Teacher Research Network
Analysis of Secondary Science Profiles
1999-2000
Prepared by Teresa Shume
Reviewed by Jeff Pribyl
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I – CONTEXT

The analysis is based on 19 profiles: seven student teachers, eight first year teachers, and four second year teachers. Five of the student teachers were teaching high school biology while the other two are teaching chemistry and middle school science. Among the first year teachers, the study is following one chemistry class, one seventh grade life science class, two biology classes, two eighth grade earth science classes, and two ninth grade physical science classes. The second year teachers represent one class of each of the following: chemistry, biology, ninth grade earth science and ninth grade physical science. Nine participants were female, ten were male.

Some participants were teaching in Catholic schools, but most were in public schools. Three are pursuing masters degrees. Some were teaching college prep classes, while others were teaching middle school science or high school courses that are not generally considered college prep. Some were teaching in urban settings while a number of the participants were in large rural districts. Most practicing teachers held licensure in the content areas they were teaching for this study, except two who were teaching on variances. Some participants brought considerable applicable experience. One brought thirteen year of college teaching experience, while another spent seven years working as a scientist for a major drug company. Another worked as a state biologist before returning to school to complete her teacher licensure program.

Pseudonym	Years Experience	Subject *(for study)*	Other Factors
Angela	Student Teacher	AP Chemistry	Rural community
Anna	Second Year	Earth Science (9th)	High school in large metropolitan community
Betty	First Year	Biology (10th)	
Brian	Student Teacher	Biology (10th)	Degreed student in 5th year program
Donna	First Year	Biology	
Dottie	First Year	Chemistry (10-12)	Master's Degree & 13 years teaching chemistry at college level
Frank	Student Teacher and longterm sub, total = 5 months	Biology (10th)	Seven years as a scientist for a major drug company
Jenny	Student Teacher	Biology (10th)	MAI student, Catholic college prep school
Julia	Student Teacher	Human Biology	Urban high school
Kathy	Second Year	Physical Sci. (8th)	Masters student, Large metropolitan community
Lars	First Year	Life Science (7th)	Enviro.Ed. Experience
Maggie	Second Year	Biology (10th)	Rural Catholic college prep school
Marty	Student Teacher	General Sci. (7th)	Previous teaching experience at a Catholic school in Mississippi
Marv	Second Year	Chemistry (jr/sr)	Teaching under a varience while completing licensure
Matt	Student Teacher	Biology (10th)	MAI student, Catholic college prep school
Olaf	First Year	Earth Science (8th)	Rural community
Stewart	First Year	Physical Sci. (9th)	Suburban community
Stutz	First Year	General Sci. (HS)	
Tom	First Year	Earth Science (8th)	Suburban community

II - KNOWING SCIENCE CONTENT

A - Deciding What to Teach

Participants rely on a range of factors when deciding what to teach. A sampling of what drives decisions about content selection follows:

❖ - Kathy (2nd year) uses pretests at the beginning of the school year along with "Know, Want to Know, Learned" (KWL) charts to find out about students' prior knowledge.

❖ - Maggie (2nd) does her best to create curriculum that addresses both what she must cover and the student interests.

❖ - Deciding what to teach for Marv (2nd) revolves around the fact that he is teaching a college prepatory course. Marv tries to give them a good foundation on which to enter college. (Marv profile, p.2)

❖ - Stewart (1st) and Tom (1st) consult with other teachers in their schools. (Stewart profile, p.1 and Tom profile, p.1) During his interview, Tom also stressed the importance of making the content relevant to the students' experiences and interests. (Tom STII)

❖ - Olaf (1st) uses the textbook as the organizer of content for his courses, but also brings in science topics from the newspaper, magazines, and from television to discuss with his students. He does this even if the topics of the articles are not directly related to the topic being studied. (Olaf profile, p.1)

❖ - Betty's (1st) decisions on what to teach are driven by the curriculum established by the school, the graduation standards, what the book has intended for students to learn, and by what she believes is important for students to learn. (Betty profile, p.2)

❖ - Dottie (1st, 13 years college teaching) decides what to teach by looking at a number of factors. These include the major concepts she thinks the children should know about chemistry, the topics covered in the textbook, topics that might be applied to the students' lives, and topics that will prepare the students to take a general studies chemistry course in college. (Dottie profile, p.2)

❖ - Lars (1st) bases his selection of content on his own philosophy and beliefs as well as the Minnesota graduation standards. (Lars profile, p.1)

❖ - Angela (profile, p.1), a student teacher, relied upon her supervising teacher and the textbook to determine content to be taught.

❖ - Franks (ST) curriculum was dictated largely by graduation standards. (Frank profile, p.2)

Interestingly, most of these factors are teacher-centered and reflect the teacher's opinion about curriculum selection. While a number of participants mentioned a focus on what they belief students need to know (ex. Betty, Dottie, Lars), the only factors from the list above that are truly student-centered are Kathy's (2^{nd}) use of prior student knowledge and KWL's, Maggie's (2^{nd}) and Tom's (1^{st}) concern with student interests. (Some other participants included student interests as a factor in determining how to teach, not what to teach; this will be addressed in a later section.)

While graduation standards play an important role for some (Frank, Lars, Betty), they are of little importance to other (Olaf, Angela). Frank, Lars, Olaf, and Angela commented that their use of graduation standards reflected the use of the standards in their school or district. Betty does not discuss the use of the standards in her school or district. Whether or not the school and/or district uses the Minnesota Graduation Standards appears to have considerable impact on whether our participants use them in their teaching. Further study on this topic would be revealing.

One element that might guide the selection and sequence of content that was only mentioned in two profiles is student misconceptions. Jenny indicated that she spent considerable time with students trying to discern the thought processes that could lead to students' misconceptions. (Jenny profile, p.2) Frank mentions misconceptions when describing some of his assessment techniques, but it seems to be a passing reference rather than a critical factor. (Frank profile, p.5) But like all the participants in this sample, neither Jenny nor Frank mention the use of education research into student misconceptions. This likely indicates a lack of awareness that this type of research exists or a lack of access to the literature, but this cannot be stated unequivocally as the researchers in this study did not specifically ask participants about their knowledge of research about student misconceptions.

B - Knowledge of Standards

Some participants are familiar with the Minnesota graduation standards as evidenced by the fact that some of them were implementing graduation standards packages while being observed. Anna (2^{nd}) was on the second day of a four day sequenced graduation standards package called Fruitvale when she was observed. (Anna, profile, p.1) Kathy (2^{nd}) was also observed implementing a graduation standards package designed to assess student ability to utilize scientific method. (Kathy profile, p.1)

Some participants who were not observed implementing graduation standards during observations still provided evidence of being familiar with them. For example, Maggie's (2^{nd}) understanding of science standards is solid as she could easily articulate similarities and differences between state and national standards. Marv (2^{nd}) also discussed his use of Minnesota graduation standards performance packages (Marv profile, p.4) while Betty and Lars included them as a factor that drives curriculum selection. (Betty profile, p.2 ; Lars profile, p.1)

A group of participants (Stutz, Matt, Jenny) who graduated from one of the universities involved in this study were not exposed to the graduation standards during their methods courses. Stutz (1^{st}) has become familiar with the graduation standards since accepting his first teaching position. (Stutz profile, p.2)

Some other participants (Olaf, Angela, Marty) indicated a limited use and knowledge of the Minnesota graduation standards. Olaf reports that his district is not working much with Minnesota Graduation Standards yet and so he has not paid any attention to them. (Olaf profile, p.1) Angela (ST) appears to be familiar with the standards but they did not influence her selection of content (Angela profile, p.1) (Although this might be an indicator of her cooperating teacher's influence so it is difficult to know Angela' true beliefs about the standards and curriculum selection because she is a student teacher.) Marty's weak knowledge of standards may be a result of his disposition pertaining to his teacher preparation program: to get by with only what was necessary for certification. (Marty profile, p.1)

Some participants (Kathy, Tom) rely on district goals to guide their selection of content. Kathy knows the district goals and has them posted for her students. She knows that the school goals are related to the state and national standards. (Kathy profile, p.2) Tom uses school district competencies to determine what science content he teaches. (Tom profile, p.1)

A more in-depth study would result in a fuller description of the level of understanding about standards these participants bring to the classroom. It seems that whether or not the school or district has embraced standards is a powerful factor. Further, it appears in general that the second year teachers in this study implemented and discussed graduation standards more than the first year teachers or student teachers who participated. Our sample, however is quite small and it is not possible to say if this trend can actually be attributed to amount of classroom experience.

C - Knowledge of Science Content and Accuracy

Many of the participants in this study had undergraduate degrees in their content area (ex. Marv, Maggie, Matt, Jenny, Angela, Tom, Stewart) and made no content errors when observed (ex. Brian, Anna, Kathy, Tom, Lars). Indeed the only profiles that included any concerns about participants' knowledge of content were Marty (ST) and Julia (ST). Having taught at a private school in another state before working on his Minnesota certification, Marty seemed to regard his teacher preparation for Minnesota certification as a “speed bump in his path to employment.”(Marty profile, p.1) His attitude relating to content bordered on arrogant and was reflected in inconsistent preparation for teaching lessons. (This concern was addressed by his university supervisor and cooperating teacher.) Julia’s coverage of the topic for one of her lessons was described as superficial and parallel to the book. (Julia profile, p.1)

Be it that most participants have considerable university coursework in science and made no errors during the observation, many profiles deemed participants to have a strong base in science content. This may be a dangerous contention as the ability to excel in a series of reductionist courses does not guarantee the sophistication and depth of knowledge necessary to make connections between the various courses taken. Do they have a “big picture” which connects major concepts across various disciplines? Can they find the elements within a complex series of scientific concepts that connect to students’ everyday lives? Can their knowledge of content contribute to constructing meaningful and scaffolded learning experiences for students?

While much remains to be learned about these questions in future studies, a few profiles shed light on some of these questions. Stutz, for one, demonstrated an understanding of content and scientific process sufficiently insightful and sophisticated to challenge students to devise an experiment to measure oxygen content in the air using equipment from a selection he prepared in advance. (Stutz profile, p.1) Success in planning and implementing such an activity would seem to reveal a deeper understanding of science concepts.

Frank (ST) too appears to bring a sophisticated understanding of science content that allows his students to make a critical connection of how biology is related to their lives outside of school (Frank profile, p.3). Frank’s background in “doing” science has clearly transferred to his approach to having his students “do” science in the classroom. Indeed Frank and his students have almost identical perceptions of how biology is connected to the world. (“Learning About the World” Scale, CLES) This may be due in part to Frank’s seven years as a scientist for a major drug company. (Frank profile, p.3)

D - Inquiry and the Nature of Science

This study regards elements of inquiry to include: asking questions, generating hypotheses, designing experiments, conducting experiments, using controls and variables, generating data, manipulating data, making generalizations from data, defending conclusions, developing models [physical, mathematical, mental], using models, arguing from data, and replicating experiments. (STOI)

Some participants were observed using inquiry-based activities (ex. Anna, Stutz) while others described their commitment to using inquiry in the classroom (ex. Lars, Marv) . In both lessons observed, Anna(2^{nd}) attempted aspects of inquiry including data collection, analysis and interpretation of data and modeling. Stutz (1^{st}) also presented a lab activity during an observation in which students were challenged to devise an experiment to measure oxygen content in the air. (Stutz profile, p.1) Lars, one the other hand, described an investigation where students were given the same set of materials and then challenged to come up with a problem to study pertaining to the moon and then invited to devise an experiment in response to the problem using scientific method. (Lars, STII, p.2) Marv described an acid / base chemistry lesson where students carry out procedures they designed to test their hypotheses. (Marv profile, p.2)

Participant conceptions about the definition of inquiry range from simplistic to more sophisticated, but none of the definitions proffered were especially insightful. One of the more sophisticated responses came from Betty (1^{st}) who describes inquiry as either "providing questions or allowing students to come up with questions that they will discover the answer to." Some first year teachers hold a less sophisticated perception of inquiry. Olaf (1^{st}), for example, uses the term inquiry somewhat interchangeably with investigations and laboratories. (Olaf profile, p.1) And Stewart (1^{st} year) defines inquiry as "try things, trial and error...Trying to bring in real world stuff..." (Stewart, STII, p.2)

While there are many facets to inquiry and several definitions exist, the perspectives expressed by some participants reveal misconceptions or simplistic explanations of inquiry. Within the scope of the data we collected, many failed to see inquiry as a scientific way of approaching a question and instead viewed it as an exercise where students enter into an activity blind, responsible to discover some information that they could have been told in advance, but were not. For example, Anna(2^{nd}) describes inquiry as..."Its going in and discovering a subject or an object, instead of just being told what it is. So it's the students going through a series of activities or events so that they come up with some idea of what the topic is, or what the method is of whatever." (profile, p.2) Dottie (1^{st}, 13 yrs at college level) defines inquiry as "being able to explore a concept and determine some of the properties of that concept without being told ahead of time. (Dottie profile, p.1) While Betty indicated that a lot of what she teaches "is left for the students to fill in the missing pieces and they do that through inquiry." (Betty Profile, p.3)

Some participants held conceptions of inquiry that were quite broad, seemingly encompassing many or most hands-on activities. Frank (ST, 7 yrs scientist) believes scientific inquiry occurs "when students are allowed to explore and develop an understanding of a concept through hands-on activities and questioning which is directed by the teacher." (Frank profile, p.1) Angela, in turn, views inquiry as "the idea that you know a little bit about something and it's just enough to peak your interest, so you're going to go out and look for more or try and find something else that relates to it." (Angela STII, p.3) An example she gave of doing inquiry in her chemistry class was testing the water softening capabilities of different chemicals and other methods of softening water. (Angela profile, p.1) It would be interesting to know the parameters of Angela's definition of inquiry; indeed, what would she offer as a "non-example" of inquiry?

At least one participant holds a somewhat mechanical and rigid view of scientific method. When asked to describe inquiry, Kathy (2nd) talks about "the" scientific method as a specific process to be followed; this reveals a lack of understanding that scientific method is a way of approaching a problem rather than an unalterable series of steps.

When defining inquiry, some participants pointed to issues of student control where students are empowered to ask questions and to seek answers to their own questions. Tom (1st) explains inquiry as taking "the initiative to ask some questions about things they don't really know about yet. And to kind of also use what you already know to help them find out." (Tom STII, p.4) Tom contends that students in middle school often just want to know the answers while he wants them to investigate to find the answers out for themselves. (Tom profile, p.1) Marv's interpretation of scientific inquiry is to "allow the students to take control of researching a topic, be it either a lecture item or a lab." (Marv profile, p.1)

Two of the participants indicated they used less inquiry in life science courses than in physical science courses. Frank believes that life science simply lends itself less to inquiry than physical science, probably because his understanding of physical science content is stronger than his life science knowledge. (Frank profile, p.3) The other participant who uses inquiry more frequently in physical science courses is Lars, who points to time constraints in life science courses as the reason for doing so. It is unlikely that his reasoning for using inquiry more in physical science is parallel to Frank's because Lars, licensed to teach life science with a strong background in environmental science, is well versed in life science. (Lars profile, p.1 & 2)

E - Hypothesis, Theories, Facts

A number of participants confuse the definitions of hypotheses, theories, and facts by simply placing them place them on a spectrum of certainty including: Kathy (2nd year), Anna (2nd year), Stewart (1st year), Tom, (1st year). Some participants describe an evolution of an idea / prediction from hypothesis to theory and finally to fact. While a hypothesis not disproven again and again by many scientists over a period of time may very well become a theory, theories do not mature into scientific facts. Participants seemed to have the most trouble defining a theory, as the following passages will show.

Kathy describes her point of view:

> "Hypothesis to me, would be the proposed reasoning. OK, we have that gathered information, we are going to make an educated guess on what is going to happen. Fact is...it's been tested, proven...something that we hold true. Theory would be something that has been tested in some instances, not quite ready to be a fact yet. Its kind of the next step to being a fact. Most people would say, 'Yeah, that sounds pretty good but we have got to do more. We are not going to accept that as true yet.'" (Kathy, STII)

After defining facts and hypotheses, Tom indicates that a theory is "something in between". (Tom profile, p.2)

Anna explained her view in her interview:

> "A hypothesis is something that you think is going to happen, based on prior knowledge maybe you have found that someone else had had, so for example...if I mix red and blue together, I will get purple. And then you go through and test that and it if happens then it happens. A fact, as far as I use it, and have understood it throughout all these years, it is something that is proven. It is something that you know is going to happen, like if you mix red and blue you should get purple. That's what...that's just not even something to question. Theory is something that scientists think to be true, however, there may be some variables that could happen too, that would cause it not to happen. So that is something that they are...you know, like the big bang theory, they have a pretty good ideas of some things that happen, but they don't know for sure. There is just no way to know, perhaps, or...(Anna, STII)

Stewart states that a hypothesis is "just and educated guess... using what you already know." A theory is "something that hasn't been disproven, so it's okay. It's not a fact for sure because it could still be proven wrong." A fact is "something that is true all the time, no matter where you are on Earth. (Stewart, STII, p.2)

Another misconception about laws and theories is that they can be placed on a spectrum according to age. Olaf's "understanding of the term theory is that it is a fact that has not been proven for long ...and a law has been proven for a long time." (Olaf profile, p.1)

In contrast, Lars, a first year teacher, points out that there are no scientific facts because any theory or law can be disproven if a new example arises. He also correctly contrasts laws and theories by stating, "A theory tries to provide an explanation of why something is happening, a scientific law tell you what's going to happen...The law of gravity doesn't tell you why." (Lars. STII, p.3-4) Another first year teacher, Tom, specifies that facts are "something that's been proven so much that it's taken as being true", the implication being that facts can not be determined to be absolutely true, but rather are accepted as so. Both Lars and Tom hold a more sophisticated understanding of the nature of science than other participants in our study.

III - KNOWING PEDAGOGY

A - Discourse: Whose Voice is Heard, Power and Control

This section will discuss the degree of control accorded to students, the power they hold in the classroom, and the opportunities to have a voice in the operation of the classroom and the learning processes that occur there. Not surprisingly, there appears to be a wide range observed in this regard. Some of the participants (ex. Marv, Kathy, Anna) share a notable degree of power with their students while others (ex. Donna) retain much of this power and control. Some seem selective about the control they accord to students in varying degrees (ex. Stutz, Frank, Dottie, Lars, Matt). Still others (ex. Angela, Betty, Olaf) assign aspects of such responsibilities to students inappropriately.

Marv's metaphor for his classroom is a "safe house". Marv allows no threats and "nobody is better than anybody else." Marv believes he and his students "act as a team, actually a scientific family would be a better term." (Marv profile, p.1) Marv's approach to constructing a learning environment has resulted in a very close and positive match between his expectations and his students perceptions. In Marv's classroom, almost anything and everything are open to question and students are supported when they have concerns about their learning environment. The amount of control students perceive they have over the process of their learning is notable in Marv's classroom. It stands in sharp contrast to most of the other participants' classroom in this study. (Marv profile p.1-2)

Some of the participants (ex. Lars, Stutz, Kathy, Anna) were observed sharing power with students by deliberately giving them a voice, an opportunity for their view point to be heard. Lars allows his students to have a voice in choices he presents to them such as selecting topics for projects and ways of presenting the information they have learned. (STOI, STII, p.1,p.8) Lars makes an effort to allow each student an opportunity to express his/her perspective. For example, while students sat in groups to work on the biomes project, each student created their own field guide (STOI). Also, after a role play activity, each student was asked to write out their own solution for the environmental problem debated in the activity. (STOI post –interview) Lars explained how his classes do not involve pure inquiry, neither does he aim to pour information into their heads. The researcher who observed Lars indicated, “It seems that Lars’ approach might be described as a dialectic between the students’ voices and the teacher’s voice. (Lars profile, p.4)

Stutz, also a participant who shares control with his students, commits the class time necessary to allow students to have input on the safety regulations for various activities. He leads the process to assure that certain things are in place but believes in student ownership. He stated that this has really helped to eliminate most problems in his classroom. (Stutz profile, p.2) Kathy and Anna are participants who also actively and deliberately share power with their students; this aspect of their classroom is described towards the end of the sections entitled, “Role of Students.”

In some participants’ classrooms (ex. Frank and Dottie), students do not have a say in selecting content to be learned, but do have a voice in how learning occurs. Frank’s (ST) students are allowed to pace their learning, and have a say in deciding how their learning is going and what activities work best for them. As with Frank, Dottie and her students realize that the planning of her course is directed by the teacher (Dottie CLES #13) However, Dottie and her students agree that they are allowed to help decide how well they are learning and have a say in deciding which activities work best for them. Control is essential in learning and Dottie and Frank have accomplished the transfer of some of this control to their students.

One of the ways in which Matt and Stutz share power with their students is by making an effort to develop a social connection with students by conversing with them and by trusting them with a certain amount of freedom and responsibility. Matt indicated that he and his cooperating teacher have spent significant time helping the class develop cohesiveness. Students are allowed a great amount of freedom and responsibility, and it appears to work in terms of maintaining a safe environment. Further the researcher who observed him indicated that Matt has a personality that invites dialogue and easy conversation. He is open to trying strategies that allow him to mingle more with students and dialogue, as opposed to being in front of the class. (Matt profile, p.2) Stutz, in turn, was able to dialogue with students both on and off subject matter. They did not take advantage of this during his observation. Stutz also indicated that he spent some time going to after school functions, dances, games. He mentioned the fact that they really liked seeing him there. He really believes this is an important aspect of teaching. (Stutz profile, p.2) Forging social bonds and trusting students with a measure of freedom and responsibility is a way to share control in the classroom.

Dottie, far more than other teachers in this sample, admits that she limits student-student interactions in her classroom environment. Her students agree with her perception. The lack of student-student interactions severely limits feedback critical for learning. This lack of student-student interaction is consistent with Dottie's expectations of the students that she has in her general chemistry classroom. She believes that they will never pursue chemistry as in in-depth course of study. As a result Dottie has to control the dialogue regarding chemistry in her classroom. Here, we see the relationship of expectations of students to the structure of a learning environment in which those expectations are closely matched with teacher actions that often result in a self-fulfilling prophecy. (Dottie profile p.4-5)

Donna restricts the power and control students have in her classroom. For Donna (1st), discussion is mostly teacher-student. There is some student-teacher dialogue but very little student-student dialogue. In lecture, girls are involved in listening and taking notes but contribute little to the discussion. Donna most often calls on boys. They answer all of her questions, occasionally challenge her and joke with her. The girls remain more passive. Often the open ended questions are asked of the group as a whole and one of the gifted students (male) is often quick to answer. Donna then starts prefacing questions with a different student's name. Another classroom where gender bias may be present is Frank's, however Frank's classroom seems more student-centered than Donna's. In Frank's (ST) classroom, females more than males believe that they are asked to explain their ideas. This requires more investigation. (Frank CLES, question #20, profile p.5)

In three participants' classrooms (Angela, Betty, Olaf) , the students were burdened with being responsible for elements of their own learning that exceed what many students can handle successfully. The first such participant is Angela (ST), a student teacher who was critical of some of the textbooks she has used. She feels that they were not systematic enough, trying too hard to relate to things students know about and not focused enough on what is really important in chemistry. (Angela profile, p.1) Such a criticism comes from a person who does not take responsibility to help students connect chemistry content to everyday life. Indeed, she indicated it is up to the student "to try to figure out how things in science apply to their own lives" when describing the role of students. (Angela profile, p.3) . Clearly, a student who cannot see connections between the content and his or her personal life would be deemed to be at fault for that failure. This is a situation does not empower students to be responsible for their own learning, it burdens them with an aspect of learning for which few students are equipped to manage alone.

Likewise, in Betty's classroom, students are deemed to be at fault when learning activities do not meet their needs. Betty's students have little control in planning, little time for reflection on their learning, and little to say to deciding what activities work best for them. Yet Betty believes that her selection of activities correlates with "what works for students." Betty rationalizes this contradiction by believing "some students just don't take advantage of the opportunities." (Betty profile, p.4) Here again, students are accorded a responsibility that burdens them rather than empowers them.

Olaf runs a very teacher-centered classroom where his discipline of students was very casual. (Lars profile, p2) Here too, students are given freedoms that may actually inhibit or interfere with their learning.

Similarly, Lars too assigns a certain level of responsibility to his students for their own learning. In contrast, however, Lars offers support and coaches students to learn how to learn and how to use their work time. During one observation (STOI), Lars helped some students to develop researching skills by stepping them through the process of procuring information about the tundra from a "T" encyclopedia. (STOI)

B – Learning Strategies Used by Participants During Observations

Each participant was observed teaching a lesson on two different occasions. There was a wide variety of learning strategies employed by the participants during observations. While a number of participants lectured, there is also an impressive array of activities which engage students in learning. What follows are some brief excerpts that provide a taste of what the observers saw out in the classrooms in terms of learning strategies and use of class time during observations.

> "Brian utilized a variety of instructional tools within the DNA lesson: models, newspaper clippings, cooperative learning groups, Y charts, and good discussion techniques" (Brian profile, p.1)
>
> "During the fish lab, Jenny had the student working in small lab teams. She briefly reviewed the standards for working in teams, the same expectations covered in class with regard to effective cooperative learning. Teams had roles and the procedures and outcomes were clear." (Jenny profile p. 1)
>
> "In the lesson that was observed, Angela presented the concept (enthalpy) for 15 minutes at the start of the class, then students worked in pairs on a lab using a lab packet. Angela monitored progress by moving from pair to pair." (Angela profile, p. 2)
>
> "Frank began the lesson with a discussion of the general characteristics of reptiles and their anatomy, then students dissected turtles." (Frank profile, p,2)
>
> "Kathy used a jigsaw technique to present new information. Within each group, student had assigned roles related to the presentation of the content in their section. Later, in her second lesson, teams made observations of Oobleck which were shared with the class. These

observations were then used by each team to develop a hypothesis which was tested the next day." (Kathy profile, p.2)

> "Anna's class was first observed collecting data on the second day of a four day sequenced graduation standards package called Fruitvale. In her second lesson, Anna presented information about properties of rivers and corresponding vocabulary. Groups then used sand and water to create models of the three stages of a river's life. Groups then presented their models to her and answered questions orally." (Anna profile, p.1-2)

<u>C – Learning Activities Described by Participants</u>

Besides the strategies observed in the classroom, various learning strategies were described by participants in the course of the interviews. It should be noted that this section and the section that follows ("Criteria for Choosing Learning Strategies") are about the participants perspective or view of their own choice of teaching strategies. Whether or not these estimates and judgments provided by participants are accurate or not is beyond the scope of this study, (except for the two lessons that were observed). Further, whether or not the participants have the skills and talents necessary to implement all of these strategies successfully is also beyond the scope of this study. An example of such a caveat follows:

> "In the interview, Julia did not understand the term 'pedagogy.' She stated that she would like to have the students learn by doing activities and problem solve. Julia said, 'Like with the blood lab, finding out information on their own' In the class observed the students did type their own blood, but nothing was discussed as to how that worked" (Julia profile, p.1)

It should be noted, however, that the vast majority of observed lessons described in the profiles were deemed successful by the researcher who observed them. It seems likely, then, that participants do have the skills and knowledge necessary to implement these strategies successfully. Nonetheless, it would be prudent to note the limits of our study at this point.

What follows are some observations about how participants describe the main activities they use to teach, beginning with a sampling of these strategies.

❖ - Tom starts each class with a 5 minute "slip" that usually is a set of review questions. He then typically gives a 10 minute talk on the subject of the day. For this, he frequently uses visual aids and provides a note-taking sheet for this students to fill in as he talks. He then follows with an activity, demonstration, video, or discussion. (Tom profile, p.2)

❖ - Activities used by Betty include: "Worksheets, debates, labs, reading assignments, research, and presentations mostly." (Betty profile, p.4)

❖ - When asked to describe the kinds of activities he does, with his students, Lars listed: read magazine articles and answer questions, videos, class discussions, debates, "stuff on computers", "stuff out of books", written and verbal presentations, posters, worksheets (ex. vocabulary terms), using field guides to identify mammals, leaves, and other living things. (Lars STII p.4)

❖ - Dottie's science activities include demonstrations, mini-labs, and lab experiments. (Dottie profile, p.3)

❖ - Activities used by Marv include anticipatory sets , demonstrations, and labs. (Marv profile, p.3)

❖ - The types of activities that Frank uses include: discussion-based lecture to keep the students actively involved in learning, small group activities where he asks a question and the students come up with an answer, hands-on dissections in cooperative groups, and fun activities during test reviews. (Frank profile, p.4)

Some participants also described the kinds of supplemental resources they use to augment their teaching. To enrich his classroom, Frank uses current science-related events that show up on television or in magazines, the internet, and science professionals from his seven years working with Bayer. (Frank profile, p.4) To enrich student learning, Betty also uses current events and her own knowledge of science. (Betty profile, p.4) To supplement her classroom, Dottie "uses activities other teachers have told me about, the internet, and a variety of books" she has collected for different activities. (Dottie profile, p.3) Marv augments instruction through the use of college texts, other high school texts, the internet, and colleagues. (Marv profile, p.3)

When describing what proportion of the class time their students spend engaged in activities verses seatwork, some participants (Frank, Olaf, Betty, Marv) indicated their students spend more time doing seatwork or listening to lecture. Frank tries to keep a balance between seat time and activity time. At this point in Frank's career however, he is sorry to say that "about 65% of the time is seat/lecture time while the other 35% is what I would classify as science activities." Frank continues to work at bringing those numbers closer to 50/50. (Frank profile, p.4) Olaf mostly lectures and does few laboratories, (Olaf profile, p.1) Betty indicated the use of time in her class "is probably 60% lecture or me telling, reviewing, questioning." The remaining 40% is where the students take the lead and "do it on their own." (Betty profile, p.3) Marv, in turn, estimates there is a 3:1 ratio in his classroom between seatwork and activities. (Marv profile, p.3)

Other participants (Donna, Tom, Kathy) estimate that their students spend more class time engaged in activities than partaking in passive endeavors such as seatwork and lectures. In the interview, Donna stated that her students were involved in some kind of activity 75% of the time. This is consistent with the two classes observed. (Donna profile, p.2) Tom tries to change what he is doing at least every 13 minutes because of the attention span of middle school students. Tom describes his class time as about 25%-30% sitting and doing seatwork. (Tom profile, p.2) In her interview, Kathy states that students are actively engaged in learning science 85% of the time. This ratio refers to both the year's total and daily ones. (Kathy profile, p.2)

At least one participant, Dottie, indicated that she believes the split between active and passive uses of class time is 50/50. In chemistry Dottie estimates that 50% of the time is spent on lab activities (and only 25% of these have an inquiry aspect), while the remaining 50% of the time is spend on seat work and lecture. (Dottie profile, p.3)

It should be noted here that participants bring a variety of definitions of the term "activity" to this study. For example: Kathy defines the word activity as being engaged in learning and provides examples such as doing a presentation, participating in demonstrations, discussion, worksheets that involve synthesis, evaluation or analysis. (Kathy profile, p.2) Angela considers anything more involved than "just copying down words…" to be an activity. (Angela STII, p.4) Frank defines a science activity as either a laboratory experiment or a demonstration. (Frank profile, p.1) Dottie considers and activity to be a laboratory experiment or a demonstration (Dottie profile p.1) And perhaps the widest definition of "activity" offered was that of Stewart; he considers an activity to be anything in which students use their minds. He feels that "worksheets are definitely an activity." (STII p.3)

When describing the learning strategies they employ, some participants stressed the importance of variety. Stewart likes to include 3 or 4 different things in each class period in include a variety of different learning styles. He likes to do demonstrations and often has one or two students help with those. (Stewart profile, p.2) Lars strives to bring a variety of activities into his classroom and avoids predictable routines. It's not the big predictable lecture-lecture-lecture-lab on Friday. (Lars STII p.5) Tom feels "the key to middle level is just vary things as much as possible." (Tom STII, p.6)

D – Criteria for Choosing Learning Strategies

This section will examine some of the reasons why participants choose the learning activities that they indicated they use most frequently. Rationales offered by participants include relying on their own experiences as students, Some participants (Jenny, Marty, Stutz) rely on their own experience as students as a primary factor in selecting learning strategies. Jenny admitted in the interview that her primary foundation for pedagogical decision came from her experiences as a biology / mathematics student, while some came from her general methods course which dealt with different strategies. (Jenny profile. p.1)

In Marty's case, he decided that his lesson on stalagmites would mirror things he was exposed to in undergraduate school. Students worked in small groups to replicate models and to describe the process. He had then engaged in a "recipe" lab to create stalagmites over the course of two weeks. He used some cooperative learning coupled with effective discussion techniques. Students also completed worksheets. (Marty profile, p.1)

One of the factors that figures prevalently into Stutz' selection of teaching strategies is his own experience as a student. He states,

> "First I thought back to when I was in school and what I liked and didn't like. The things I didn't like would fill up many chalkboards. I realized that there were things that really engaged me. I wanted to do those things with my students. I want them to get their hands on thing I want them to experience science with all their senses. I have them write songs, posters, etc. At this age [9^{th} grade], they need this type of learning." (Stutz profile, p.1)

While some participants rely on their own experience as students to help select learning activities, Stewart turns to "materials that have been there" for ideas on selecting activities. (STII, p.3) He also does things that he had done before or that other teachers have recommended. (Stewart profile, p.2)

Besides issues of reliability, efficiency and time constraints were discussed by some participants (Betty, Dottie, Frank, Julia) When under time constraints, Betty chooses activities that she feels her students would learn the most from. (Betty profile, p.3) When time becomes an issue, Dottie selections activities that she "thinks will apply most directly to the topics that she is covering. (Dottie profile, p. 3)

Frank too expressed a concern with time constraints and the need for effective and efficient learning activities. The criteria Frank uses in choosing science activities is to try to find activities "that are educationally sound, meaning that true learning is taking place and we are not just playing games," Frank explains that time is always a factor and so "the activities cannot be a waste of the students' or teacher's time." He believes the worst thing a teacher can do is "rush through materials they need to cover in a lecture just to say they finished the textbook." Frank would much rather sacrifice some of the material to cover the concepts his class does cover in depth.

Frank's perspective contrasts sharply with Julia's who is also concerned with efficiency, but sees it in a very different light. Her observer stated,

> "During her observations, Julia used a straight lecture format to convey information. She indicated this was the fastest way to get a large amount of information to the students."

The researcher indicated, however, that the coverage of the topic (blood) was superficial and paralleled the reading. (Julia profile, p.1)

Although not always the most efficient of approaches, some participants (ex. Marv, Dottie) choose to select activities because of the connection to students' lives / world. Marv believes it takes patience, technique, real-life applications and real-life results when using a student-driven approach. Marv's strategy is to overlap his students' chemistry with real-life situations, allow them to carry out procedures they design, and then test their hypotheses. Further, Marv believes real-life situations aid in retention of science concepts. (Marv profile, p.2) Dottie, too, points to the importance of making connections with students' lives when planning her acids and base lab. (Dottie profile, p.2)

Another factor that influences some participants' rationale for selecting learning activities is their perspective on what aspects of learning science are truly important. While Angela's criteria are not limited the need for rote practice with some concepts, she does state that rote practice is necessary for some things, such as moles. "It's one of those things that I really believe you have to practice on your own in order to get it...rote practice, I think, in some cases is just about the only method to get things done. (Angela, STII, p.5) Frank, in turn, values the role of scientific vocabulary terms when he indicates that being a student in science is similar to a student in Spanish or English because science has its own language and for a student to be truly successful they must understand the language of science. (Frank profile, p.1)

Some participants (Julia, Matt) indicated that a primary factor in choosing various learning strategies was to modify the pace so as to provide some variety to students. Julia states in her interview that she would try to use activities

> "Once a week to break up the monotony of sitting in class all day. Give them a day to get up and walk around but still be learning and still be doing something related to the class, but where they don't have to be sitting straight ahead focused on what I'm talking about of what I'm trying to get across. (Julia STII, profile, p.1)

Matt too expressed a concern with breaking up the intensity of abstract concept with a fun activity. When asked why Matt chose to play codon bingo with his students to readdress the topic of protein synthesis, he states,

> "Well there are a few reasons. First and foremost it's largely because the other methods that we have been working in to solidify protein synthesis have been a little bit more abstract, a little bit more

traditional: working on models, reading about it, writing about it so we really got to thinking about it, and I decided it was time to come up with a method that students could enjoy. Also being that the weather is finally getting warmer, students are less tolerable of a less exciting lesson." (Matt profile, p.1)

These two participant seem to have injected fun learning activities to relieve students of the boredom, monotony, or intensity of the way most of their time is spent.

Several criteria for selecting learning strategies were described by the participants including their own experiences as a student, time constraints, efficiency and effectiveness of the methods chosen, connections to students' lives, aspects of science deemed especially important, issues of pace and variety. Interestingly, however, one factor that was rarely described as being important in selecting learning activities was how well the activities suited the learning goals for that lesson.

One of the few who does offer this as a factor, Kathy selects activities because they are the best at getting students to meet the outcomes for the day. Kathy posts goals for her students' learning daily. (Kathy profile p.2) And while Dottie does not discuss learning goals directly, she uses criteria that are similar in nature: it fits well with the topic she wants to cover, it allows the students an opportunity to explore some of the properties of the concepts she wants to introduce, it introduces techniques that she wants the students to understand, and the supplies and equipment are available. (Dottie profile, p.3)

Learning goals and activities will surely evolve the more one teaches a particular course; few of us get it "right" the first time. Nonetheless it was surprising that so few participants discussed the importance considering any learning goals when selecting learning activities. This was a significant omission in the data collected.

IV - KNOWING STUDENTS

A – Role of Students

Participants who assign students roles that tend to be passive include Julia (ST) and Olaf (1st). Julia's observer notes, "She teaches in a teacher-centered style with the students listening and taking notes or following directions. (Julia profile, p.2) Olaf reports that his students' role in the classroom is to complete the assignments and tests he assigns and to take notes. Specifically he describes the role of the students as "note taker and homework doer." (STII p.5) The role of student as receptacles of knowledge is a simplistic ones, as is Stewart's (1st) idea that the student's role is simply "to have fun." (Stewart STII, p.4)

Participants who include both passive and active elements in their descriptions of roles for their students included Dottie (1st/13 yrs college), Tom

(1st), Betty (1st) and Marv (2nd) . Dottie believes the role of the student is to "try to understand the major concepts, participate in lab activities, and sometimes to do demos for the class." (Dottie profile, p.1) Tom feels that a student's role is to "be respectful, be prepared, and be involved." (Tom STII, p.8) Betty's students have many roles: writers, listeners, teachers, followers, creators, leaders, researchers, and she believes they should be intuitive. Marv believes it is the students' job to produce while he is there to act as a guide reinforcing their learning. Marv "gives them the tools and then it is up to them to produce." Students in Marv's classroom are to "act as chemists." He refers to them as "tiger chemists." (Marv profile, p.1)

The participants who described a role for students that was especially active and involved in their own learning were Frank (ST), Kathy (2nd) and Anna (2nd). Frank believes his students play an active role in the classroom. They must "be engaged and feel ownership of what they learn while they explore the field of science." (Frank profile, p.1)

Kathy believes students are co-learners. She said in her interview,

> "I tell them right away. We are all scientists. We are all in this together. To be collecting information, to be learning about the outcomes, to be sharing with others, guiding others, if they know this...they are helping each other out to learn concepts, share what they know. I tell them about you know...your parents might be doing something that nobody else knows about, but you know a lot about. You can share that in the classroom, so we are all learners and teachers in some ways." (Kathy, STII)

Anna, who shares this perspective on an active role for student, describes students' role in the classroom as

> "A student's role is to be there on time. That' my biggest...(laughing)...And to be open to work with other students. To be open to what we are going to do. To give as much as, you know, you can't give 100% every single day, but at least to be involved and active and, you know, ask me questions or ask other people questions and not just sit there like a bump on a log and take up space. I want them to be, you know, figuring out something, even it it's not totally directed at what we are doing, you know, just to be...someone who can add to what we are doing at any one time." (Anna STII, profile p.3)

As with the description of the teacher's role, there is a trend where the least experienced participants seem to assign a more passive role for students while the ones with more experience tend to involve students more actively. One notable exception is the student teacher named Frank. Interestingly, Frank has five months cumulative teaching experience and has been asked to finish out the school year as a full time substitute. Further, he has been assured he will be offered a full time position at that school next year – not an average student teacher. In any event, our sample is composed of only 19 participants, so the trend detected may or may not be attributable to amount of teaching experience.

B - Assessment

Some participant (Julia, Olaf) responded to the questions about how they assess student learning with a fairly simplistic list of how they would go about evaluating what their student had learned. Julia, for example, said she would assess students using tests that she had written after checking references for ideas. (Julia profile, p.1) Olaf uses homework, quizzes, and objective tests as his primary assessment tools. A few lab reports and a number of worksheets were used too. (Olaf profile, p.1) Neither of these participants mentioned the importance of checking for understanding, nor did they relate their assessment to learning goals within the scope of the data collected.

Some of the assessment strategies used by participants were creative and others were less so. Brian, for example, had his students write a letter to their congressman on ethical issues relating to DNA. They were to take a stand and then defend their position using facts. (Brian profile, p.2) In contrast Angela was student teaching in a classroom where participants turned in lab packets that were primarily fill-in-the-blank. Once Angela completes her student teaching, she would rather have students do more formal lab reports. She would also like to leave some of the labs more open-ended, giving students a question and letting them figure out how to go about finding the answer rather than using the cookbook approach represented by the lab packets. (Angela profile, p.2)

Some participants described a rich list of assessment strategies, including both formal and informal strategies. Frank evaluates student learning in several ways: informal approaches such as asking questions while covering concepts to check for understanding and misconceptions, oral questions given during small group dissections, one-on-one questioning when possible, and formal approaches such as presentations, writing reports, and exam. (Frank profile, p.5) Tom uses a variety of assessments, including informal ones such as watching how students are doing and asking them questions. He also uses formal assessments such as worksheets that are handed in and tests. Dottie too usually tries to evaluate using a number of methods including informal ones like talking with students during and after lab, and formal ones such as lab reports, tests, and quizzes. (Dottie profile, p.5)

Two participants who rely in part on informal assessment described some of the specific strategies they used beyond the typical strategy of questions during class. Matt stated,

> "I spent time with them in the lunch room just a few minutes ago and they were talking about the lesson and how they liked it. I like rubbing

elbows with the students in and out of the classroom. It helps me evaluate
what I'm doing on another level." (Matt profile, p.2)

Stewart also makes an extra effort when it comes to informal assessment. He has students fill out exit cards with something they learned and a question they have. He also has had students draw pictures of scientific laws in action. (Stewart profile, p.2)

Specific strategies pertaining to formal assessment different than the typical ones listed above include the use of rubrics and checklists. Lars prepared a rubric for the project his students were working on during his observations. In his interview, he discusses how he hopes to improve his use of rubrics by preparing a sample student project to represent each level of the rubric; he believes this would help students to grasp the rubric more fully before undertaking the project. (Lars profile, p.3) Anna uses a variety of assessment formats including homework, oral testing, lab reports, projects, and presentations. When students are given projects, they are also given checklists so that they know ahead of time what they will be scored on. (Anna profile, p.2) Kathy uses projects frequently as well as oral presentations. Checklists are provided for students prior to completion of these projects. (Kathy profile, p.2-3)

For some participants (Betty, Dottie, Marv) student assessment drives the pace of their teaching. Betty assesses students by "each and every day asking questions to monitor how well and fast they are learning a particular concept." (Betty profile, p.5) Betty uses her assessment of student understanding to pace her class. She states, "If they know the answers they are ready for the test. If they do not, we try to spend more time on the concept." She then "comes up with another activity or tool for increased understanding of the concept." (Betty profile, p.5) Dottie too uses student evaluation to determine if the students have developed an understanding of the topic. The results help Dottie to determine whether she needs to spend more time on a topic or if she needs to explain it in a different way. (Dottie profile, p.5) Based on his evaluations, Marv will "pace the course." (Marv profile, p.4) Clearly a number of participants rely on student assessment to help them pace their courses.

One participant in particular discussed how his assessment of student learning drives more than the pace of his course; it drives the most fundamental aspects of his decision making as a teacher. In checking for understanding, Frank uses oral questions as his major source of insight into student understanding of concepts. Frank makes sense of evaluations by first looking for trends in the results to "see what the strengths and weaknesses are in the students' understanding." Secondly, Frank uses the feedback he receives from multiple forms of assessment to get the "whole picture." This allows him to make better decisions about whether or not outcomes were met. This overall set of evaluations/assessments influence Frank's decision making greatly. As Frank states, "If the evaluation process is not taken to heart when making decisions, why do it?" Frank further states that he "uses evaluations to make changes in this lessons to make his teaching more effective." (Frank profile, p.5)

Another participant who is actively modifying her teaching based on what she learns from students is Anna. The researcher who observed Anna indicated, "Comments in her interview led me to believe that she is learning from her work with students and making changes in her teaching accordingly." (Anna profile, p.4)

While a study of this nature could not capture the full breadth and depth of our participants' understanding about assessment, it seems that the new teachers in this study are still developing their understanding of student assessment; some still hold fairly inchoate understandings at this point in their careers.

V - ESTABLISHING AN ENVIRONMENT

A – Role of Teacher

For some participants (Julia, Stewart), a principal element of their role as teacher is to be an information source. Julia (ST) sees her role as a teacher "would be to provide them (students) with a certain amount of information and then help them to understand it and also help them...as sort of a guide, going through the park, pointing out different things while they kind of go about their own way." (Julia profile, p.1) Julia has a teacher centered style with the students listening and taking notes or following directions. (Julia profile, p.2) Stewart (1st) feels that his role is to "provide them with information, as a source person they can come to to learn if they have further questions." (Stewart STII, p.4)

Dottie and Betty point to the importance of the teacher providing leadership and direction when describing the role of the teacher. Dottie(1st/13 yrs college) believes her role as teacher is to "choose topics, introduce important topics, answer questions while students are doing labs, and to provide a safe learning environment." (Dottie profile, p.1) Betty (1st) believes her role in the classroom is that of a leader who "makes and directs the events of each day." (Betty profile, p.1)

Some participants (Marv, Tom) stress the idea that the teacher's role should be to provide support and guidance so that students can take on responsibility for their own learning. Marv's (2nd) perception of his role as teacher is to "try to act as a coach." Marv "gives them the tools and then it is up to them to produce." (Marv profile) Tom(1st) ideally sees his role as a "monitor" or "accommodator", as "someone who presents information and then helps them get through it." Tom recognizes that he often feels he has to take a more active role in managing the classroom due to the nature of middle school students. He wishes that the students would more often "realize that if they would just sit and do that, that they would actually get more out of class. They would actually get what they want out of class. They just can't see that, but sometimes they do". He sees himself as "authoritative, not authoritarian" (Tom STII p.8)

A number of participants (ex. Kathy, Anna, Maggie) describe the role of a teacher using the term "facilitator". Common threads among these participants' classrooms are that the students are expected to take an active role in their learning and the teacher offers ample support and guidance. What follows is a brief description of the teacher's role for each of these four participants.

Kathy (2nd) describes her role as a facilitator who,

> "Offers ideas, instead of telling them what to do...asks leading questions to where they're at and maybe guides them where they are going...much more guidance than a regurgitating type person. Definitely a supporter. No-answer-is-a-bad-answer type of thing...instead of having them regurgitate what I say, guide them where they should be going." (Kathy profile, p. 2)

In her interview, Anna(2nd) said she was a facilitator. She said,

> "I'm there, obviously, to get things organized and get people into the right spots to start things...and sometimes, I'll finish that first. I'm there to figure out what they are doing and hopefully I don't have to come out and tell them. I can just kind of ask them questions and see if they can figure it out. And with my smaller classes, I can do that more often, because I have time to sit next to them and go, "What do you think about this? and "Why would this happen?" (Anna STII, profile p.3)

Maggie (2nd) indicates her role in the classroom is that of a facilitator.

> "I mean, I don't give them the information; I present them information and give them experiences to reinforce that information. I give them the opportunity to learn information. They do most of the work. In some ways it takes all the pressure off of me and puts it on them, because its my job to make sure they are doing what they are supposed to do and the experiences that they have in my classroom with get them to where they need to be." (Maggie profile, p.2)

Frank(ST) offers a multifaceted description for the role of teacher. He believes a science teacher has many roles including that of facilitator, instructor, a source of knowledge, councilor, and a caring adult. He believes a supportive environment is critical to learning. To create that support, Frank spend the first class period going over the classroom expectations. Frank's number one rule is based on respect with no "put-downs." Frank explains that "he and his class are constantly reminding each other about this rule." (Frank profile, p.1)

It is interesting to note that perspectives that tend to be more teacher-centered were offered by student teachers (Julia) and first year teachers (Stewart, Dottie, Betty) while the more student-centered views were provided by first (Tom) and second year teachers (Marv, Kathy, Anna, Maggie). Again, our sample is too small to determine if this is a true trend or simply a pattern that has arisen by chance.

B – Safety Issues

For most of the participants of this study, safety was either not an issue or was handled adequately during observations. Examples of sources to support this contention include the following: "The lab activity Matt did while being observed did not deal with dangerous materials." (Matt profile, p.2) "Safety was not an issue for the activities Lars had planned during his observations." (Lars profile, p.4) "In Marty's (ST) classroom, safety is adequately addressed – no concerns here." (Marty profile, p.2) "The appropriate safety measures (goggles, hood, eye wash, etc.) were available in the lab area." (Dottie profile, p.1) "No safety warnings were given during either lesson. (Kathy profile, p.3)

In terms of safety procedures, most participants had established guidelines which they appear to follow regularly. Marty successfully implements the safety procedures developed by his cooperating teacher. (Marty profile, p.2) When asked about science safety, Matt indicated that a plan had been taught and posted and signed by parents. (Matt profile, p.2) Students who violate safety guidelines in Jenny's class can not participate in labs for the remainder of the school year. They must engage the concepts outside of class in a virtual environment (for which the school is well prepared). Parents are aware of this policy and it is supported. (Jenny profile, p.2)

A number of participants also place significant emphasis on safety with their students. The researcher observing Stewart noted, "Stewart places a strong emphasis on safety. He teaches students how to work to ensure a safe learning environment. (Steward profile, p.1) Similarly, one of Frank's main rules is that the classroom be a safe environment and there is no compromise for Frank on this rule. (Frank profile, p.1)

A few participants (ex. Frank, Dottie, Kathy) went beyond the idea of physical safety and brought up the notion of emotional or social safety. Frank has created a classroom in which students feel safe to ask questions, ask for clarification, and to express concern about anything that gets in the way of learning. (Frank CLES and profile, p.1) Dottie also points out the importance of her classroom being a safe place where students feel comfortable and free from criticism. (Dottie profile, p.1) When asked about a safe classroom, Kathy responded with comments about creating a socially safe environment. (Kathy profile, p.3)

In some cases (ex. Marty, Matt), the researchers noted how the classrooms were emotionally safe. The researcher who visited Marty's classroom described it as a "safe place for these kids to be kids and to explore, make mistakes, and learn." (Marty profile, p.2) And Matt's observed noted, "Students are allowed a great amount of freedom and responsibility, and it appears to work in terms of maintaining a safe environment. (Matt profile, p. 2)

For two participants (Julia, Donna), the researcher observing their classes had notable concerns pertaining to safety violations. Safety was a major concern in Julia's (ST) lab. Cords are strung across the floor in the center of the room. In the blood lab, students were allowed to prick other students and no one, including the teacher, wore gloves. The bleach solution for clean up was mentioned as an after-thought after the students had started the lab. Although scheduling half the class for the lab allowed for fewer numbers, students were still too spread out and there were too many at the same time to adequately supervise for safety. One student threw blood contaminated material in the wrong garbage. (Julia profile, p.2)

Likewise, in Donna's (1^{st}) classroom, safety is also a concern. During the lecture one student had a nosebleed and blood got on her desk and the floor. Donna saw the situation but did not stop lecturing. The student used the same paper towel to clean herself up and to wipe her desk. No attention was given to blood borne pathogens. In the lab, iodine and vinegar bottles were not labeled. Although students were told they should be wearing goggles, over half of the students did not wear them during the lab. (Donna profile, p.3)

The only other concern about safety was expressed by Angela, a student teacher who does not have as much control over how she teaches as she would like. The students in her class work (in pairs) through labs packets at their own pace so that at any given time, there may be three or four labs going on at the same time. Angela pointed out that some groups may be doing a lab that requires goggles while their neighbors are not wearing any because they are working on paper problems. (Angela profile, p.2)

VI - PROFESSIONAL DEVELOPMENT

(In this section, page numbers refer to their profiles unless otherwise noted.)

A – Professional Organizations

Several participants reported being members of professional organization. Members of the National Science Teachers Association include: Brian (p. 2), Anna (p. 4), Maggie (p. 3), Stutz (p. 2), Marty, (p.2), and Julia (p.2). Members of the Minnesota Science Teachers Association include Kathy (p. 3), Olaf (p.2), and Julia (p.2). Angela is a member of the American Association of Physics Teachers (p.3). This list of participants seems to include fairly equal representations from the student teachers, first year teachers and second year teachers.

B - Conferences/Workshops

A few participants mentioned participation in various conferences and workshops. Dottie, for example, has attended MSTA meetings and workshops as well as a conference specific to chemistry (Dottie profile, p. 5) Anna has attended workshops organized by her district and by the Science Museum. (Anna STII) A number of other participant also report attending professional meetings and conferences, although not the majority.

C – Other Opportunities for Professional Development

While several avenues for professional development were described by the participants, a few stand out. Brian (profile, p2) and Marty (profile p.2) have both presented research as undergraduate science students. Several participants report that working with colleagues is an important aspect of their professional development; these include Tom (p.2), Dottie (p. 5), Anna (p.4), Kathy (p.3) Stewart (p.3), and Donna (p.3). Stewart also participated in a mentor program which he found quite useful (p.3) Anna will be joining a writing team next summer to produce new graduation standards for her school. (p.4) Two participants reported they have not participated in any professional development beyond their university training at this point. (Frank profile, p.6; Lars profile, p.4)

D – Most Significant Influence

When asked to describe the areas that contributed to their knowledge as teachers, participants identified a whole host of factors. The element they deemed to be the most significant factor varied from participant to participant. A sampling of their answers includes : classroom experience (Frank, p.6; Betty, p.5), student teaching (Donna, p.3), working with others who are teaching the same course (Dottie, p.5), parents and prior life experience (Anna, p.4), her graduate program (Kathy, p.3), undergraduate content courses, (Marv, p.5), courses that include field experiences (Julia, p.2). Generally speaking, most of these items fall into two broad categories: teaching experience and university course work.

VII – GENERAL COMMENTS & QUESTIONS

A – Some General Comments

❖ - Collectively, these participant utilize an impressive array of different instructional strategies including jigsaw techniques, designing and building models, cooperative learning groups, class discussions, dissections, investigations, videos, demonstrations, debates, reading assignments, posters, songs, anticipatory sets, and others. Further, a number of these participants enhance their teaching with ideas and information from a variety of sources including other teachers, other scientists, the internet, current events, and a wide variety of books.

❖ - Notable omissions include the fact that no participants mentioned the use of educational research into misconceptions as a factor that guides any aspect of their teaching from content selection to instructional strategies. It seems likely that a lack of awareness about this large body of research is to blame or possibly lack of access to the literature, although further investigation would be warranted.

❖ - A second omission worthy of note was the fact that only one participant discussed learning goals as a driving force for selection of learning strategies. While participants did identify a series of important criteria, this is a notable omission because the notion of goal-based learning lies at the heart of the standards movement.

❖ - As teacher educators, we still have work to do with our students on the Minnesota graduation standards. It seems, however, that whether or not the school and or district where practicing teachers are employed embrace the standards has a monumental influence on their use.

❖ - Participant held a wide variety of definitions for the term "inquiry" and many of them held misconceptions or simplistic conceptions. Participants also struggled to provide accurate descriptions to differentiate facts, hypotheses, and theories. Understanding the nature of science appears to be an area of potential growth in many of the teacher education program from which our participants came.

❖ - The level of sophistication pertaining to participants understanding of student assessment varies considerably from simplistic to quite sophisticated. One of the most sophisticated perspectives comes from a student teacher.

❖ - Except for two noted exceptions, participants handled safety issues responsibly. The participants both recognized the importance of safety and had appropriate procedures in place.

B - Some Questions for Future Study

- ❖ Is it fair to assess a participant's content knowledge as strong based on the variety and difficulty of science courses they have taken? What constitutes a sophisticated understanding of content: A large quantity of factual knowledge? An elegant schemata of highly connected ideas? The ability to connect content to students' lives? The ability to orchestrate meaningful learning experiences based on an understanding of the nature of science? An understanding of the developmental flow of concepts that lead to the learning goal in question? It seems that an investigation into the participants' pedagogical content knowledge might reveal a rich array of findings.

- Two participants indicated that inquiry is more suited to their life science courses than their physical science courses. How do participants' views on the relationship of inquiry with specific subject areas relate to their depth of knowledge in those subject areas?

- Like the term "inquiry", the term "activity" is interpreted in very different ways. How does one's definition of "activity" relate to one's perspective on the roles of teachers and students? Do participants who hold a definition of "activity" that encompasses seatwork such as worksheets tend to be more teacher-centered?

- What is the relationship between experience with the standards during teacher preparation and implementation of the standards in the classroom? Which appears to have more impact: teacher preparation or the working environment in which new teachers operate?

- What role do learning goals play in our participants' design of instruction and assessment? Do they understand the fundamental relationship between learning goals and standards based education?

- Is there a pattern or evolution in the way new teachers perceive the role of teachers and students? When teacher-centeredness gives way to student-centeredness, are there certain classroom elements that shift before others? For example, do teachers tend to allow students a more active role in their own learning before permitting them a voice in classroom operation?

- What kinds of professional development are most effective in helping new teaches become members of learning communities?

COMMENTS ABOUT THE ANALYSIS PROCESS
(Teresa Shume)

A – Note to Reviewers:
I indicated that this analysis was "prepared" by me. I specifically chose to avoid the term "written" by me because I took many passages directly from the profiles. Instead of quoting each of those and then trying to differentiate those quotes from participants quotes stated within those passages, I chose to take chunks directly. I do reference the sources, but I do this in places where the words are my own too.

B – Concerns About the Profiles
❖ - Assertions in profiles need to be evidence based. Comments such as student teacher accepting jobs and "doing very well now" or student teachers being "potentially teacher of the year material" can not contribute to this study unless substantiated with specific evidence. Further, there were times when the general sense of the profile would seem to lend itself to supporting a certain assertion, but because I could not find specific evidence, I could not use that profile in that instance.

❖ - Profiles would be more useful if they contained more direct quotes from the participants. This would help to counter the loss of resolution in the date that occurs at each level of analysis.

❖ - Quotes in profiles <u>need</u> to indicate the source (from which instrument?)

❖ - Demographics and context are important for analysis. To look for trends across years of experience, previous work experience, age, etc., it is necessary to know these kinds of factors about each participant. Context sections vary widely from researcher to researcher (from scant tidbits to healthy descriptions). This is a problem.

❖ - Some assume the reader knows more context than is available. ex. Some use acronyms specific to their university. Also, the use of the term "local" is of little use unless details about the region are supplied. Perhaps I'm showing my own ignorance here, but I am unfamiliar with specialty terms such as Y charts, SLANT technique, and the "fist of five" technique.

❖ - I suspect not everyone is using pseudonyms. Some mention the names of specific universities. I recommend against this.

❖ - Inconsistencies in the profiles such as switching between the participant's name and pseudonym, suddenly changing the topic of the lesson during a description, and typos are annoying and problematic. Proofreading and spell checking are necessary before profiles are turned in. (Not a problem for all profiles.)

❖ - It would be helpful if the pages of the profiles were numbered.

C – How I Proceeded

1) First I looked for common themes or topics for each category using the profiles themselves and the description of the categories from the STOI.

2) The next step was to search the profiles for passages related to these various topics. Some passages I retyped from the profiles, others I simply summarized and referenced. It was helpful to assign brief titles to these passages as it made the next step easier.

3) l then looked for patterns, similarities, contrasts, and any notable omissions. I then did the actual writing/assembling of each section.

❖ - Reading through all the profiles is the logical way to start. But reading just each section before writing up the analysis for it is insufficient. Much information is found in other sections because each researcher seems to have interpreted the parameters of the sections differently and because one university used an entirely different format. It was necessary to look at the profiles in their entirety for each section.

E – Certainty and Doubt

❖ - I am concerned about some of the rich stuff I am leaving behind in the profiles, but I there just isn't a place for all of it. I am equally concerned that the assertions I am making are based on just a couple of observations and an interview. I worry that these findings will be flimsy because the supporting evidence is so limited by the shear quantity of time (or lack there of) we spent with these participants.

❖ - Our study is reminiscent of the TIMMS description of American curriculum: a mile wide and an inch deep. Any of the topics listed under any of the categories in this analysis could be the subject of an entire qualitative study. It is difficult to make elegant or sophisticated assertions based on only a couple of visits and an interview with each of 19 participants when we were not trying to answer a specific, focused question.

❖ - I have a sense that a degree of resolution and refinement is lost at each level of analysis. There are multiple lenses at work here: the initial observation notes/transcripts, the selection of data that went into the profiles, and then this meta-analysis. Indeed, the data seem to become coarser at each level. Trying to retain as many specific quotes and citing their direct sources would help to alleviate this problem, at least to some degree.

❖ - We began this entire undertaking with the assumption that we were going to take on a qualitative research project. We chose our theoretical framework before formulating the research questions. We even field tested our instruments before the research question was firmed up. And even, now, our research questions are broad and massive compared to the limited data that just a few visits to each classroom can provide. I have some serious concerns about the path we have taken in terms of the order in which these decisions were made. It seems a more logical path would have been: 1) establish a research question, 2) select the theoretical framework dictated by the question (qualitative or quantitative), 3) proceed with either data collection (qualitative), develop and field test instruments (quantitative).