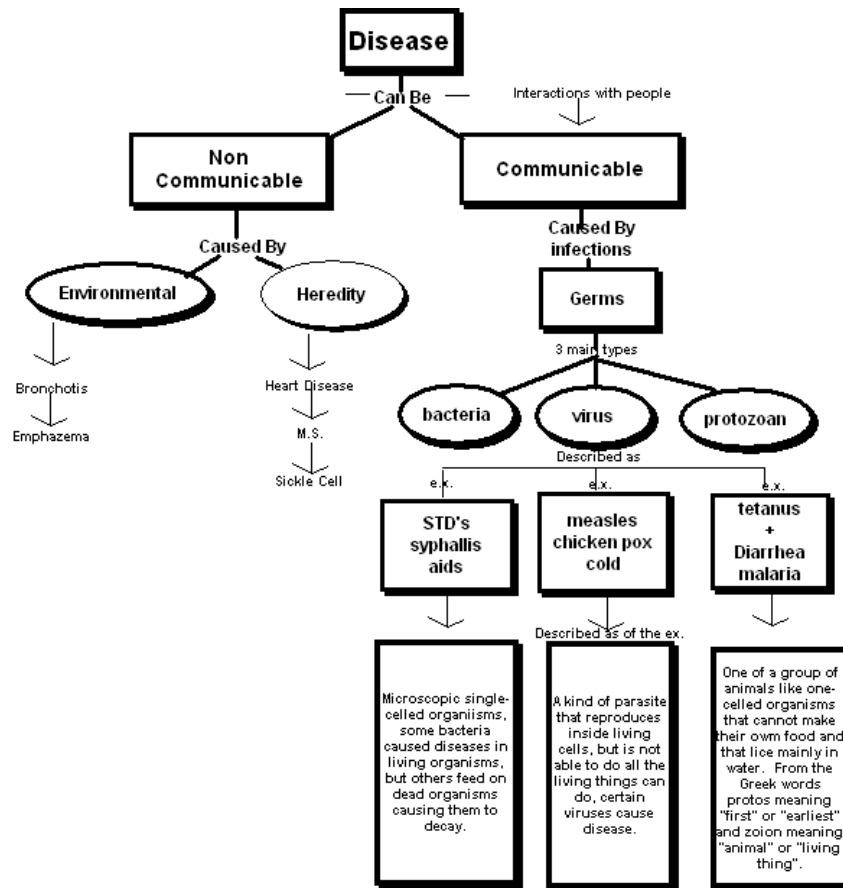

Figure 2. Re-creation of student concept map with hierarchy, linking words and cross links – Anton

Teachers Adapted Practice to Align with Workshop with Improved Student Response

Four teachers adapted their practice. Sahleh and Murray both incorporated the concept maps as intended by the unit, but also included them on their quizzes as they had done in the past. One example is Moody, who said students called her the queen of concept maps, had strong beliefs about using concept maps as creative outlets for organizing students' ideas. She only supplied 7 concept maps since she had the students work in groups and only had one class. None of the groups included cross links on their final maps since they were not required. All of the groups created hierarchical maps, and 5 of the 7 included linking words. In addition to the hierarchy and linking words, the resulting group concept maps were elaborate posters of multiple colors, incorporating Moody's previous instructional practices to meet the needs of the unit (see Figure 3 for example) while maintaining an important belief about the usefulness of concept maps expressed by Moody in the pre-unit interview – allowing the students to express themselves artistically.

Figure 3. Re-creation of group concept map with hierarchy and linking words – Moody
Note: the actual map was in different color markers, text and boxes on a large poster size piece of paper

Teachers Adapted Practice to Align with Workshop but did not Result in Improved Student Response

Two teachers adapted their practice, but their students did not seem to initially adapt their approach to concept mapping. For example, Parks introduced the students to the concept of hierarchy by modeling and direct instruction, but did not do the examples as other teachers since these students had been creating concept maps for the unit she was piloting and the initial enactment for the Communicable Disease Unit was not an introduction. Parks had the students try to incorporate hierarchy into the "dog bone"[4] method they had been using. The students continued to make the maps as they had in the past, resulting in webs with linking words rather than as presented by the teacher with only 1 of the 15 students incorporating hierarchy. Unfortunately the "dog bones" did not lend themselves to hierarchical structures (See Figure 4).

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[4] Students were given "dog bone" shaped pieces of paper, wrote concepts on each end and the linking word on the middle. They then overlapped common concepts on the end of the bone to create a "map".
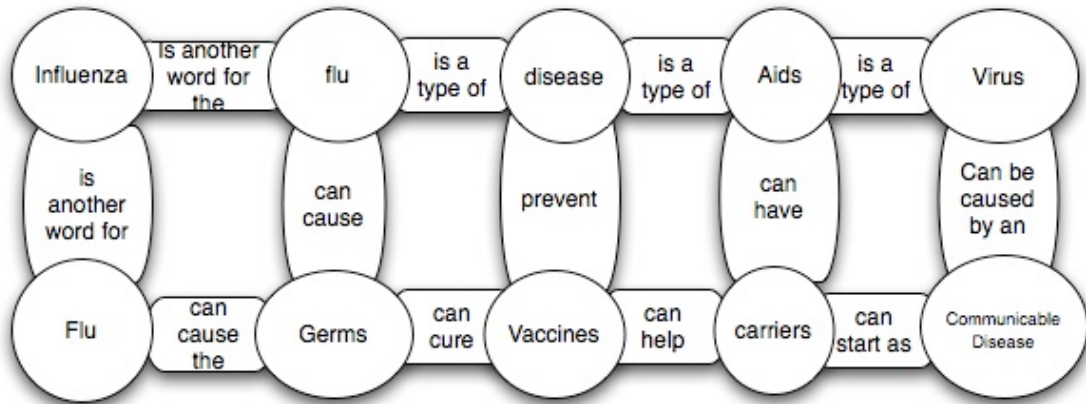
Figure 4. Re-creation of student concept map using the "dog bone" technique –Parks.

Teachers Adapted what was Learned at Workshop to Align with Beliefs

As discussed above, two teachers intentionally did not include linking words because they believed linking words made things more difficult for the students. In the first case, Merritt, all of her students created maps that were hierarchical without linking words or cross links, but she later regretted this decision, discussed below. Peterson, like Merritt, adapted her instruction to incorporate hierarchical structured maps without linking words because of her pre-existing belief based on years of experience with concept maps. Most of the 23 students' maps included hierarchy, but no cross links or linking words, not surprising since these were not included in the lesson. The types of maps created by the students separated the characteristics of disease into types, causes and treatments based on class discussions from the previous day (see Figure 5)
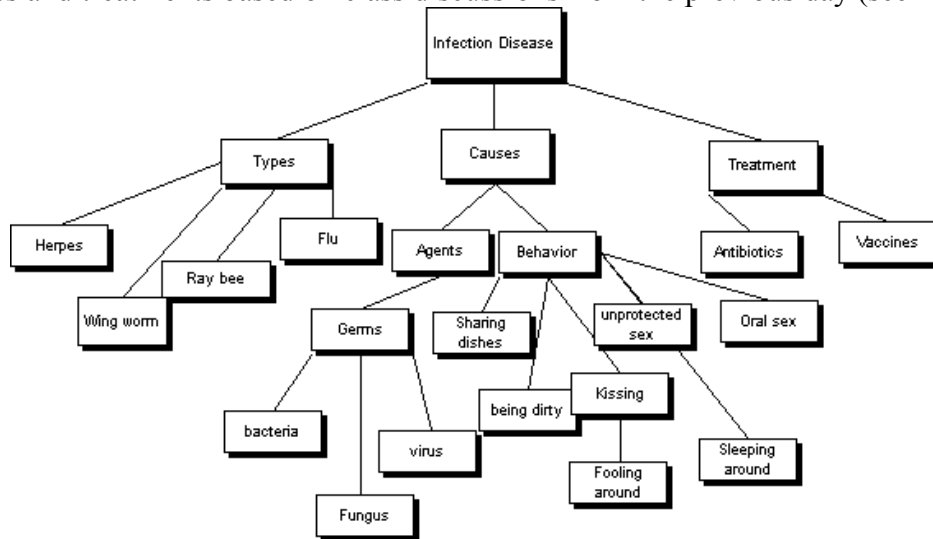
Figure 5. Re-creation of student's concept map with hierarchy but no linking words –Peterson.

Students' Response Impacted Teachers' Learning

Student response either positively reinforced practice or challenged teachers' beliefs about their use of concept maps in the classroom, both from a student learning perspective as well as an assessment perspective.

Student Response had Negative Impact on Teacher Learning

Four (Paki, Spencer, Merritt, Parks and Peterson) reported they were dissatisfied with the result of their initial attempt at concept mapping for the unit, although two of these teachers later reported satisfactions with adaptations. Paki, Spencer and Parks were disappointed in the students' initial concept maps. Although most of Paki's students attempted to incorporate hierarchy, most did not include linking words. She did not initially give the students the list of linking words, and upon reflection, decided she should post them, and did. The second workshop also gave her both the motivation to continue with the hierarchical maps, as well as the tools for adapting her practice to meet the needs she felt the students demonstrated through their work. Parks, too, was disappointed in her students' work. She realized, when the students continued to use the "dog bone" approach, and were not incorporating hierarchy, that she needed to completely adapt both her practice as well as the students' understanding of creating concept maps. The second workshop, too, gave her the tools to make these adaptations. She felt more satisfied with the students' work, but thought next year she would start the students off doing concept maps in the hierarchical fashion at the beginning of the year so the she could spend less time on teaching structure and more time on content. Spencer felt the students were not creating quality concept maps and was not sure how to address the issue.

> I wish that, like (the lead teacher) said she's done a lot in general topic and I've been trying to figure out how to do that but I honestly can't think of a question that wouldn't like drive my students into like a spiraling pit of despair because they wouldn't have any idea what I meant. (Spencer, post Workshop 2 interview, 2004)

The second workshop supplied her with information that allowed her to adapt her practice although she would have liked more specifics. The resulting practice informed by the second workshop left Spencer feeling that the student work improved, but she realized she needed to incorporate concept maps more frequently in the future to get the true advantage of concept mapping both from a student learning as well as an assessment standpoint.

Merritt, on the other hand, was initially satisfied with the students' work, but when she revisited concept maps with the students, she was disappointed that they did not remember how to create them. After the second workshop she questioned her choice to leave linking words out.

> I guess maybe, maybe the linking words would help because, you know I didn't really do the linking words in there. So maybe that would help but, I don't know because they're not even getting the idea of where to draw the lines anymore. (Merritt, post Workshop 2 interview, 2004).

She, too, adapted her practice and reported being more satisfied with her students' work.

In each case the teachers initially reported believing in incorporating the hierarchical concept maps from the workshop (with the exception of linking words for Merritt), but ended up being disappointed in their initial attempt. They were motivated to adapt, and the second

workshop influenced these adaptations.   In the case of Paki, Parks, Spencer and Merritt, the second workshop acted as mediating factor influencing their adaptations.

Peterson, on the other hand did not attend the concept mapping portion of the second workshop because she was also attending the 8th grade workshop at the same time. She, too, was disappointed in her students' maps.

> 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 can 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, there was only, we only did it twice. (Peterson, post-unit interview, 2004).

Rather than challenge her beliefs about not using linking words, it confirmed her beliefs that concept maps were difficult to create for the students, and they needed more help.

> 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. (Peterson, post-unit interview, 2004)

Despite her disappointment, she maintained her belief that adopting a hierarchical approach to concept mapping is useful and planned to continue to incorporate this characteristic. She did not plan on incorporating linking words.

In Peterson's case, the first workshop successfully convinced her to modify her concept mapping instruction to include hierarchy, but did not convince her in include linking words since she made the strategic decision not to include them based on her own experience. Dissatisfaction with her initial instruction did not challenge either of these beliefs, but motivated her to anticipate adapting her practice to include opportunity for more individualized instruction.

Student Response had Positive Impact on Teacher Learning

Eight teachers reported being satisfied with their students' work at the end of the unit, sharing that they felt the concept maps allowed them to assess students' knowledge and allowed students to organize their ideas. Teachers reported adding additional maps as a quick measure of what students learned, often as bell work[5]. Over all, at the end of the unit, all of the teachers saw value in using hierarchical concept maps, with all but one eventually having a positive experience with the enactment. Spencer, Paki, Merritt, and Parks each reported more satisfaction with their students' work after their adaptations from the second workshop, as stated above.   The success in the creation of concept maps or the belief in the anticipated success with adaptations based on the experience of practice using concept maps themselves influences teachers' instruction and planning for future instruction using concept maps.

In addition, teachers reported that they used the concept maps as direct measures of what the students were taking away from their instruction, to inform the content of their following

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[5] Activities students do at the beginning of class as the teacher takes attendance and attends to other classroom management duties.

enactment. Anton reported that she used concept maps to identify the misconception students might have and used this information to inform her future instruction.

> Well, you know looking at them I can tell where there thinking is and I can tell you know what they've learned and if what they learned is in order. I may need to go back and maybe correct some misconceptions. I was looking over them and some of them had diseases like cancer as a communicable disease instead of a non-communicable. And so right there I can zero in and I know they're thinking that this is something about … and I do come back and correct. You know I made a general announcement that arthritis and cancer are not communicable diseases. And I saw that, I saw several people that had them and I, you know I'm thinking that OK if several people have this misconception that's something I need to address. (Anton, Post-unit interview, 2004).

Parks used the maps to identify variations between classes, to determine if she was successfully covering the same material in each class.

> I would lay them (concept maps), you know the different classes side by side and I could see that I was teaching with different emphasis. And it was like OK well you know what you forgot to, to really put a hammer on that and even sometimes they (students) would look at me and say you didn't and I was like OK what happened was that on one of those days when we had an interruption…(Concept maps) helped me because, like I said, when I realized that there were certain topics that I was not hitting equally and only one did it I went back and re-taught that lesson. (Parks, post-unit interview, 2004)

Both Parks and Anton use the students' work product (concept maps) to measure their instruction and inform their planning and later instruction.

The practice, informed by the student work, influenced teachers' beliefs and the application of their knowledge in future instruction in two ways. First, the practice challenged or reinforced the teachers teaching of concept mapping itself. When challenged, teachers adapted their practice, often informed by workshops. Second, the students' concept maps were used as an indirect measure of what students learned, or knew, which ultimately informed teachers future instruction by guiding the content they planned to cover.

Professional Development Design

Based on the above analysis we have identified key components of professional development for long-term curriculum aligned professional development designed to maintain systemic change. Professional development needs to instruct the teachers on the content of what they are doing and emphasize the advantages of including what they are learning in their practice. Some might suggest that this is simply attending to teacher buy-in, but providing teachers with the rationale also gives teachers motivation for adopting what they learned and/or adapting what teachers know (Richardson, 2000; Turnbull, 2002). Adding to existing knowledge that expands on what they have taught in the past proved less problematic in this study than changing an existing negative belief about the efficacy of a particular component of instruction. The initial instruction needs to both address those who are learning something for the first time as well as those with experience, including opportunity for peer exchange or other activities to foster a sense of confidence in the teachers' ability to teach and necessity to apply what they are learning. Peer exchange also contributes to the creation of a community of learners (Borko, 2004; Lave & Wenger, 1991) as well as giving teachers an informal opportunity to reflect

(Schön, 1983), both critical components for creating optimal professional development (Richardson, 2000). The public reflection also allows novice teachers and experienced teachers alike to learn from others who share their classroom experiences, particularly when the other teachers are teaching the similar units in the same environments. The teachers doing the sharing also gain through this public act of reflection, reminding themselves of their own ideas and giving fresh insight into their experience (Kubitskey, Fishman, & Marx, 2003). Previous enactments shared through reflection also supply the lead teachers/professional development designers an impetus for incorporating practice and student learning into the professional development. In addition, professional development designers should also look to outward means of collecting such information, such as classroom observations, online discussion groups, reflective journals etc. Professional development, which justifies the reason for instructional shift while supplying teachers with the mechanism to make this shift, influences teachers' practice.
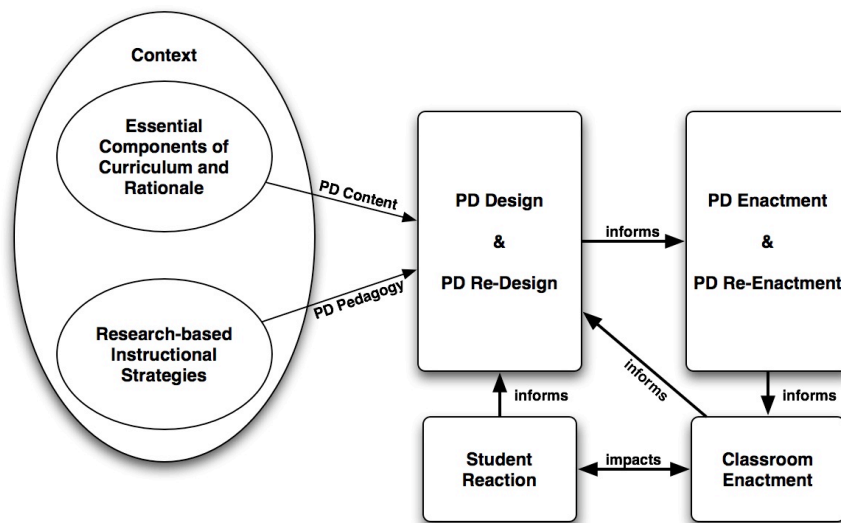
Figure 6. Professional Development Design Model

Combining these characteristics, we propose the following model for professional development design (see Figure 6). This model assumes long term professional development proximal to practice, with participating teachers teaching the same grade and same unit at the same time. The initial professional development is designed to inform the teacher of the content and pedagogy of the curriculum and gives a rational for incorporating this knowledge into their teaching utilizing instructional strategies characteristic of quality professional development (for example peer exchange, model teaching, and instructions on adaptations). The practice and resulting student work then inform the next professional development opportunity as a follow-up to the previous professional development's impact on practice. The means of incorporating enactment and student work into professional development proves problematic since collecting this information is often time consuming. One possible solution is to develop a formal means for peer exchange where teachers share their practices and student work in such a way that professional development designers have access to that information prior to the professional development itself. A less inclusive means is having lead teachers instructing the professional development share their own experience, relying on the spontaneous peer exchange to add variety. In any case, care must still be made to stress the adaptation issues, and not to focus on a

laundry list of activities to add to a given unit. Note that any given professional development opportunity probably contains both "new" information as well as reflective components from past instruction, informing teachers' immediate future while allowing them to reflect on the past in an organized, structured manner.

The advantage of this professional development design model is that it incorporates good strategies while being responsive to the teachers' needs at hand. The design encourages sharing and group reflection, while supplying feedback to the professional development designer. It is also flexible enough to meet the needs of the population it is intended to inform.

This model can create an environment of teacher *"buy-in"* incorporating good strategies and actual classroom enactments for validity, while intentionally addressing teachers beliefs by attending to their confidence. The nature of the reform, where the professional development supplied to a group of teachers teaching a common curriculum in similar contexts lends itself to the creations a *professional community of learners.* The communal reflective nature of the design also contributes to the creation of community. Assuming that the curriculum informing the professional development adopts science and pedagogy aligned with national standards, the chances of improving teacher *subject matter knowledge* and *pedagogy for science inquiry* increase by adopting good professional development strategies.

Future Study

This paper is limited in that it focused on non-subject matter content (e.g. the content knowledge of concept mapping and not science). Future studies need to include the study of professional development supporting teachers learning and implementation of subject matter in their classroom. In addition, studies should include an examination of the application of this model to professional development design to identify its strengths and weaknesses in practice. One of the useful aspects of this model is its ability to be utilized by practitioners, and is not dependant on formal researchers, resulting in a conundrum since formal research is necessary to test the veracity of this model. Finally, this research does not solve the ever popular – which came first, change in beliefs or change in knowledge? What is evident is that these are intertwined and both influence practice. What needs to be studied is the influence of professional development on practice when the professional development intentionally focuses on attending to teachers' beliefs and how this mediates implementation in classrooms in different settings. Teachers' confidence that emerged from this study suggested that professional development may influence teacher self-efficacy, but the self-efficacy may also impact the influence of professional development on teacher practice. Future research should also focus on these issues to better untangle the influence of professional development on teacher beliefs and knowledge, how these beliefs and knowledge influence teacher practice, and the ultimate impact of practice on this while cycle.

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