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Case Studies of Preservice Teachers' Conceptual Ecologies

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ABSTRACT

This qualitative study investigated two preservice teachers' conceptual ecologies in professional development during the science teacher preparation program. The notion of a conceptual ecology contains nature of knowledge, science and science teaching, learning, and content knowledge and comfort level. The data were collected during the participants' preservice year and their practicum experience. Both data collections and analyzing were from the various sources of interviews, teaching observations, journals, and information and profiles by the participants' supervisor. Two preservice teachers serve as cases representative of this study. Results show that problems preventing the preservice teachers from moving closer to conceptual change teaching were their understandings of the nature of science and the nature of knowledge. The preservice teachers' views about knowledge come from, and what knowledge is, are largely shaped by the nature of science and learning drive pedagogy and classroom practice. Knowledge of and comfort with the subject matter are also important.

Key words: conceptual change, conceptual ecology, preservice teacher, professional development

I. Introduction

The science education literature of the 1980s and 1990s includes numerous studies of students' conceptions about scientific phenomena. From these research, students' conceptions are often different from those of scientists(Driver & Erickson, 1983; Driver, Guesne, & Tiberghien, 1985; Garnett, Garnett, & Hackling, 1995; Osborne & Freyberg, 1985; Pine & West, 1986). As well, students' conceptions may be highly resistance to change(Driver *et al.*, 1985; Novak, 1988; Osborne & Freyberg, 1985; Strike & Posner, 1985). The theory of Conceptual Change Learning was proposed by Posner, Strike, Hewson, & Getzog(1982), in order to make these students' conceptions orient to scientific conceptions. There are two important factors in conceptual change learning that can help students experience conceptual change: status of conception and conceptual ecology. The idea of status of students' conception is represented on student learning as a rational process. The idea of conceptual ecology is composed of numerous components and

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includes their interactions in individual epistemological and psychological contexts of the conceptual change(Kwak, 2001; Park, 1995), while the conceptual change means the status of conceptions as intelligibility, plausibility, fruitfulness, and dissatisfaction.

However, some researchers (Demasters, Good, & Peebles, 1995; Pintrich, Max, & Boyle, 1993; Strike & Posner, 1992; Vosniadou & Ioannides, 1998) argued that both psychological and epistemological contexts of learning should be included in the research on conceptual change. Moreover, they argue that teaching conceptual change should understand the whole aspects of individual learning to address the facilitating and debilitating components. The research on conceptual change needs to refine the components of conceptual ecology and their interactions, because individuals learning should involve a complex and interactive approach.

There are a few studies on preservice teachers' conceptual ecology, especailly related to thier conceptions of teaching science. This research focuses mainly on describing the individual journeys, by analyzing aspects of conceptual ecology, taken by two preservice teachers in professional development during the science teacher preparation program. I used the notion of a conceptual ecology containing nature of knowledge, science and science teaching, learning, and content knowledge and comfort level. In a larger study, I investigated the preservice teachers' conceptual ecologies as they participated in a science teacher preparation program. One's views about knowledge come from, and what knowledge is, along with the nature of science and learning drive pedagogy and classroom practice(Schwab, 1964; Latour, 1987). Knowledge of and comfort with the subject matter may also be important. Teachers who are confident in their knowledge of a subject may be more willing to address student conceptions in their classroom practice. For these reasons the case studies focus on the preservice teacher's understanding of the nature of knowledge, science and science teaching, learning, and their knowledge of and comfort with science.

Ⅱ. Research Methods

1. Science Teacher Preparation Programs

The secondary science teacher preparation program, at the time of the study, that preservice teachers had an academic major, a 40-credit liberal studies component, and a professional education component. The academic major(for example, biology, chemistry, earth science, physics) typically consisted of 34 credits of course work offered by subject departments. A significant number of preservice teachers added either minors in a second teaching subject(typically a second science or mathematics) or a broad field science major(requiring an additional 25 credits). The professional education component, in addition to the science program, typically required 24 credits of educational foundations and other statutory requirements selected from a broad range of possible courses, and the two-semester science program. This included a science methods course(for preservice teachers in all science subjects) and a pre-student teaching practicum in the first semester, and a full school semester of student teaching in the second semester.

2. Data Collection

The data upon which this paper bases its conclusions were collected during the participants' preservice year and their practicum experience. The methods used for gathering data included interviews and observations. I observed preservice teachers teaching during both a practicum experience and a semester-long student teaching experience. Four interviews were utilized to assess their aspect of conceptual ecologies at the start of their teachers' preparation program(two for opening interviews) and at the end of their students teaching experience(two for closing interviews).

3. Data Analysis

The four main components of a preservice teacher's conceptual ecology(e.g., nature of knowledge, science & science teaching, learning, and content knowledge & comfort level) were derived from data. An interpretative research design was operated based on principles of naturalistic inquiry(Erickson, 1986; Lincoln & Guba, 1985). A key features of this analytical procedures was constant comparative analysis(Strauss, 1987) by which I applied to the texts generated from the various data sources. Our intention was to develop exemplary cases for induction science teachers' conceptions of teaching science. Two types of triangulation were implemented(Denzin, 1978; Mathison, 1988): Data triangulation and investigator triangulation.

Both data collections and analyzing were from the various sources of interviews, teaching observations, journals, and information and profiles by the participants' supervisor. Different methods were also deployed, for example, interviews, census data, and document to validate findings. As investigator triangulations, three colleagues who had been working on the same project were asked to analyze and to interpret the data. Each one was to read and to analyze transcripts of the participants. They were also asked to read interpretation of the data, and later to discuss with me whether they agreed with this analysis. All three concurred with this interpretation of the participant. Moreover, once the data analysis was done, we checked with the participants whether they agreed about our interpretations on them.

Ⅲ. Results: Cases

Each case study begins with a brief account of one's personal history. Subsequent sections elaborate on each case's nature of knowledge, science and science teaching, learning, content knowledge and comfort level, and summary of one's teacher preparation experience.

1. Case of Mel

Mel is exceptionally tough, and resilient. Midway through her methods course semester, she underwent serious surgery yet missed only a few days of classes. Mel is very organized and likes to plan ahead. She sets high standards for herself and for her students. She became so frustrated during one of her interviews that she had to stop the interview to regain her composure. Mel is also very charismatic and popular with her colleagues. She is a high energy person, who is very outgoing and friendly. Much of Mel's enthusiasm for science comes from her early experiences as a summer camp counselor.

Mel's practicum and student teaching experiences were at the same high school. The student population was predominantly white and middle to upper-middle class. The salient features of the science department were its self-developed unified science curriculum and a team teaching concept. As part of this curriculum effort, the science faculty has developed its own integrated science workbook. As a result of the team teaching concept, the teachers tried to teach the same lesson each day.

Mel's practicum experience was in a room devoted to problem-solving activities. Group work was common. Often the goal was to develop explanatory models of natural phenomena. Mel posed problems to the class and then acted as a 'devil's advocate' by challenging inconsistencies and other potential problems their models might contain.

Mel's student teaching in a class of 16 students were observed. Although her cooperating teacher was the same as her practicum teacher, this classroom was organized in a very traditional manner. The students sat in three long rows of student desks with additional seats on the left and right in the front of the room. During whole-class discussions, Mel most often positioned herself in the front of the room. She used the blackboard to clarify questions and draw illustrations. Mel created a classroom climate that was friendly, supportive, welcoming, and accepting. Mel's cooperating teacher at the high school was committed to a problem-solving approach to teaching. Much class time was spent on the unified science workbooks. Mel often had the class read from the workbooks and fill in the blanks left open in the paragraphs, or underline specific sentences in the workbook.

Nature of Knowledge

Mel's understanding of the nature of knowledge had an important effect on her classroom practice. On entering the teacher preparation program, Mel revealed in her opening interview that she saw knowledge as reliable information (derived though the scientific process) that had structure and made sense. She still held this view in her closing interview.

Mel's understanding of knowledge is supported by our observations of Mel's teaching. It must be understood that Mel's practicum and student teaching experiences were quite different. In Mel's practicum classroom, students constructed explanatory models to solve problems with information received from the teacher or from their own observations. The emphasis in Mel's problem-solving classroom was on sense making, and this also profoundly affected her understanding of the nature of science.

During Mel's student teaching knowledge came from and was stored in the students' workbooks. Mel acted as the final authority on decisions about what was to be written in the workbooks. Her students seemed comfortable if not excited about this classroom format. The nature of Mel's questions was to probe for student understanding of workbook information. Students who could not remember or brought up other ideas were directed back to the workbook information through Mel's questioning of other students. Mel also spent some class time having the students read aloud from the integrated workbook. She would tell the class which sentences to underline. At other times she would direct their questions to the workbook.

Student: What is a gene?
Mel: Read me the definition from your reading.

The student reads the definition.

Mel: A portion of the DNA molecule. (Restating the reading)

Mel's observed actions of directing her students' toward textbook explanations is commensurate with information from her interviews. The following excerpt is from Mel's closing interview. She talked about the model-building activities that her students did as part of an open-ended problem-solving activity.

> *We've done a lot of modeling activities where we don't give them (students) very much information and then somehow they have to come up with different (explanatory) models. Sometimes... their thinking isn't always right or they think of something that may work, but it's not quite right for the right reasons. I at least try to refer back to their models throughout the unit and try to make them believe or see a better alternative.*

Mel used "correct" student knowledge in class discussions by having these students explain their textbook knowledge to their peers who were not yet able to product this knowledge when Mel asked for it. Although Mel was not really a presenter of information, she deferred that roll to the workbook and students who can recall the assigned readings.

Science

Mel's understanding of the nature of science had an important influence on her teaching. In her opening interview, Mel brought up two defining ideas about the nature of science. First, something is science if the tools of science are being used. For example, two students using a calculator to figure out the caloric content of different foods is not science, but more like math.

However using a triple beam balance or a Punnett square is science. Second, something is science if it involves content that Mel perceived as part of science. Making blueberry muffins is not science, but talking about a textbook illustration of the circulatory system is science.

Interviewer: What about the science aspect?
Mel: Yes, I think there is science there. Yes. The vascular system and just talking about it. I mean as far as the concepts there, I think science is there.

On another topic, Mel made a similar statement.

Interviewer: Is it science?
Mel: Yes
Interviewer: In what way?
Mel: Genetics is pretty science related and biology related, so, yes, in that aspect I would say it is science.

In her closing interview, an important change in Mel's understanding of science came up. Mel still judged science on the basis of tools and content but had added process. Something can be considered science if it has any one of these three features. Mel even changed her mind about calculating the caloric value of different foods.

Interviewer: So what makes this scientific?
Mel: I think calories are scientific. And just looking at that aspect of food makes it more of a scientific view of food.

Science is also a process. The process is mainly investigative and a thought process. Process can be content free. As Mel said;

I think I've been talking about science as a subject. Arthropods I think of as scientific. I think that is true, too. I think it (science) is a process. I think students need to see that, too. That there is a process to it. I suppose you could be scientific about anything, really.

The result of the scientific process should be to put together a big picture showing the interconnectedness of things. Mel added;

If I would think of science, I would think of a scientist doing science in their lab. I would think that they have to look at the whole picture of something and not just a fragment. I mean they might be studying a fragment, but you certainly have to know how that fits into everything else.

Science Teaching

In her opening interview, Mel presented a very simple conception of teaching. The most salient feature of teaching is getting students to think. To do so the teacher might act as a discussion facilitator to get her students to generalize from their observations of a box full of insects. Teaching might also happen if a TV program sparked some thinking in the mind of a learner. Interaction between a teacher and a student is better however, but not necessary for teaching.

Interviewer: What would you expect would happen if interaction occurs?
Mel: I guess I would just see this student thinking more.

Lecturing or simply presenting material is a low level of teaching because it doesn't get the students to think as much.

In the closing interview, Mel presented a much more complex picture of teaching, although some of the elements of her opening interview still remained. Teaching was still interaction with students to make them think. Facilitation of this can be through discussion, investigation, or even lecture as long as thinking occurs. An important addition to Mel's view of teaching was the role of student conceptions. Diagnosing student "misconceptions" was an important teaching task for Mel.

Interviewer: You find out that they have these misconceptions, what do you do then?
Mel: Well, to try to figure out a way to change their misconceptions.

Learning

Mel's view of knowledge was supported by her view of learning in her opening interview. Thinking, solving problem, observing, and understanding are all features of learning. Mel characterized memorization as a kind of low level learning, because too often there is no understanding concurrent with the memorization.

I don't think memorizing is understanding. It is just kind of listing vocabulary or tacts or numbers. Sure, you might be able to spit them all back later, but if you don't know what it means or what is behind it or why you memorized it in the first place, I don't think that is learning.

The influence of Mel's classroom experience can be seen clearly in her closing interview. She viewed the nature of learning as a sense-making activity. Sense making is putting things together to make a big picture. Mel commented;

And just to use that and they can start putting things together rather than trying to remember all these little fragments of chopped up information.

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In order to do this students must take responsibility for their own learning. The ultimate goal of teaching is to help students fit things together to make this big picture. She stated that the exchange of ideas between students is very important, and that students need to see how things fit together. These were the salient features of the student teams as they solved problems and built explanatory models in her classroom.

Comfort Level

Mel's attitude was somewhat different from the other interviewees. In the opening interview, she tried to be very precise in her responses, indicated by her careful hesitations and clarification questions to the interviewer. Mel seemed to be nervous about being questioned and answered carefully.

> *Let me think, I need to write this down a second so I can tell you my thoughts without mumbling them all,*

and added, *"Let me think about this for a minute."* Mel tried to give right answers and clarify questions with the interviewer.

In the closing interview, Mel was confident of her knowledge and even said so. Teaching the content made a difference.

> *Interviewer: Can you see a difference in your knowledge and confidence in the materials you taught versus before you started teaching.*
> *Mel: Yes, I just think I've learned it now.*
> *Interviewer: Why? What do you think accounts for that?*
> *Mel: Because I had to spend so much time figuring out how I would teach it to someone else. So I had to make sure I really understood it.*

During the closing interview, Mel did not ask for clarification from the interviewer. Mel's knowledge appeared more organized. She included a few more terms and used them more precisely. She seemed to have a much clearer idea of what she knew and what she didn't know. Mel's understanding of the subject matter was clearly a factor affecting her confidence during the interview. What might be of further interest is how her comfort level with the material affected her teaching.

Summary of Mel's Experience

Mel's understanding of the nature of knowledge and the nature of science were two very important influences on her teaching. Her placement in a problem-solving classroom had a very significant influence on her understanding of the nature of science. Mel's view of science was reformed in this classroom. Her students worked in research teams to pose and solve problems. The problem solving curriculum, however, didn't lend itself to opportunities for Mel to help

Table 1. Summary of Mel

	Opening	Closing
Nature of Knowledge	· Knowledge is reliable if it makes sense. Knowledge has structure, should fit together. Knowledge can be represented through examples.	· Epistemological commitments to sense making & observation. Knowledge has structure, should make sense, & can be represented by examples.
Science	· Science is content bound. Science requires thinking & understanding & the tools of science.	· Science is content and process. Science is using the tools & skills of science to put together a "big picture."
Science Teaching	· Teaching is getting students to think. The role of the teacher is discussion facilitator.	· Teaching is getting students to think, & build a "big picture." Role of teacher is to diagnose misconceptions, lecture, facilitate discussions & investigations.
Learning	· Learning requires motivation. Its features are thinking, solving problems, observing, hands on/minds on understanding. Learning is best accomplishes through interaction with the teacher.	· Learning is understanding (=sense making). Learning begins with students knowledge. Students learn by discussing & exchanging their ideas.
Comfort Level	· Mel tried to be very precise in her responses, indicated by her careful hesitations and clarification questions. · Mel seemed to be nervous about being questioned and answered carefully.	· Mel's knowledge appeared more organized. She included a few more terms and used them more precisely. She seemed to have a much clearer idea of what she knew and what she didn't know.

students explicitly address their conceptions and the status they attached to their conceptions. This is another important feature of a conceptual change classroom(Hewson et al., 1998). Mel, however, developed enough interest in her students' conceptions to diagnose them occasionally. She felt that the role of the teacher in a conceptual change context was to find student misconceptions. However, Mel didn't know what to do with her students' conceptions once she elicited them.

Mel stated often that she thought it was important for students to put together a "big picture." This may be in reference to the model building focus of the problem-solving process. The problem-solving curriculum in her practicum placement facilitated and exchange of ideas among her students, who were encouraged to take responsibility for their learning. This is an important feature of a conceptual change classroom(Hewson et al, 1998).

Initially, Mel defined science by its tools and content. After her student teaching experience, science was also a process concerned with putting together the "big picture."

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At this time it is evident that Mel had not been able to implement conceptual change teaching in her classroom. Her questioning of students was mostly for the purpose of determining how much textbook information her students could recall. Class discussions were used to explain textbook material (making scientific conceptions intelligible). Students often provided the explanations. In her action research journal, Mel made a comment that she really doesn't know what to do with student conceptions once she has them. In one lesson she gave the students thirty seconds to write down everything they could about "dehydration synthesis." Mel said;

> *I gave the students thirty seconds to think and write down an answer. I then randomly picked a student. She gave me a great def.! However, I'm not sure where this got me except to focus the students and make sure that all of them were writing something down,*

It is evident that Mel had not yet learned to work with her students' conceptions. Mel were interested enough in their students' conceptions to take time for diagnosis. But both were unequipped with strategies for using these conceptions in their teaching.

Mel's adherence to the textbook information may have been the result of the unified curriculum she had to teach. Students were expected to come out of her sophomore science class with the same basic information as students from sophomore science classes taught by the other teachers at this school. She was also expected to keep pace with the other classes, so there were almost no time to attend to the "diversions" of alternative student conceptions. This is evidenced by Mel's reference to "funnel days" in her journal.

> *On Wednesday -- it was "funnel day" as the department calls them -- lecture...pour in information.*

2. Case of Robe

Robe is a very introspective person who takes time to observe and think about her classroom practice. She preferred to have her students work in groups.

Robe's high school chemistry and physics classes were taught by the same person who "had a very different way of teaching" that deserves mention. Her teacher would give only a very brief introduction to a unit and then assigned the class problems to work out by themselves or in groups. He would spend the rest of the hour with a broom sweeping up the floor. When everyone was totally frustrated or stuck at a certain point, the teacher would put down the broom and show the class how to do the problems. Sometimes he would let the class struggle for days.

Robe's practicum placement was in the same school as Mel's. They were there at the same time but in a different classroom. Robe's student teaching placement was in a small town in south central Wisconsin. The town's economy is based on tourism and agriculture. The town has a thriving artisan community. The student population of the school was about 250, predominantly white and middle class. The school had no official tracking, so Robe's classes contained a wide range of abilities. Robe's classes were small (15-25 students). She taught freshman biology classes, and 95% of her students were freshmen. Robe taught in a classroom with a curriculum developed by her cooperating teacher under a district-wide scope and sequence umbrella. Robe was somewhat constrained in her teaching by her cooperating teacher's attitude about time. He thought that spending extra time on a difficult topic was babying the students, that they were just being lazy. Robe complained a little about this in her journal.

Nature of Knowledge

Like Mel, Robe's view of knowledge was important in determining her classroom practice. Robe believed that knowledge is external truth students must discover through observation, discussion, sense making, and ultimately, reliance on the judgement of authorities, especially the teacher. The opening interview contains several themes about how knowledge is characterized by Robe. There are right answers and misconceptions. At the end of the interview Robe made the following comment.

> *Robe: Do you know the right answers after this, so we can look at them? This is going to bug me now.*
> *Interviewer: There are no right answers.*
> *Robe: Yes there are.*

In her closing interview, Robe made no distinction between information and knowledge, and used the words interchangeably. Understanding became more sophisticated than merely thinking. It involved making links between bits of information. This conception is closely linked to Robe's idea of good teaching and is discussed further in that section.

> *Interviewer: Students are not learning if it's not new information?*
> *Robe: Yes. I think learning is something new. Even if it's learning a new experience, I think learning is something different or new from something they have already known or didn't know. To regurgitate something you already know, to me, it's not learning. That's my understanding of what learning is, taking in new knowledge.*

It is important that this information may be correct information. Old information can be new information if it was not remembered. The quality of the information is also important. Low quality information, like the names of bones, can be merely memorized.

More of Robe's view of knowledge came out of her closing interview.

> *I only gave them information that I felt comfortable with. I wouldn't tell them anything that I wasn't sure about, and if they asked about it, then I would either say I would look it up, or have someone else... look it up.*

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Knowledge also has structure and can be presented in an orderly fashion.

> *DNA is made of proteins. Proteins are made up of amino acids. I mean you have to realize where's the stopping point to teaching...? I mean how far down do you go? Do you do down to the three base pairs of an amino acid, or do you do down to ... each base.. you know, where do you stop?*

More of Robe's understanding of the nature of knowledge came from our observation of her teaching. Robe's teaching style was very fact and concept oriented. She typically began lessons by asking students what they could recall learning about a topic. Interspersed with her questions, she presented facts about the topic. After she had presented the topic, she stopped and had her students write down what they thought of each other's ideas, including her own. These student writings often become the basis for lively class discussions. Students felt free and at least to bring up their own ideas and argue them in the class forum. This attitude of respect for each other's ideas is an important feature of a conceptual change classroom(Hewson et al., 1998). The focus of Robe's classroom often changed from teacher centered to student centered. When it was teacher centered the topic was being framed, or Robe was making sure that the students were coming away with correct information. When the focus shifted to student centered discussion, student conception were being elicited and discussed.

Science

Robe's views about knowledge are supported by her views of science and science teaching. In her opening interview, Robe created an image of science largely defined by its content. Anything related to life or the environment is science. The content of science has two aspects. One is a fixed body of facts. The other is the changing knowledge base that results from the process of discovery through experimentation. Robe said,

> *There are certain basic things...that are always going to be the same, that aren't going to change. Then, after a certain point, there is always new things being learned about, and they are always changing answers about where something came from, or why did it do this.*

The process of scientific discovery requires such skills as weighing and measuring. Science should result in thinking and learning. Without these outcomes science hasn't really happened. For this reason Robe doesn't think that someone following a recipe for blueberry muffins is doing science.

> *Science? In reality I would say no. Because if someone is baking something...I don't think they are really thinking about--they are not learning anything from this.*

The idea that science involves discovery is commensurate with Robe's ideas about the nature of knowledge. Knowledge can be discovered, and belief in its reliability can be justified, through observation and experimentation.

In her closing interview, Robe still defines science as being topic bound.

> *I guess my definition of science would include every living thing and everything that it interacts with, non-living or living. What their relationship is, I guess would be science to me.*

Robe clings tenaciously to her conception of a content-bound science, even though the interviewer challenges her several times about this definition.

> *Interviewer: What makes you a science teacher rather than an English teacher?*
> *Robe: The topic.*

Robe believes that science is a very broad topic and that almost everything can be science if it can be shown to relate to science content in some way. This content bound definition of science sometimes made it hard for Robe to make up her mind about something being science. She struggled with whether or not baking muffins is science.

> *Robe: In my broad sense, yes, it's science. It's food. Probably not. It's home ec.*
> *Interviewer: Why do you exclude this one?*
> *Robe: I guess I just don't think of making blueberry muffins as scientific information. The reason it's giving me trouble is because I would never give a lecture or demonstration on how to make blueberry muffins in a science class, whereas all these other things that we have talked about are something, to me, would be important to learn in science class...whereas this I would throw it into home ec. category. There's what I'm struggling with.*

The goal of science was stated by Robe in the following excerpt.

> *He (the scientist) finds out new information and figures out why something does what it does, how it works. Yes, I think that's a big part of it. I think that's a big part of anything. I think humans in general have this desire to know why something does what it does and how it works.*

In the end it is apparent that Robe had not changed her view that science is defined by its content and a few skills that are necessary to engage in the process of discovery, which is to gather facts and develop explanatory models of how things work.

Science Teaching

Robe's views of knowledge were again reflected in her understanding of science teaching. In her opening interview, Robe revealed her opinion that teaching begins by generating interest. This may include the rationale for learning the topic at hand. After interest has been aroused, the role of the teacher may be to present information, provide good explanations and examples, and questions of the students. Even a TV program can teach if it meets these criteria.

> *If it is an informative show and the kids are interested in what is going on, I think, yes, there is teaching going on. You can learn a lot from it, an informative show, more than the teacher standing up there and lecturing to you.*

Questioning is a better strategy then explanation. Robe added,

> *I think it is better to ask questions and let the kids explain what they know rather than have someone stand up there and say, 'This is what this is and this is what it is not.'*

At some point, however, it is appropriate for the teacher to step in and provide the correct explanation. When asked to change a scenario she did not consider teaching into one that was teaching, Robe made the following comment.

> *That he(the teacher) explains and tells him(the student) the correct answer.*

Finally, the student should come away with some understanding of the topic. This idea came out in Robe's comment about lecturing on evolution to first graders.

> *Interviewer: Is there science teaching going on here?*
> *Robe: Yes, if he(the teacher) explains it in a way that they(the first graders) are going to understand. If he explains it in a way that they (the first graders) are going to understand. If explains it in very simple terms that they are going to understand and gives it to them in a way that they are going to be interested in what he is saying. Yes, there is science teaching going on. Teaching is lecturing.*

There is no significant change in Robe's view of the nature of science teaching in her closing interview. Teaching is still closely linked to learning.

> *I guess my definition of teaching is if the students are learning something.*

Teaching is still predicated on introducing new information, questioning or answering questions, or providing correct explanations. Ideally, teacher questioning should get students to think about their conceptions.

Yes, I would say there is teaching going on, kind of in a different way that he is asking them a question to think about, maybe something they haven't thought about yet in a different way.

Although teaching is still very much the presentation of information, the quality of the presentation makes a difference.

Interviewer: Is it (presenting a class with the names of bones) teaching?
Robe: I would say it's semiteaching. I mean the teacher told them the names of the bones so they are getting new information. Is it a very good way to teach? I would say no.

Learning

In her opening interview Robe saw learning as understanding based on thinking and requiring motivation. In her closing interview Robe distinguished between two types of learning, understanding and memorization. Robe described understanding as making links between bits of information.

I think a very good way to teach things is to compare it(new information) to something new that they already know. I think that's a good way to get them to learn new information, if they can link it on to something else, than just going from something very totally new.

Comfort Level

Robe stated at the beginning of her closing interview that teaching is important to learning a subject.

I think once you've taught it, I think teaching it is the best way to learn it. If you can explain it to someone else, then I feel you really have...an understanding of it.

This is reflected in Robe's change in comfort level from her opening to closing interview. In the opening interview, Robe sounded nervous and uncomfortable about being tested. She was uncomfortable because she couldn't explain well enough some of the concepts. Some of the frustration may be due to Robe's conceptions that teachers should be able to provide good explanations. Robe said;

Now, how well you explain it is, you know, I suppose what defines what a good teacher is.

In the closing interview, Robe sounded relaxed and more confident of her knowledge. She still became nervous when she couldn't develop a good explanation for the interviewer about some topics. Sometimes she became a bit defensive, "You didn't ask me that question before." Robe spent less time trying to recall details of concepts. She had apparently looked up some of the content questions from the first interview, either because she taught them or because she was curious, and drew confidence from that. At the end of the second interview, Robe sounded satisfied with her performance. She joked with the interviewer.

> *I think...I could have done better. So if you want me to redo it, I'll be happy to! (laughing)*

Summary of Robe's Experience

Like Mel, Robe's views about the nature of knowledge and the nature of science were important ingredients in her classroom practice. Her classroom practice in turn was an important step to learning biology in a manner useful for teaching. Robe stated at the beginning of her closing interview that she had a better understanding and more confidence in her biological knowledge for having taught it. Her constructs of the biological concepts we presented earlier in this paper, however, don't reflect much of this learning.

Robe's stated view of the nature of teaching in the interviews was one of looking up information in a textbook, preparing an intelligible explanation of it for class, and then presenting the information to the students. In practice, however, she used considerable class time for students to present their conceptions of the topic of study. Diagnosis of student conceptions is an important feature of conceptual change teaching. However, instead of using strategies to get students to make judgements about the status of their conceptions relative to other conceptions, Robe saw it as part of her role to step in with the authoritative "correct" information. Robe's actions may be the result of her understanding of the nature of knowledge and the role of the teacher. If so, then her methods class was not effective in modeling the role of a conceptual change teacher.

The students liked Robe's student-centered discussions. In her journal, Robe wrote about a survey she gave her classes about her teaching and how she ran her class.

> *The question about discussion really surprised me. A lot of the kids thought discussion in class was pretty good.*

Apparently, by keeping the discussions student centered, Robe captured the interest and approval of her students. She made them feel good enough about the value of their own ideas that they came to value discussion. This kind of classroom climate is a key ingredient for a conceptual change classroom. This was not always true in her class. At the beginning of the year, Robe had a lot of trouble getting anybody to respond during discussion. Perhaps her students were too used to teachers who did not value their ideas.

Table 2. Summary of Robe

	Opening	Closing
Nature of Knowledge	· Epistemological commitments to sense making, direct observation, & authority. There are right answers and misconceptions. Knowledge can be explained, or built from other knowledge. Knowledge can be explained and memorized.	· Epistemological commitment to authority and sense making. Knowledge has structure & can be discovered through observation. Knowledge can be explained & memorized. Knowledge can be represented by examples and analogies.
Science	· Content defines science. Science consists of both fixed and changeable facts. Science results in thinking and learning. Science requires skills (weighing and measuring)	· Content still defines science. The goal of science is to figure things out.
Science Teaching	· Teaching and learning go together. Teaching can be lecturing, presenting information, providing explanation. Teachers should spark student interest, question students, leave students with correct understanding.	· Ideas about teaching didn't change, except Robe adds the thought that teaching should be about helping students to link their ideas together.
Learning	· Learning is understanding. Requires active involvement (=thinking), & motivation.	· Understanding is making links between bits of information. Learning features are interest, questioning, & active involvement.
Comfort Level	· Robe sounded nervous and uncomfortable about being tested. She was uncomfortable because she couldn't explain well enough some of the concepts. Some of the frustration may be due to Robe's conceptions that teachers should be able to provide good explanations.	· Robe sounded relaxed and more confident of her knowledge. She still became nervous when she couldn't develop a good explanation for the interviewer about some topic. Sometimes she became a bit defensiv.e · Robe spent less time trying to recall details of concepts. At the end of the second interview, Robe sounded satisfied with her performance.

Ⅳ. Conclusions

This study demonstrated that preservice teachers' aspect of conceptual ecologies in professional development during the science teacher preparation program. A preservice teacher's conceptual ecology contains nature of knowledge, science and science teaching, learning, and content knowledge and comfort level. By illustrating these case studies I was trying to present their conceptual ecologies at the beginning and at the end of their journey through teacher preparation program.

Problems preventing the preservice teachers from moving closer to conceptual change teaching were their understandings of the nature of science and the nature of knowledge. The preservice teachers were not provided with an adequate opportunity to think about and test their conceptions about the nature of science and the nature of knowledge. Teachers who understand science to be a collection of facts, and knowledge to be a body of information external to the learner, are most likely to hold conceptions about teaching that are commensurate with their ideas about knowledge and science.

Time constraints prevented our preservice teachers form adequately reflecting on their student teaching experiences, and we have no reason to believe that the time situation gets better when they enter their first year of regular classroom teaching. Their teacher preparation program may also have been an inadequate introduction to conceptual change methods. The conceptual change model was explicitly presented in the methods class and was modeled by the teacher. The modeling, however, never went beyond the diagnosis of student conceptions. Never were they shown in class how to create a situation where students could test their conception about something against some alternative conception offered by another student or the teacher. They were shown some videos of two master teachers modeling conceptual change teaching, but this was evidentally not an adequate intervention to make conceptual change teaching intelligible to our volunteers.

As suggested earlier, the preservice teachers were in the process of constructing an identity for themselves as a teacher. And so for the science learner, the type of prior knowledge that student teachers brought with them will affect the role that they were able to construct. There are similarities between the jobs of the student teacher and their students: Each must build new conceptions will be in conflict with those they already hold. Some individuals will have to undergo conceptual change if they are to reconcile the conflicts that they are faced with. It was a hope that both the experiences of the methods class, and the practicum and student teaching experiences, the preservice teachers had not only been made award of their conflicts but also had been provided with the support and skills to undergo conceptual change.

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