ABSTRACT
        This preliminary case study examined the knowledge
and beliefs one seventh grade science teacher to determine: (1) how
the teacher's knowledge and beliefs about teaching and learning
informed her thinking and actions; (2) what her conception of
teaching was; and (3) what were the constraints of the instructional
setting. Data was collected from three sources: classroom
observations conducted for 10 consecutive days, three interviews, and
a collection of student assignments. Analysis of the data provided a
teacher profile that included a description of: the teacher's role;
students' roles; the teacher's subject and pedagogical content
knowledge; constraints to implementing teaching consistent with
beliefs; the teacher's stage in Kaufman's teacher development
framework; and the teacher's view of the nature of science. Further
questions to supplement the study are raised, and limitations and
strengths of the present study are discussed. Contains 23 references.
(MDH)

How a Teacher's Beliefs and Knowledge Inform Practice

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Paper presented at the Annual Meeting of the

National Association for Research in Science Teaching

Atlanta, Georgia, April, 1993

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Introduction

The purpose of this study is to describe and interpret how the knowledge and beliefs of a teacher inform and shape the teaching process. I begin with an overall description of the knowledge and beliefs of the teacher as revealed through interviews and observation of classroom instruction. In this description I seek to give the reader a sense of the teacher's perceptions of her role as a teacher and the influences which have shaped those perceptions. I present a view of the classroom by analyzing the activities that take place there and identify the constraints of the instructional setting. Next, because it is often the nature of this type of study to discover questions more compelling than those with which the study began, I pose some directions that might be fruitfully followed for the next step (were this a full-fledged study).

Studies similar to the one proposed here have been conducted to determine the influence of teacher beliefs on the curriculum implementation process in science classrooms (Cronin-Jones, 1991) and the extent to which the nature of subject matter, more specifically the role of scientific theories, is a factor in the decision-making surrounding instruction (Duschl & Wright, 1989). It appears that most investigations of this type have been undertaken with a view toward understanding why curriculum implementation does not match curriculum design. My view is a little broader; I want to understand how to help teachers adopt best practices that fit within their own frameworks.

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In their description of the business of schools, Oakes and Lipton (1990) distinguish between training which prepares people to respond appropriately to events and needs, and sense-making, which enables people to construct individualized meanings and responses to their experiences. I purpose this research with the intent of applying constructivist epistemology to the teaching process. The goal of this research is to make sense, to understand why teachers do what they do. The current emphasis of cognitive theory on learning as a process of knowledge construction, which occurs as sensory data are given meaning in terms of prior knowledge, has the potential of helping teachers construct teaching models which embody research and pragmatic findings concerning best practice. Learning occurs by interpreting information, not by recording it, and is dependent upon the "intentions, self-monitoring, elaboration, and representational constructions of the individual learner" (Resnick, 1989, p.2). Unfortunately, many current practices which are common in classrooms such as drill, lecturing, seat work and content coverage may be the major determiners of how teachers and students construct their view of schooling and learning. In such a setting, as Brown and Campione (1990) suggest, the goal of schooling becomes getting the task completed rather than coming to understand. My view is that changing the concept of instruction from one which emphasizes training to one which emphasizes meaning-making must begin with teachers' conceptions of teaching and their beliefs about the learner. From there, it should be possible to help teachers identify changes, if any, that

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they would like to make and to facilitate making them in a manner that takes them from their existing conceptions to those they desire to embrace.

This is a preliminary study conducted to determine the feasibility of the method and identify its strengths and weaknesses. It was carried out in the classroom of a second-year middle school science teacher, Kim Taylor (name changed to ensure confidentiality), to answer the research questions outlined below.

Research Questions

1. How do Kim's knowledge and beliefs about teaching and learning inform her thinking and actions and what are the influences that have shaped her beliefs and knowledge?

2. What is her conception of teaching?

3. What are the constraints of the instructional setting?

Research Design

Kim was recommended by her principal and was willing to participate. She felt the project would require reflection on practice and would therefore be beneficial to her. She has taught earth science, physical science and life science, but observations were made only in one seventh grade life science class. Her degree is in molecular biology.

Data collection came from three sources. Classroom observations were conducted for ten consecutive days. Fieldnotes were taken in class and were expanded either immediately after class or at least before the end of the day. Preliminary analysis was conducted immediately by searching for assertions to explain

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classroom behaviors. Assertions were listed along with confirming and disconfirming evidence using the method suggested by Erickson (1986).

Three interviews were conducted to allow Kim to express her beliefs and explain her philosophy. The first interview was conducted after the fourth observation, the second interview followed the ninth observation and the last interview took place after the observations had been completed. Questions were of three general types. There were questions which were very open-ended such as: What are three things you most enjoy about your career? Some questions were based on teaching episodes and were therefore very specific to gain an understanding of particular incidents or practices. Here is an example of that type of question: Sometimes when a student doesn't know the answer to a question, you'll ask for help; you'll say, "Can someone else help?" And then after they help, you'll return to the first person with the next problem that is similar. Could you tell me about that? The third category of questions were structured questions specifically designed to follow the model suggested by Spradley (1980). The questions included descriptive, structural and contrast formats. For example, a series of questions used to gain an understanding of her rationale about what to include in a unit contains the following series of questions. The descriptive question: Describe how you put a unit together. The structural question: What are the key components of every unit? The contrast question: How do you decide what to put in and what to leave out? Sometimes these questions are separated

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by others which seek clarification of the answers she has given. The interviews were audio-taped and transcribed. The first interview was not conducted until after four hours of classroom observation, so it was interesting to see if certain assertions about beliefs were confirmed by Kim's description of herself.

The final data source was a collection of the student handouts including a problem set, a review sheet, lab instructions and a test, as well as the instructions that had been written on the overhead and on the board.

The class was made up of 12 girls and 8 boys with an additional girl joining the class starting on the fourth day of observations. The class met the last hour of the school day. Kim told me it was her smallest class.

Case Study

In a study of the preparation of middle school teachers to teach mathematics, Borko, Eisenhart, Brown, Underhill, Jones and Agard (1991) provided a diagram of a conceptual framework which depicts the interactions of the influences of various factors related to the teaching of mathematics. The factors include: the individual participant's knowledge and beliefs, the individual's classroom thinking and actions, university experience, public school experience, personal history and the research project itself. My broad description of Kim is based on this framework.

The teacher's role

When asked about her role, Kim characterized herself as a facilitator who is interested in supporting the learning process:

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I've always wanted to be more of a facilitator, than a dominator. And as I've taught, I've realized that sometimes that's not possible...sometimes you really need to clamp down on what's going on, so that you're preserving a good environment for everybody to learn in. I do see myself as a person who helps them with the information. I do a lot of questioning of things. I try to bring concepts out of them as opposed to feeding them concepts. So, I want most of the learning to go on in them, as opposed to me dumping things on them. (First interview, p.1)

She identified two origins for this philosophy. In her own schooling she felt the teachers who were most successful were those that used the Socratic method of questioning. Her university experience suggested that students should not be viewed as empty receptacles.

Her methods of instruction are congruent with this belief. In this section I examine her beliefs about the varied roles of the teacher as question poser, classroom manager, evaluator, diagnostician, planner and parent liaison and connect them to the practices that best exemplify the belief.

Lab activities are planned to 'bring concepts out of them' as characterized by the following purpose listed for the students on the overhead: "To figure out, using the materials provided, two different, efficient methods for determining the number of popcorn kernels in your cup" (Fieldnotes, p. 8). The whole group discussion following this activity illustrates her common use of questions seeking understanding rather than questions seeking single right answers as exemplified by the following exchange:

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Kim:  What does the popcorn lab have to do with ecology?
S1:   To figure the population in one area.
S2:   Like the graph paper we did.
Kim:  Why would we want to know, need to count?
S3:   To see if the animals are endangered.
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S4: To tell if they are over-populated or destroying habitat, like deer over-grazing. To make sure other animals aren't harmed by a large deer population.
Kim: They could use the information to determine how many hunting licenses to issue.
S5: How do they know when an animal is endangered? (reconstructed from Fieldnotes, p. 34, 36)

In the introductory quote where Kim talks of her desire to be a facilitator, she mentions the need to preserve an environment for learning. I asked her how she sets the tone at the beginning of the year:

> I set the tone by stating some ground rules. And I think they're respectful ground rules, of the kids and of me. I don't say much about, there's no hitting, no pushing, none of that. I just say, you have to respect me and I have to respect you, so I hope that goes back to me not being such an authoritarian. And also my tardy policy...I just say, it's impossible for me to always be on time, so I can't expect it from the kids. The thing to do, if you are an adult and you are tardy, is just walk in quietly and don't make a big deal about it. And so I try to emphasize that with the kids. If your tardies get to be a problem, then we'll deal with it. But if you're tardy a couple of times, and you're quiet and don't come in and talk to people and be disruptive along the way, then I can overlook it. Because that's a mature thing to do. My rules are kind of like that, and so they kind of make the kids responsible for their actions. (First interview, p. 12)

One of the first assertions that I made was that Kim does not allow interruptions to interfere with instruction. Some of her methods for preserving the learning environment include: beginning instruction immediately, taking care of administrative matters only after students are engaged in a task and ignoring student diversions. While students are generally on task the environment is also playful. She takes advantage of student humor for a good laugh and even introduces some humor herself. One day when the discussion was centered around which methods of estimating

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population size fit which organisms, a discussion between students developed over whether fishing worms were sold by the container or by weight. Kim produced a jar full of little pink things for all to see and proclaimed that she had gotten them from a vet; they were worms from a dog's stomach. Students queried: "Are they alive?" "Are they all from one dog?" She smiled and told them it was actually ramen noodles that she had colored, but wouldn't it be difficult to count all of those? The students agreed, but thought she should push the joke further. They said: "You shouldn't tell your other classes they are noodles and open the jar and start eating them." We all had a hearty laugh and a few disdainful sighs before the lesson went on.

Another part of her role is assessment which includes grading papers, entering grades into the computer and diagnosing student progress. She believes that papers should be graded and returned quickly if the feedback is to be meaningful. However, time is a constraining factor. In practice, she has developed some techniques that reduce the load such as grading only one out of three questions at random from the set. The computer printout allows her to survey how students are doing and also how everyone did on a particular assignment. She says she tends to grade harshly, so reflecting on the grading on a particular assignment gives her information about how to grade in the future.

Testing is done frequently to provide students with information about how they are progressing:

> I see the short term evaluations as really helping them to see
> how much they've retained, monitoring their progress more

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frequently, as opposed to here, it's the end. And, Oh, they don't know anything. So, if you can monitor their progress along the way then they haven't missed out on everything for the rest of the unit. You can have a little intervention and possibly help them with understanding on whatever they need to. (First interview, p.7)

While the students were working in small groups solving the problem introduced earlier about finding efficient ways to count corn kernels, Kim was moving from table to table watching what students were doing and monitoring their work. After the students had completed making their estimates, describing their methods and comparing their methods with those of classmates; Kim provided a concise overview of methods for estimating populations. Her ability to diagnose student difficulties was revealed in the way the methods were presented. For example, she asked, "Is it efficient to mass only one?" Many students had tried to determine the mass or volume of a single kernel of corn. Some students had determined the number of kernels in 25 ml, but then multiplied that number by 100 to determine the number of kernels in 100 ml. She helped them reason how to solve the problem in one way and accepted an alternative solution from a student. Her presentation made it clear that she was aware of the difficulties students had encountered and she helped them identify and address them.

Her belief in developing independent learners extends to evaluation. I saw a form from the previous unit being returned and asked Kim about it. It was a self-evaluation form that students used to assess their own work. She evaluated their work as well, but her comments about the students' lack of experience in evaluation are interesting:

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They also did a student self-evaluation and that was kind of
funny because they didn't really know how to deal with it.
They could give themselves anywhere from 0 to 2 on 15 things.
And I asked them, "Did you have your materials every single
day?" If they had done that all the time, then they'd give
themselves a 2, if they never had them, they'd give themselves
a zero. At the end they graded themselves much more harshly
than I would. And I don't know what they were thinking
because I told them, "You're just going to grade yourself."
And then they turned their sheets in and I just wrote exactly
what they wrote on the grade book. And some of them, out of
30 points, some people would give themselves Ds and they'd
say, "Why did I get such a bad grade?" And, I'd say, "You
gave it to yourself and that's what you got." For some reason
they were really upset by that. Like I didn't look at it
again and reward them for being honest. (Second interview, pp.
9-10)

Kim describes planning as taking place on three levels: unit
planning, weekly planning and daily planning. When planning a
unit:
I sit down and think about the major concepts I want to cover
during the next unit. And I do sort of, I'm a big one for
those schematic maps. So, I brainstorm on my ideas and make
little bubbles and connect them with lines and things like
that. And then I go through my files and other people's files
and I compile a list of resources...And I compile all that,
and then I go back through and sort of think about what would
fit where. And I usually like to plan week by week...in terms
of planning daily things to include a little flexibility.
(First interview, p.2)

When I asked her to identify the key components of a unit, she

identified a series of activities used to address a concept within

a unit. From what I have seen in her classroom that series works

in a cycle. The activities include an introduction to the concept,

some lab activities, discussion of applications, guided practice

and evaluation.

In practice the key components were carried out in the

following way. The first two days of the unit were conducted

before I began visiting the classroom. One of those days was spent

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watching a film, The Living Planet. From looking at the questions which accompanied the film (document 1), I assume that the film served as an introduction to the whole ecology unit as well as to the population concept. The other day was devoted to becoming familiar with terminology such as ecology, niche, habitat, community, population producer, consumer and scavenger. She began the first lesson I observed with a review of terminology which led into an introduction of Popcorn Lab A, referred to above with the purpose of determining methods of estimating population size. A class discussion followed the completion of the lab (day 3) which clarified the methods they had used and helped them determine appropriate populations for each method. This discussion was used to introduce the problem of what to do with mobile populations and was picked up again on day 4. Class discussion centered on how to determine the number of trout in a lake. Figure 1 displays a summary of the activities for days 1-3 and identifies the roles of teacher and student as well as skills addressed and the type of grouping. Its purpose is to show that Kim not only plans a variety of activities, but also integrates various skills into lessons and utilizes a variety of grouping arrangements. Figure 2 shows the activities carried out each day to demonstrate that she carried out the plan as she described it.

Another part of her role as a facilitator that is demonstrated in Figure 1 is her attention to the skills necessary to carry out the task. In the short time I observed her classroom, she reinforced writing skills, computational skills, graphing skills,

Figure 1. Kinds of Activities, Days 1-3.

Activity	Teacher role	Student role	Additional Skills	Group Size
Day 1				
Review of terminology (esp. factors influencing population size)	Asking questions	Answering questions		Whole class
Instructions for lab write-up	Asking and answering questions	Copying purpose	Writing in complete sentences	Whole class
Intro to Popcorn lab A	Modeling use of balance and graduate	Asking questions		Whole class
Estimating number of kernels	Roving, answering questions, making suggestions	Measuring Collecting data Discussing possible sol'n.	Multiplication, division, solving simple equations, use of calculator, use of units	Small group
Day 2				
Estimating number of kernels	Same	Same	Problem solving	Small group
Lab write-up	Same	Communication of sol'n.	Writing	Individual
Day 3				
Share solutions	Taking attendance	Discussion	Verbal explanations	Small group
Class discussion	Moderator	Generate solutions	Taking notes	Whole group; individual

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Figure 2. Schedule of Activities

Day 1

Teacher reviews terminology, especially factors influencing population size.

Teacher goes over instructions for lab, including expectations of complete write-up and review of what each part should contain.

Teacher models proper use of balance and graduated cylinder.

Students discuss how to go about solution of the problem, collect data, and figure out how to use balance and read it properly.

Day 2

Students continue collecting data. They calculate how many kernels of corn the cup contains and compare their answers of one method with another.

Students write out the materials and procedures they used. They also write up results.

Day 3

Students compare the methods used by their group to the methods used by other student groups.

Class discussion centers on why one would need to know population size.

Methods for estimating populations are elicited from the class. As the steps for a method are contributed, the teacher reveals the next step on the overhead. Students are taking notes to have concise statement of the methods used. Example problems are included.

Quiz of two problems, estimating number of organisms in prescribed area.

Day 4

Review of quiz solutions.

Class discussion centered on question: How would you estimate the number of trout in a lake?

Teacher introduces population census method; reviews how to solve equation.

Popcorn Lab B

Day 5

Data Collection

Students answer questions based on activity.

Day 6

Discussion of role of ants in the environment

The activity uses a graph to represent a map. Teacher reviews mapping and graphing skills.

Students do activity determining location and sizes of territories by plotting anthills on map.

Day 7

Students complete questions dealing with ant activity.

Students begin population estimation problems for review. Teacher introduces strategy to follow to solve the problems.

Day 8

Students complete review problems.

Students work on review of terms and lab techniques.

Day 9

Test

measuring skills, communication skills and note-taking skills in
addition to providing students with strategies for problem
solution. When discussing how the lab write-up will be assessed
she shared:

> I told them that it was important to me to see the format that
> time because they hadn't done a lab write-up for a while...
> Because I also think that the English skills and communication
> skills are neglected in science sometimes and they are very
> important... I'll also assess the creativity of their methods
> that they came up with. (First interview, pp.3-4)

The test required students to read a short article and respond to
questions about the population concepts in relation to the article.
She believes tests should be an extension of learning, giving
students the opportunity to show progress in developing skills in
reading and writing as well as demonstrating how the science
concepts they have learned can be applied to new situations (First
interview, p.4; Second interview, p. 3).

Kim also talked about daily lesson planning, but I will
address that in a later section to make a connection between her
view of planning and her view of science.

Finally, she talked about the necessity to keep the
communication lines with parents open. When asked to identify what
she would change about education, she replied that she would
involve families more. She said:

> So many parents have not got a clue about how their kids are
> doing in school or who their kids hang out with or what's
> going on with their kids. And, I find it really hard to
> combat those kinds of problems. If those are the things that
> are causing learning problems or success problems, then I just
> feel helpless. And I think that a school that really involved
> the parents with what is going on...that would be my ideal to
> get parents actually in the classroom working with the
> teachers to help their kids. (Third interview)

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She sums up her hopes for parental involvement by suggesting that she would like to see them be supportive of what kids do in school and supportive of teachers when they need to discipline.

Students' Roles

Kim discusses students' roles in terms of the expectations she holds for them:

> I expect that they turn all their assignments in. Not everybody does that, so we work on it, but I expect them to be responsible enough to do that. I expect them to participate fully in class, because as you've noticed I give hardly any homework. Even studying for this test, they had Friday to work through the review sheet and look through their labs, and so I really expect cooperation in class. I also expect positive attitudes, some real effort at learning. I expect organization, too. (Second interview, p.6)

Kim provides students with support to carry out the expectations. For example, class participation is fostered by providing students with a variety of learning activities and grouping arrangements (Figures 1 and 2). Cooperation is encouraged by her respect for students. She validates students in many ways including: encouraging politeness by using excuse me and thank you, informing students of changes in plans and providing accompanying rationale, accepting alternate solutions to problems, accepting student correction of a mathematical error, remembering who originated an idea and giving that person credit for it, and listening to a student explanation of why a grade should be changed. She also communicates standards through explicit directives such as turn to page 174, read and study it in total silence for one minute, starting now. Behavioral expectations include adherence to certain standards, but many of these are contextual. For example, she does

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not speak until she has the floor. However, students are free to
talk to one another when doing group work and I found that their
conversations were on task most of the time.

Kim helps students with organization by providing them with
various types of structure including: daily schedules, problem
solving strategies and a lab write-up format. However, her press
for understanding goes beyond recipes for learning. A common
question posed to students is: What's a useful thing to do?

Knowledge

Background

Shulman (1986) describes three categories of content knowledge
important to the development of knowledge for teachers. Subject
matter content knowledge includes understanding the facts and
concepts of a discipline as well as the methods and rules that
guide study. Shulman uses Schwab's distinction of substantive and
syntactic structures. "The substantive structures are the variety
of ways in which the basic concepts and principles of the
discipline are organized to incorporate its facts. The syntactic
structure of a discipline is the set of ways in which truth or
falsehood, validity or invalidity, are established" (p. 9). The
second category, pedagogical content knowledge, includes the
influence of prior knowledge on students' learning and
understandings of what makes certain topics difficult to learn. He
includes "for the most regularly taught topics in one's subject
area, the most useful forms of representation of those ideas, the
most powerful analogies, illustrations, examples, explanations, and

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demonstrations-in a word, the ways of representing and formulating the subject to make it comprehensible to others" (p. 9). The final category, curricular knowledge, consists of knowledge of the alternatives available within the discipline. It also includes knowledge of connections that can be made laterally with other subjects being studied at the same time, and knowledge of vertical connections within the subject area between past and future topics.

Kim's Knowledge Base

Several factors have contributed to Kim's strong knowledge base. First, with a degree in molecular biology, she recognizes that she has a strength in an area of biology not shared by many other teachers. As part of her undergraduate experience she worked in a lab on campus for two years on an independent study project. She was around graduate students and the principal investigator and got a feel for how research is carried out. Her course work has provided an understanding of the facts and concepts and her practical experience has provided a knowledge about how science is carried out. Her strong background stems from an original goal to become a scientist with a grade point average so high that friends encouraged her to go to an Ivy League School. She discovered, however, that there was not enough interaction in research and that she needed a broader field of study than what is offered by a single research problem pursued for several years.

She credits her colleagues for helping her with curricular and pedagogical content knowledge:

> In terms of my curriculum in life science it really comes from
> Ron. Because he's another person who's been teaching this for

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a long time. And I make modifications, but last year when I was forming a base for myself, I just sort of followed him. Because these guys are master teachers. They have all taught for a long time in the district. And they are all very creative people and I just have a lot of respect for everything they have done. The things they have done are tried and tested, but they are also open to new things and are always adding new labs. So my base is what they've given me and then I branch off sort of from there. (First interview. p. 9)

From the first lesson there was strong evidence that Kim believed in helping students make connections. She referenced former units; for example, when explaining a niche, she asked: "What does an adaptation have to do with a niche?" They had studied adaptations in the previous unit. She referenced another unit to offer an analogy. She reviewed the relationships among cells, tissues, organs and the body and likened their organization to that found among populations, communities and ecosystems. Another technique was to apply the concept to the immediate context of the classroom or the state with questions such as: What is the population of humans in our classroom? What kinds of populations will we find in Colorado?

She presses for understanding in other ways as well: by making her rationale in thinking about a problem explicit, moving from examples to generalizations and establishing connections between terms.

Constraints

After reading several other case studies (Brickhouse & Bodner, 1992; Cronin-Jones, 1991; Duschl & Wright, 1989; Tobin, Kahle & Fraser, 1990), I expected to find constraints implied as logical reasons for inability to accomplish teaching according to beliefs.

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Kim can identify several factors she would like to change, but they were alluded to in answer to a direct question about constraints, rather than being used as reasons hindering accomplishment.

She mentioned how financial constraints limit planning time and mandate larger classes. She believes that there are no mechanisms for communication between the various levels of schooling in the district causing a difficulty in planning curriculum. She has a textbook which doesn't fit her style, but it doesn't constrain her very much because she only uses it occasionally when it fits her purposes.

On the other hand Kim spontaneously identified supports. It was this proclivity which caused me to ask the following more focused question: Do the settings in which Kim works influence her capability to mature so rapidly? I provide only the beginning of an answer, but the question might be pursued in a longer term study.

Stage Theory

Background

Personality theory assumes that an individual's behavior and response to change can be explained by unique characteristics of the individual (Spector, 1989). Several studies done on the developmental stages of teachers (Katz, 1972; Huberman, 1989; Spector, 1989) suggest that they progress through similar developmental concerns. In the first stage often referred to as survival, the teacher is absorbed with self-adequacy and subject-matter adequacy. The teacher is in greatest need of understanding,

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direct support and guidance at this time. The second stage, referred to variously as consolidation, stabilization and adjustment is characterized by learning to cope with the school situation and school expectations. Teachers in this stage can still benefit from on-site help and may be more able to contribute in a collaborative setting. The third stage is characterized by maturation, with ventures into renewal through experimentation or activism. Teachers at this stage benefit greatly from attending conferences, joining professional associations, reading journals, and participation at teacher centers. If growth continues, the next stage is one of leadership. Teacher growth may take the form of providing inservice, participation in degree programs and continuing with the professional commitments of the previous stage. Teachers do not progress through the stages at a uniform rate; indeed some do not reach the higher levels. An understanding of the stages of teachers' growth provides a framework for the development of realistic expectations for staff developers to use as they help teachers met their needs and address their concerns.

Kaufman (1988) describes a similar view of teacher development as being influenced by three concentric spheres of context. The student is in the center circle. The student-teacher relationship defines the central goals of the practice of teaching. Working within this circle, the teacher is acquiring the tools of classroom management, mastering the curriculum, and perfecting instructional skills. The next wider circle is the circle which contains colleagues. Working within this circle the teacher is translating

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what she knows as a reflective practitioner so that it can be used by peers. Such translation may take the form of peer coaching or problem solving. Without a collegially based organizational culture, such interactions may not occur. The final circle is that of the profession. Within this circle the teacher is involved in professional organizations and constructing knowledge through action research. Most schools provide support for the teacher to learn in the student-centered context. Kaufman suggests using the differentiated contexts of student, colleague, and profession to develop a staff development program for the support of the professional development of all teachers.

Kim's Roles beyond her Classroom

In addition to the teacher-learner relationships in her classroom, Kim is active in extra-curricular activities coaching debate and sponsoring the flag girls. As part of the collegial relationship within her department, she serves as department chairman, although she assures me that this is a shared task. In the professional circle, she has developed molecular biology labs which she shares with teachers in seminars conducted at the district and state level. She has been invited to present at a national conference next year (Figure 3). How is it that a second year teacher has advanced so far beyond expectations? I did not submit this question to Kim, but she told me of many supports in her spheres of context. The university research group still provides support by encouraging her use of molecular biology labs and helping her obtain needed materials. She also has obtained a

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Kim's Roles

District, State, Nation

Department

Extra-Curricular

Classroom
Teacher-Learner
Facilitator
- Question Poser
- Diagnostician
- Evaluator
- Classroom Manager
- Planner
- Parental Liaison

high school activities

Collegial
- share curriculum idea
- make decisions regarding
  implementation of middle
  school science
- attend department chair
  meetings

Professional
- developed molecular
  biology labs
- conducted seminars
  to share with other
  teachers

grant which supports her work as a presenter at seminars. Her colleagues provide classroom support with curricular materials and ideas as I mentioned earlier. I have identified other supports and constraints which are listed in the appendix. My point here is to indicate that I think it would be useful to pursue how some teachers are able to respond to needs beyond their classroom much more quickly than others.

Another questio   interest generated by the data, is: What are the ways in which her beliefs in the importance of instruction and the importance of responsible behavior interact? I have collected data that could be used to partially address this question, but I have not yet analyzed it.

Nature of Science

Finally, I would like to suggest one more possible avenue. As I considered Kim's view of the nature of science, the parallels between her description of science and her descriptions of teaching and learning were striking. In fact, since she had already shared her views on lesson planning with me in an earlier interview, she used that process as a metaphor to explain the scientific method. I have extended that metaphor in the following realistic vignette in an attempt to gain an understanding of how her conceptions of science influence her conceptions of the processes of teaching and learning. The words are nearly entirely hers, but I have interpreted them by rearranging them in new ways. She has read this case and did not ask me to reconsider any portions of it.

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'A Mixture of Logic and Art'

I think science is the whole process of asking questions and then figuring out how to answer them; learning how to approach a problem. It includes experimentation, but it goes beyond experimentation; it's a way of thinking. Science begins as a systematic process with the scientific method which provides a plan for addressing everything. You have to learn how to think about things before you can branch off and be a little more creative. Experiments can be an elegant mixture of art and logic.

Science is driven by the need to know why, but teaching is so attractive to me because I'm always involved in learning new things. I'm surrounded by creative people and I have tremendous respect for their work. Their ideas are tried and tested and yet they are open to new ideas. Another parallel is the Socratic method of questioning that I use. I like to ask questions that will clarify or that will get students to think in another direction. I could also compare the methods of science to the methods of teaching. For example, during my first year the Hunter model served as my method for teaching. It formed the framework for my lesson plans which I typed out every day. I'd start out with my overview and then I'd think about what materials I needed for the day and the appropriateness of activities for my grade level. I'd consider how much time it would take, think about an anticipatory set and so on. Lesson planning had to be a rigorous thing, until I taught my mind how to do it. Now, I'm able to deviate a little.

In fact, I also use the same model with my students. Sometimes I say to the kids, you know when I do my lesson plans, I always have a system and it's like a write-up. Even if sometimes you don't think one part is as important as the rest, you can still use it. It's a format that you work in and so it helps you think through all the parts. I hope I've trained them to think in a disciplined manner about how to attack the problems. In this unit we've dealt with the pattern of doing problems and I've provided them with a model for thinking about population problems. They can be a little imaginative and apply what they have learned about sampling popcorn to other populations. I can ask: What other things do you think this could be? This is a model, but what does it remind you of and how could you use it? When I grade their written work, I'll be looking for their ability to communicate their ideas, but I'll also assess the creativity of the methods they came up with to solve the problem. By the time we get to the test, I expect that they will have internalized the concept to the point that they can show me how it can be applied.

I think that there has been a lot of squawking lately about the lack of basic knowledge that kids have. There is so much in biology that you could cover; you could make a case for the importance of teaching it. But I'm more interested in whether or not they can think through a problem. Sure they need content, but if they have the processes, then they can figure out the missing content for themselves. I don't agree with people who say there is a basic amount of information that kids should have.

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As I began to think about the new question I had posed about the ways in which Kim's conception of science informs her teaching, I realized I needed more information to extend this line of thinking further. For example: Does Kim adopt a realistic view of science that accepts scientific knowledge as true, "existing independently of personal experience," or an "instrumentalist view that emphasizes the practical utility of scientific explanations?" (Lederman, 1992, p. 348). I would presume from the way she teaches that she is an instrumentalist, but that is only conjecture. However, I felt compelled to report as much as I know because Lederman provides a model of the effective teacher and then raises a question about the relationship between a teacher's view of the nature of science and classroom practice. First, he indicates that in a study of 18 high school biology teachers, those who were most effective were typified by:

> inquiry-oriented questioning, active participation by students in problem-solving activities, frequent teacher-student interactions, infrequent use of independent seat work, and little emphasis on rote memory/recall. With respect to classroom climate, classes of the more effective teachers were more supportive, pleasant, and "risk free," with students expected to think analytically about the subject matter presented. (p. 348)

In summarizing the results of recent work carried out by a number of investigators in various studies he further adds:

> As a consequence of this more recent research, it appears that the most important variables that influence students' beliefs about the nature of science are those specific instructional behaviors, activities, and decisions implemented within the context of a lesson. It appears that continued stress on higher-level thinking skills, problem solving, inquiry-oriented instruction, and frequent higher-level questioning

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within a supportive risk free environment are at least related to desired changes in students' conceptions. Debate still surrounds the issue of whether a teacher's understanding of the nature of science is directly related to the development and/or performance of any of the aforementioned variables or other aspects of classroom practice. (p. 351)

The reason I find Kim's case compelling is that she exemplifies so many of the behaviors Lederman identifies as necessary to effective science teaching and appears to define much of teaching and learning in terms of what she believes about science.

Limitations

There are several approaches to data collection that were not addressed because of the limited scope of this particular study that would enhance it a great deal. For example, I did not take part in department meetings or personal planning sessions or paper grading. Participation or at least observation of these tasks would give a richer view of the context.

More information about her conception of the nature of science would also be useful. Has she had any course work in the history and philosophy of science? I think it would also be instructive to study two teachers simultaneously in the same setting.

Strengths

In many studies, researchers are present only on occasion. I think a stretch of continuous observation is advantageous because it allows a better idea of the consistency of approach, makes patterns of action and reaction more apparent and fosters an understanding of the connections occurring in lessons across time. I also found it very valuable to analyze in a broader sense than the daily assertions provided after a number of lessons had been

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observed. I think periods of observation that coincide with units might be interspersed with periods of analysis. In that way intriguing patterns can be identified early and become the focus of continued study.

Using multiple data sources was a strength of this study which can be further expanded as indicated in the limitations.

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Constraints

1. Financial
   A. Planning time
   B. Class size

2. Administratively top-heavy
   A. Site-based management hasn't really addressed this; witness middle school example

3. No mechanism for communication between elementary teachers and middle level or high school and middle level

4. Text doesn't fit style

5. Too many parents expect school to take care of physical, emotional, disciplinary and educational needs of kids

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6. Time constraints

7. Students view of grading

8. Interference of intercom

Supports

1. University research group

2. Grant to support work in development of labs for teachers

3. Encouragement to present

4. Support of colleagues

5. School time for department meeting

6. Planning time with 6th grade teachers

7. Reading journals

8. Materials not a problem

9. Curriculum not restrictive

Example of Assertion

Students learn by making connections

Reference to former unit
  talking about niche and refers to adaptations p.6
  cells p.4

Use of analogy
  cells, tissues, organs, body; populations, communities,
  ecosystems p.4

How does this apply to you?
  population of humans in our classroom p.4
  examples of populations in Colorado p.4
  ant study could have taken place just east of us p. 82
  students and cartoons p. 84

Encourages student examples
  student talks about single large fungus in the news   p.36

Usefulness of method in solution of real world problems
  how will we know if it's endangered p.36
  how many hunting licenses should be issued p.36
  ladybugs can be purchased by volume p.36
  see how stock of trout is doing in a lake p.54
  ask your parents about the census p.70
  talks about her own experiment with ants p.82

Whole area of skills
  relates exercises to notes p.60
  shows relationship between way trials are conducted and ability
   to answer question p.68