

TEACHER EXPERTISE AND PERSONAL THEORIES OF LEARNING:  
MASTER AND NOVICE SCIENCE TEACHERS' INTERPRETATIONS OF A  
CONSTRUCTIVIST TEACHING EPISODE

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This study is an investigation of some of the similarities and differences between Novice and Master science teachers. The research focused on Novice and Master teachers' personal theories of learning as revealed through their perception and interpretation of a videotape of a teaching episode. The teaching episode was selected to illustrate teaching practices consonant with constructivist learning theory. Participants' interviews, during and following the video-clip, provided the sources of data. I transcribed all the interviews and analyzed them using both deductive and inductive analysis tools. Category development proceeded using both open-coding, for data-driven category development, as well as anticipated categories drawn from the three theoretical frameworks. Anticipated categories were drawn from research studies of teacher expertise, from the teacher development literature, and from cognitive science expert/novice research. Qualitative data analysis methods were used to determine Novice and Master teachers' perceptions and interpretations of the video-clip. The Novice teachers were pre-service science teachers. Some had completed student teaching and some were about to student teach. The Master teachers were Nationally Board Certified science teachers. The Novices were students in a reform-based teacher education program. They have had a variety of experiences with contemporary methods of instruction, but from this research, appear to straddle both a traditional

approach to learning and a more constructivist approach. For both the Novices and the Master teachers, the best indicators of their personal theory of learning lies with the role they see for the teacher in the science classroom, the degree of responsibility for learning that is placed on students, and the role student misconceptions play in teaching and learning science.

## BIOGRAPHICAL SKETCH

Kimberly Noethen received her Bachelor's of Science degree from Spring Hill College in Mobile, Alabama. While there she majored in Biology and minored in both Chemistry and Philosophy. Following her undergraduate work, Kimberly taught high school biology at Pine Crest School in Fort Lauderdale, Florida. During that time she completed her Master's of Education under Dr. Nancy Romance at Florida Atlantic University in Boca Raton, Florida. In the year 2000 Kimberly received the Teacher of the Year award from the organization Biological Sciences Curriculum Study (BSCS). In the summer of 2001 Kimberly began her doctoral work with Dr. Deborah Trumbull at Cornell University. In 2004 Kimberly received both the Outstanding Graduate Teaching Assistant Award from the Cornell University College of Agriculture and Life Sciences, and the Julian and Veta S. Butterworth Doctoral Research Award from the Department of Education at Cornell University. Kimberly was born in Munich, Germany. In the United States she has lived in New Jersey, Florida, Alabama, New York, and Massachusetts. As a traveler she has visited over fifteen countries including Russia, the Netherlands, Croatia, Spain, and Austria.

This dissertation is dedicated to my parents

Grace Ann Noethen

and

Helmut Wilhelm Noethen

in appreciation for their sacrifices, their struggles, and their dreams

for their children.

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## TABLE OF CONTENTS

1. Chapter 1 Introduction	1
a. Research Focus	1
i. Motivation	2
ii. Research Focus and Questions	3
iii. Theoretical Frameworks	4
b. Research Design	6
c. Data Analysis	8
d. Expected Results	8
2. Chapter 2 Literature Review	10
a. Introduction	10
b. Contextualizing Teaching and Learning	11
c. Theoretical Frames Bounding Research Design	13
i. The Changing Role of Today's Science Teacher	14
ii. A Teacher's Image of Themselves as Teacher	17
iii. Theory Development: Making the Implicit Explicit	18
iv. Schema Development In Expertise	22
d. Research Design Decisions in Light of the Literature	25
i. A Constructivist Perspective on Learning	25
ii. Participants	30
iii. Data Collection	33
iv. Data Analysis	35
3. Chapter 3 Research Design	37
a. Introduction	37
b. Central Research Question	37
c. Research Sub-questions	37
d. Participants	38
e. Data Collection	39
i. Video-clip Description	40
ii. Interview Guides	43
1. Video-clip A Interview Guide	43
2. Video-clip B Interview Guide	45
3. Follow-up Interview Guide	47
4. Chapter 4 Data Analysis	53
a. Introduction	53
b. Inductive Analysis Procedures	56
i. Getting My Feet Wet	56
ii. Master Codes	56
iii. Novice Codes	58
iv. Aligning the Filters	59
c. Deductive Analysis Procedures	60
i. Focus and Perspective	62
ii. Schemas and Personal Theories of Learning	64



d. Meshing Deductive and Inductive Analyses	65
e. The Product of Combined Inductive/Deductive Analysis	68
i. Focus: Student Learning versus Survival	70
ii. Theory of Learning: Traditional versus Constructivist	72
iii. Schema: Rich versus Simple	73
5. Chapter 5 Results	75
a. General Interpretations	75
i. Video-clip A Interview	76
ii. Video-clip B Interview	89
iii. Summary	94
b. Theories of Learning	95
i. Novice Teacher Audrey	95
1. Old Models vs. New Models	95
2. Onus	98
3. Extracting Information	98
4. What's a Theory Good for Anyway?	100
ii. Novice Teacher Jessy	103
1. What's My Role?	103
2. Sum of My Experiences	104
3. Bloom's Taxonomy	106
4. Popping the Misconception Balloon	107
iii. Novice Teacher Luscien	108
1. Inquiry-based or Something	109
2. Teacher: Mosaic Builder	109
3. Ownership	111
4. Misconceptions: Wallowing or Brilliant Ideas?	112
5. Those Who Need More	113
6. Thinking About Thinking	116
iv. Master Teacher Ann	117
1. Student Ideas and Onus	117
2. Don't Lead Them Astray	118
3. Reaching Past the Comfort Zone	121
v. Master Teacher Rachel	122
1. Thinking Takes Time	123
2. Keeping the Students in Control	123
3. Teaching Does Not Equal Learning	125
4. Putting the Brakes On	127
vi. Master Teacher Mercedes	130
1. The Having of Right Ideas	130
2. Bad Odors and Emptying the Trash	134
3. Personal Learning Space	134
4. Teacher: Bearer of Knowledge	136
c. Focus	139

i. Novice Teachers	139
1. Audrey	139
2. Jessy	141
3. Luscién	142
ii. Master Teachers	144
1. Ann	144
2. Rachel	145
3. Mercedes	146
d. Schema	147
i. Progression of Ideas	148
ii. Storying/Knowledge	150
iii. Question-by-Question	152
iv. Composite Synthesis for Schema Development	156
e. Summary	158
6. Chapter 6 Conclusions and Areas for Future Research	160
a. Conclusions	160
b. Areas for Future Research	165
7. Appendix	167
8. References	171

## LIST OF FIGURES

Chapter 1 Figures	
1.1 Expected Results	8
Chapter 4 Figures	
4.1 Overview of Data Analysis Procedures	55
4.2 Category Overview	69
Chapter 5 Figures	
5.1 Progression of Ideas Continuum	149
5.2 Storying Continuum	152
5.3 Question-by-Question Continuum	156
5.4. Trio of Continua for Schema Development	157
5.5 Composite Continuum for Schema Development	158

## LIST OF TABLES

Chapter 1 Tables	
1.1 Theoretical Overlaps	6
Chapter 4 Tables	
4.1 Master Codes	57
4.2 Wisdom Sub-codes	58
4.3 Novice Codes	59
4.4 Code Origination	60
4.5 Anticipated Categories	61
4.6 Code Overlaps by Category	66
4.7 Schema Codes	67
4.8 Personal Theory of Learning (TOL) Codes	68
4.9 Focus Codes	68
Chapter 5 Tables	
5.1 Question 1 Summary	77
5.2 Question 2 and 3 Summary	81
5.3 Question 4 Summary	83
5.4 Question 5	85
5.5 Question 5 and 6 Summary	87
5.6 Master Impromptu Responses	89
5.7 Novice Impromptu Response	90
5.8 Question 2/3/8 Comparison	90
5.9 Question 15 Summary	93
5.10 Master Teacher Ann Storying Summary	150
5.11 Master/Novice Storying Comparison	151
5.12 Question-by-Question Summary	155
Appendix Tables	
A.1 Summary Table for Progression of Ideas	167
A.2 Master Teacher Ann's Progression of Ideas	167
A.3 Master Teacher Mercedes' Progression of Ideas	168
A.4 Master Teacher Rachel's Progression of Ideas	168
A.5 Novice Teacher Jessy's Progression of Ideas	169
A.6 Novice Teacher Luscién's Progression of ideas	169
A.7 Novice Teacher Audrey's Progression of Ideas	170

CHAPTER 1  
INTRODUCTION  
Research Focus

This study is an investigation of some of the similarities and differences between Novice and Master<sup>1,2</sup> teachers. The specific research focus explores Novice and Master teachers' personal theories of learning as elicited through their perceptions and interpretations of a teaching episode. This research investigated how teachers thought about learning, which was inextricably bound to conceptions about teaching. Acknowledging this relationship, this research project highlights core views about learning that guide a teacher's practice.

This video-clip used in the research was selected as an example of teaching practices consonant with constructivist learning theory. Master teachers were seventh grade physical science teachers. Novices were prospective physical science teachers. To get at differences between Novice and Master teachers, participants viewed a section of the teaching episode and were then interviewed about their perceptions and interpretations. To get at personal theories of learning, portions of the interviews focused the participants on issues related to learning, taken from the context of the video-

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<sup>1</sup> Most research on teacher expertise uses the term "expert" to categorize developed or experienced teachers. I have chosen to refer to those teachers who would usually be called "experts" as "masters" instead. I feel that the title "expert" is too often associated with a wealth of factual knowledge. Alternatively, I feel that the designation "master" captures both the advanced skill as well as the craft nature of teaching.

<sup>2</sup> When discussing participants in my research I refer to Novice and Master teachers. I've chosen to capitalize "novice" and "master" when I use these terms because they refer to the two groups of participants in this research. In cases referring to participants from the supporting literature I retain the lowercase lettering.

clip lesson. Participants' interviews, during and following the video-clip, provided the sources of data.

I hypothesized that Novice and Master teachers would perceive and interpret the episode of classroom teaching differently. Differences between novices and experts are substantiated by the cognitive science literature (Beilock, Carr, MacMahon, & Starkes, 2002; Gobet & Simon, 2000; Rowe & McKenna, 2001), teacher development literature (Eraut, 1994; Korthagen, 2001) and other studies of teacher expertise (Carter, Cushing, Sabers, Stein, & Berliner, 1988; Livingston & Borko, 1989; Oppewal, 1993; Peterson & Comeaux, 1987).

Based on the three areas of research I've drawn from, I hypothesized that one explanation for differences in perception and interpretation of a specific episode of classroom teaching may be differences in Novice and Master personal theories of learning. Personal theories of learning can be more practically useful than public, and/or academic theories of learning. Personal theories of learning are constructed from experiences and in being so closely linked to the identity of the teacher are more accessible for use in moment-to-moment decision-making. I expected Novice teachers to have less-developed personal theories of learning, in terms of Korthagen and Lagerwerf's (1995) conceptualization of theory development, than Master teachers' theories of learning. Novice and Master teachers were expected to use their theories of learning as a lens through which they perceive and interpret the specific episode of classroom teaching.

### *Motivation*

The motivation for this research started when I was supervising student teachers and working with their cooperating teachers. At the same time I was

taking a psychology course, the Biopsychology of Learning and Memory. We were studying expertise in chess experts and I began to wonder if the differences in chess experts could be extended to explain the differences I was seeing between the cooperating teachers and the novice teachers. Recognizing that there is a world of difference between the knowledge base of teaching and chess, for the design of this study I relied heavily on the literature from teacher development and studies of teaching expertise, while lightly building on the cognitive science research of expertise in chess, tennis, soccer and more complex domains like nursing.

Both research and experience tell us that master teachers see classroom events differently than novices. Master teachers have abilities to see and address the individual needs of their students. Novice teachers, on the other hand, tend to have limited frameworks for processing classroom events. They have simple perceptions of classroom events and of students in their classroom. Novice teachers are also strongly concerned with surviving as a new teacher. Master teachers focus on the salient events of the teaching experience, attending to issues of student learning.

### *Research Focus and Questions*

- How do Novice and Master science teachers differ in their interpretations of a teaching episode?

If you show a Master teacher a video-clip of someone else's teaching, what will they have to say? If you show the same clip to a Novice teacher, will their responses be different? The central research question for this research embodies these thoughts. Perhaps, the differences in their interpretations relate to their personal theories of learning, in other words, how they think people learn. If we can characterize their personal theories of learning will

there be differences between the Novice and Master conceptions of learning?

The two sub-questions of this research address these ideas,

- How do Novice and Master science teachers' perceptions and interpretations of a teaching episode relate to their personal theories of learning?
- How do Novice and Master science teachers' personal theories of learning compare?

### *Theoretical Frameworks*

Three literatures contributed to this research: teacher development, teacher expertise, and cognitive science studies of expertise. The table below represents several key concepts from these theoretical frameworks and the conceptual overlap among the three frameworks. Each literature includes references to schematization of experiences. In the cognitive science studies expertise is characterized by rich connections between schemas.

Schematization allows for flexibility, the ability to anticipate, automatization of skills, and the ability to recall more, and salient, events. Expert chess players could recall the correct location of more pieces on a chessboard than novice chess players (Gobet & Simon, 2000). Expert chess players also process information in parallel, whereas novice players process information about the chess pieces in series (Reingold, Charness, Schultetus, & Stampe, 2001). Consequently, the expert player is able to more quickly determine whether the king, in a small configuration of pieces, is in check. Tennis experts, when showed a segment of tennis play, could more quickly anticipate when the winning stroke had been made. Novice tennis players lacked this ability (Rowe & McKenna, 2001). In studies of teaching expertise, expert teachers recalled more events from the classroom than did novice teachers (Peterson &



Comeaux, 1987). Expert teachers, during planning, anticipated the kind of concepts students would have difficulty with as well as the kinds of questions students might ask. Novice teachers lacked flexibility in bringing student's questions back to the lesson goals, while expert teachers could navigate the variety of different directions the lesson could take and could steer the lesson back to the stated objectives (Borko, Bellamy, & Sanders, 1992). These abilities, attributed to expertise, are explained by the master teachers' schematization of past experiences leading to rich, related networks that the teacher can shift between during planning as well as during instruction (Livingston & Borko, 1989).

Lastly, key concepts from teacher development also include schematization of understandings leading to theory-like comprehension of teaching and learning. Master teachers are also, perhaps because of automatization of the logistics of classroom instruction, less concerned about survival and more concerned about student learning (Fuller & Bown, 1975).

A significant issue for novice science teachers is the changing role of the teacher in the science classroom. Science education reform movements such as those described by the National Science Education Standards (N.R.C., 1996) and the Benchmarks for Science Literacy (A.A.A.S., 1993), for example, emphasize a shift from teaching centered on the teacher's ideas to centered on the students' ideas. To achieve this shift, teachers are instructed to involve the students in constructing knowledge. This shift stands in strong contrast to a classroom where the teacher is the bearer of knowledge and the students are seen as receptacles for the knowledge. As teachers move towards this reform-minded perspective their expectations for student

participation as well as their self-expectations shift (Bell & Gilbert, 1996; Keiny, 1994).

Table 1.1. below, summarizes the overlap among key concepts from the three literatures that bound this study. It illustrates the attention each literature gives to schematization of experiences. Additionally, it points to the similarity of schema description in each literature: automaticity, anticipation, recall, flexibility, and rich connections.

Table 1.1 Theoretical Overlaps

<b>Teacher Development</b>	<b>Teacher Expertise</b>	<b>Cognitive Science</b>
		Automaticity
	Anticipation	Anticipation
	Recall	Recall
	Flexibility	Flexibility
Schemas → Theories	Schemas	Schemas
Rich Connections	Rich Connections	Rich Connections
Concerns		
Role		
Image of Self		

### Research Design

Key decisions made for this research design involve the choice of an episode of classroom teaching, the participants, the sources of data, and the data analysis process. The video-clip was chosen carefully because its design was closely linked to constructivist learning theory. The importance of students' prior conceptions about the science concepts was emphasized in the clip. The 10-minute clip was selected from the "Private Universe Project in Science" professional development series produced by the Harvard-

Smithsonian Center for Astrophysics Science Education Department (1995), and freely available through the Annenberg site, [www.learner.org](http://www.learner.org).

Once the video-clip was selected I then selected the participants. Nationally-board certified teachers with certification in middle school physical science formed the Master group. Pre-service teachers seeking certification in middle school physical sciences, from the teacher education program of a university in the Northeast, formed the Novice group. Seven participants for each group ensured collection of rich data through semi-structured interviews.

The video-clip was split into two segments, Clip A and Clip B. After viewing Clip A the participants were interviewed for their general interpretations of the clip. Interview B, following Clip B, focused the participants more on learning and began to shift their interpretations from a focus on the video-clip teacher's perspective, Robert, to a focus on their own perspective about teaching and learning. The broad questioning allows participants to report what was significant to them from the first of the two video-clips. Asking what will happen next challenges the participants to make a prediction much like the expert tennis players were asked to anticipate the final stroke from a videotaped tennis match (Rowe & McKenna, 2001). Questions in the Clip B interview move the conversation towards issues of learning. Not only do these questions begin to focus the participants on learning but they also begin to shift attention to the participants' personal views.

A week following the Video-clip Interviews, I returned to conduct the Follow-up Interview. Unlike the Video-clip Interview, which aimed to get at their personal theories of learning implicitly by analyzing another's teaching, the

Follow-up Interview aimed to explicitly explore their personal theories of learning.

Data Analysis

The Video-clip Interviews were transcribed verbatim. Data analysis proceeded through both inductive and deductive methods. Inductive analysis proceeded using open-coding, as from Strauss and Corbin (1990). Deductive methods attended to codes drawn from the theoretical frameworks shaping the study (Huberman & Miles, 1994).

Expected Results

Below is a schematic of the results we would expect based on the literature framing this research. We would expect a Master teacher (M.) to interpret the video-clip using a rich schema for teaching and learning, espouse a constructivist theory of learning, and be primarily focused on student learning. We would expect a Novice teacher (N.) to be focused on survival in the classroom, have a traditional view of learning and exhibit a simple schema for interpreting classroom events.

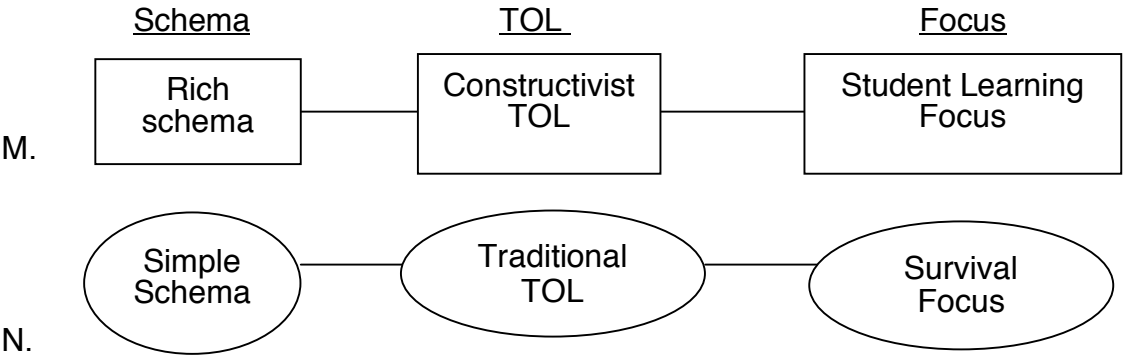


Figure 1.1. Expected Results

In Chapter 2, I describe the three literatures that bound the study. I detail the decisions behind the research design as well as the key themes from the literature that were pertinent for data analysis. Chapter 3 outlines the

research design, giving attention to the interview guides used to collect the data. Following the research design is a detailed description of category development in Chapter 4, Data Analysis. The complicated and rich results of this study are described in Chapter 5. Conclusions and areas for future research are detailed in Chapter 6.

## CHAPTER 2

### LITERATURE REVIEW

#### Introduction

My interest in research of expertise began during my Master's coursework as I investigated transfer of learning in complex domains of knowledge such as transfer of problem solving abilities (Niedelman, 1991) and computer programming in different languages (Harvey & Anderson, 1996). My interest was piqued as a student struggling with problem solving as well as a teacher whose students struggled to transfer what they have learned to new situations. As a teacher I was intrigued by how we could examine learning in experts with the hopes of facilitating learning in novices so new knowledge/understandings might transfer to future professional situations. Years later, while taking a Biopsychology of Memory and Learning course I encountered a study of differences between expert and novice chess players, specifically regarding the role of contextual details: details intrinsic in experiences, in memory formation and learning (Reingold et al., 2001). I took on as a special project a review of studies of expertise and the potential extensions to teaching. As I read studies of chess expertise and expertise in other domains I began to consider whether some of the techniques used during these studies would be suitable for consideration of differences in expertise among teachers, specifically the use of images such as chessboards in studies of chess expertise (Gobet & Simon, 2000; Reingold et al., 2001) and video from tennis matches in investigations of expertise in athletics (Rowe & McKenna, 2001). At this same time I was also working closely with student teachers during their practicum and in this context also began to consider differences between these novices and their cooperating teachers.

As my attention was drawn to differences between the novice teachers and their cooperating teachers, I began to conceptualize this research project. Studies of expertise from the cognitive sciences provide theoretical support in terms of schema development as well as support in research design. What follows is a discussion of the theoretical frames that bound this research study. Following the Frames section is a section explicating the research design decisions I've made considering existing research in teacher expertise, cognitive science and teacher development. But first, I consider the context of this study in terms of perspectives of teaching and learning.

### Contextualizing Teaching and Learning

Theoretical perspectives about teaching and learning are implicitly and explicitly imbedded, not only in teachers' choices and teacher education, but in the American educational system. A teacher's prior experiences of school, other students, and teachers can shape their reactions to the multitude of scenarios that a school day presents. Past experiences of learning create a landscape for a person's understanding of teaching and learning. In other words, people often expect everyone to learn in the manner they themselves learn best (Kagan, 1992). As teachers, their method of instruction, their teaching style, their understanding of what it means to be a teacher, all relate to the context of their past experiences as learners and their experience of their past teachers (Fuller & Bown, 1975; Grossman, 1990; Kagan, 1992; Keiny, 1994; Korthagen, 2001; Stofflett & Stoddart, 1994). However, societal views of teaching and learning impact personal views that shape how teachers think about teaching and learning.

As members of society people are not isolated from societal ideas. Thus our personal theories are constructed, in part, from implicit and explicit

interactions in society, as well as from our own personal ways of making sense of our experiences (Bavelas, Kenwood, & Phillips, 2002). One's experience of society is an experience of historical precedent even as society is newly constructed today. Thus, historical views of the teaching profession are well-woven into the manifestation of modern society. Michael Eraut (1994) describes and analyzes the historical roots of the teaching profession. Part of his explanation for the lower status of teachers in today's society relates to how people become teachers and the nature of teacher knowledge. Eraut explains that teachers have not historically governed entrance into the teaching profession. Entrance was and is issued by state governance. Eraut suggest this devalues teaching as a profession by putting power for entrance into others' hands: teachers are not allowed to govern entrance into the profession and thereby cannot control the quality of individuals entering teaching. Historically, professions grounded in empirically-derived theoretical knowledge were considered more valuable. Practical knowledge is historically less valued because it lacks the well-established theoretical principles found in science. Teacher knowledge, according to Eraut, is an integration of theoretical and practical knowledge. Modern societal views of the teaching profession still persist in considering teaching as a less prestigious profession with an amorphous, and thus less valuable, knowledge base. Though societal views of teaching are not central to the framework for this proposal, the impact they have on a teacher's view of teaching and learning is noteworthy. Regardless of years of experience, a teacher's personal understanding of the role of teachers, their image of self as teacher, and how they think people learn are all influenced by societal and historical messages.



However, it is one's personal prior experiences that create a global perspective through which social-psychological, emotional and situational influences are filtered. These prior experiences as a student can strongly shape a teacher's frame of reference about teaching and learning. Students carry these frames of reference with them from their early education to their college education, into their teacher education, and into their classrooms.

Gonzalez and Carter (1996) conclude not only from their own work but also from the teacher development literature that,

*“. . . novices enter teacher education programs with richly formulated, deeply personal, and quite persistent understandings of what it means to teach. These understandings, derived from being pupils in classrooms, serve as theoretical frameworks within which novices interpret and judge suggestions by educational faculty or classroom teachers and invent a personal meaning of the experiences they have in the field. Experienced teachers also have strongly formulated personal understandings of their teaching, but these are grounded in accumulated experiences over the span of several years. As a result, their explanations reflect a narrative of classroom events.”*

Gonzalez and Carter highlight the deeply personal quality of past experiences and the impact of well-developed frameworks on teachers' practice.

#### Theoretical Frames Bounding Research Design

The teacher development literature is rich with theoretical and empirical reflections on the progression towards expertise, while studies of teacher expertise again provide support for the design of this study. Teacher development, though not often characterized in terms of development of teacher expertise, has been conceptualized from other perspectives including:

changing teacher concerns (Fuller & Bown, 1975), conceptual change (Keiny, 1994; Stofflett & Stoddart, 1994), conceptualizing pedagogical knowledge (Grossman, 1990; Shulman, 1986), schematization of experiences (Korthagen, 2001), developing one's craft (McDonald, 1992), an interplay between social, personal and professional experiences (Bell & Gilbert, 1996), and theory development (Eraut, 1994). I selected the following aspects of development from the teacher development literature to form part of the theoretical framework of this study: shifts in a teacher's role in the science classroom, changes in a teacher's image of self, and development of a teacher's theoretical understandings of teaching and learning. A fourth and last framework considers the extent to which research into expertise in cognitive science shapes schema theory and how teacher expertise relies on schema theory as an analytical frame.

Each of these frameworks, compiled from theoretical and empirical writings highlight what I expected would be issues impacting a teacher's personal theory of learning. Each of the four frames presented is a potential lens through which participants in my research may situate their analysis of the video-clip I will present. More specifically, because of the significance of these issues as presented in the teacher development literature, I anticipated that these would be recurrent themes for the participants and for my research design. The absence of these frames, also a possibility, would be puzzling and noteworthy.

### *The Changing Role of Today's Science Teacher*

The National Science Education Standards (N.R.C., 1996) and the Benchmarks for Scientific Literacy (A.A.A.S., 1993) delineate recommendations for changes in the method and manner of teaching science.

Among the recommendations is a shift from teacher-centered to learner-centered instruction. This changing role, from 'sage on the stage' to 'guide on the side' as the common quip describes, is often an intense renegotiation of "what it means to be a teacher of science" (Bell & Gilbert, 1996). Several studies explore this renegotiation.

Keiny (1994) explored this shift as a change from an instrumental view to a developmental view of the teacher's role. The instrumental view is a more teacher-centered understanding of schooling, while the developmental view is a more learner-centered view of education. Keiny's study suggests a teacher's view of the role played by teachers can shift. In the case of the participants in Keiny's study, that shift was achieved through a structured and supported process of teacher conceptual change. This conceptual change was facilitated by social reconstruction of conceptions about teaching and learning (through group discussion and reflection among the teachers) and opportunities to try out new ideas in the teachers' own classrooms.

Bell and Gilbert (1996) capture the essence of the changing role of science teachers in their study that describes teachers' renegotiation of "what it means to be a teacher of science." This redefinition hinges on the social construction of understandings related to this changed role. The teachers described in the study participated in support programs for teachers implementing constructivist teaching strategies. As such, the kinds of understandings that were enmeshed in "what it means to be a teacher of science" included different expectations for student behavior, classroom management, and student responsibility for learning, all drawn from a constructivist tradition. Past experiences of didactic instruction provided the network of expectations and understandings about teaching and learning.

Social, personal and professional development contributed to teachers' conceptual change about the role teacher's play in the science classroom. Social negotiation among the teachers is essential for making this shift in understanding about the role of the science teacher. The role of a social context for development of alternative conceptions speaks to the power of prior conceptions (drawn from past experiences). In other words, from Bell and Gilbert's view, we would conclude that a community is required to support change of prior conceptions. The socially derived new view of teachers in the science classroom was complemented by a personal acceptance or rejection of the renegotiated role the teacher plays in the science classroom, considered as personal development. Lastly, as Keiny concludes, Bell and Gilbert suggest that the opportunity to try out new ideas in the classroom was a necessary component of teacher professional development. Social, personal and professional development, as described by Bell and Gilbert, each contributes to renegotiation of prior understandings of the role of the science teacher. They stress, however, that it is the social component on which development hinges.

Stofflet and Stoddart (1994) addressed conceptual change in science teachers. For teachers to make a shift to a conceptual framework in line with current reform views Stofflet and Stoddart explained that prior conceptions about teaching and learning must be addressed and reconstructed. The researchers suggest that teachers, like any other learners, draw from their own experiences for both their understanding of pedagogy and content: teaching as they have been taught and passing on inappropriate understandings of science developed over the course of their education. The researchers hypothesize that teachers' experience of learning science

determines how and what they will teach. The teachers who participated in their study formed two groups and were taught conceptual change learning theory and pedagogical implications using two different methods. The group whose instruction was developed from the perspective of conceptual change learning theory went on to successfully design and implement lessons in line with conceptual change pedagogy. The didactically instructed group neither designed nor taught lessons that aligned with conceptual change learning theory, but instead taught, what the group members called conceptual change lessons in a didactic fashion. The researchers suggest teachers need opportunities to reconstruct their understanding of science and how to teach science. For these researchers, conceptual change pedagogy facilitates reconstruction of understandings and challenges preconceptions about teaching. To renegotiate such a complex understanding of “what it means to be a teacher of science” (Bell & Gilbert, 1996), or in Stofflett and Stoddart’s words, “how and what” a science teacher teaches, prior conceptions must be challenged and understandings reconstructed. To undergo change, teachers from Stofflett and Stoddard’s study needed new experiences of the style they would later use to teach. Thus Stofflett and Stoddart associate change in understanding about teaching and learning with new experiences of teaching and learning that differ from past experiences.

#### *A Teacher’s Image of Themselves as Teacher*

A third aspect of teacher development is the phenomenon of shifting one’s image of self. Other studies have documented the role that prior experiences as students play (e.g. Daley, 1999; Korthagen, 2001). After spending 17-20 years as a student, new teachers experience some fascinating changes during their first few years of teaching. Teachers shift from seeing

themselves as a student to seeing themselves as teachers. Fuller and Bown describe this as shifting concerns, early centered on self-preservation, and later centered on student learning. Both a new teacher's image of self and their conception of teaching and learning, in Fuller and Bown's (1975) account, are strongly guided by past experiences. Past experiences as a student color the new teacher's perspective on how to teach and how students will learn. Past experiences of teachers color expectations of students and self. Not only do new teachers, more often than not, identify with the students they teach rather than the teachers they work with, but they identify with students that resemble themselves. They might proceed to teach informed by their awareness of how they themselves learn best as opposed to using methods informed by the content. At the same time, Fuller and Bown suggest images of one's own teachers, drawn from years of schooling, can exert a strong pull on how new teachers conceptualize teaching and learning.

*Theory Development: Making the Implicit Explicit*

A last significant characteristic of teacher development, for framing this proposal, looks at how teachers access and develop theoretical understandings. Michael Eraut (1994), with his description of public versus private theories, makes a helpful distinction. Public theories are "systems of ideas published in books, discussed in classes and accompanied by a critical literature which expands, interprets and challenges their meaning and theory validity." Emphasizing the relationship between theory and practice, Eraut describes educational theory, public theory, as comprised of "concepts, frameworks, ideas and principles which may be used to interpret, explain or judge intentions, actions and experiences in education or education-related settings." Private theories, in contrast, are "ideas in peoples' minds which they

use to interpret or explain their experience.” There is, of course, a dialectic between public theories and private theories. Eraut defines his use of the term theorize as not building a theory but, “to interpret, explain or judge intentions, actions and experiences.” Private theories do not have to be explicit and might only be recognizable from someone’s actions. Teacher theorizing, according to Eraut, manifests in what teachers do while teaching. Teacher development thus involves the redefinition of private theories. Here we might expect a dialect between private and public theories. Eraut’s notion of private theories might be stretched and compared to preconceptions and understandings about teaching and learning at varying stages of development. This redefinition of private theories could be compared to Keiny and Stofflett and Stoddart’s change of teachers’ prior conceptions about teaching and learning. Eraut explains that teachers’ prior experiences as students and their exposure to society and common conceptions of teachers and teaching yield strong, though maybe not explicit, private theories that guide teachers’ practice. The persistence of these private theories likens them to preconceptions, how an individual makes sense of patterns they see, and in some cases, conceptions that might limit a teacher’s ability to foster student learning.

The work of Korthagen and Lagerwerf (1995) sheds light on the role of past experiences in theory development for teachers. Their work shifts from analysis of student’s levels of understanding science to investigations of teacher development. Korthagen and Lagerwerf describe development of understanding, theorizing perhaps, from gestalts, to schemas, to theories. Korthagen and Lagerwerf suggest, as does Eraut, that theories are well-developed reasonings from personal past experiences. However, Korthagen and Lagerwerf characterize less developed reasonings as gestalts or bare

images. These gestalts are amalgamations of situations a person previously encountered. Gestalts are associated with feelings, sights, sounds, of past experiences that later shape one's reactions to similar events. Schemas are made up of collections of gestalts whose characteristics and qualities begin to be articulated. The implicit begins to be made explicit. Schemas are also associated with interconnections between gestalts. Sometimes, people will develop schemas from multiple related gestalts, creating interconnections between gestalts or even between related schemas. Keiny (1994) describes schemas in a similar way. Keiny describes a conception, not as just an ideology, belief, a philosophy or personal knowledge, but as a comprehensive organized body of knowledge held at a given moment by someone, which includes schemes of concepts. These schemes of concepts, according to Keiny, are rooted in personal beliefs and experiences and influence the way teachers teach and interact with students. For Keiny, the instrumentalist and developmental views of teaching and learning might represent two different schemas, though in a broader sense. Stofflett and Stoddart (1994) also use the term schema to describe the complex nature of changing teachers' understanding of teaching and learning,

*“Teachers must experience the innovative pedagogy first as learners before they can develop intelligibility of the methods being taught. This experience challenges their preexisting scheme for teaching and learning: the subsequent cognitive conflict allows the accommodation to the new pedagogical conception.”*

Similarly, Kagan (1992) references the relationship of past experiences to development of a teacher's image of self as teacher. For Kagan, the image of self as teacher can be reconstructed with new knowledge about students



and classrooms. Cognitive dissonance between past beliefs and current experiences results in changing beliefs and images. In essence, there is a shift from focusing on the self to focusing on the students, specifically on student learning. The consequence of this shift is a change in perspective, now seeing self as teacher. This, Kagan suggests, implies that the schema for a teacher's image of self as teacher and the schema for the image of students change in concert.

Picking up with the last level in Korthagen and Lagerwerf's theory of levels, people can develop theories from their schemas. In doing so, the reasoning and complexity involved in approaching certain situations is made explicit. Master teaching at the theory level is valuable because the teacher is not operating from a gestalt, or initial reaction to a situation, unclarified, ambiguous in motivation and unbalanced in consideration of alternative responses. Rather, Master teachers have developed understandings as rich schemas and can articulate the reasoning behind their choices. There is a point reached, though, when a Master teacher, for example, has such well developed schemas and theories that they can experience what Korthagen and Lagerwerf call a level reduction. Intricate and interconnected schemas and theories can collapse into a gestalt. Such a level reduction allows Masters to respond to situations as if without thought, more automatically. Novices, operating from gestalts, are not aware nor capable of explicating, on demand, the reasoning behind their gestalt-driven choices; whereas, Masters are able to expand their gestalt to the complexity of a theory. According to Korthagen and Lagerwerf, the key to teacher development through these levels is reflective practice. The value and role of reflection in teacher development is

echoed by Eraut (1994), Kagan (1992), Keiny (1994), Fuller and Bown (1975), Shulman (1986), Grossman (1990), and Rogers (2002), for example.

### *Schema Development in Expertise*

The bulk of schema theory can be found in research on expertise in cognitive science. Experts with rich schemas often show qualities such as automaticity, anticipation, and salience. These qualities derive from well-known research on expertise in a variety of knowledge-domains including chess, soccer, golf, tennis, springboard diving, and nursing. The two latter domains more closely resemble the domain of teacher knowledge than the former four, teacher knowledge being more complex and less rule-governed. However, important insights into schematization of experiences from each of these domains support my research.

Considering automaticity as a characteristic of schematization, expert springboard divers (Huber, 1997), chess experts (Reingold et al., 2001), expert tennis players (Rowe & McKenna, 2001), and experts soccer players (Beilock et al., 2002) all exhibited automatic processing of their skill during execution. As would be expected, when expert soccer players were asked to dribble a soccer ball through cones using their dominant foot while executing a second task, they greatly out dribbled the novices. When asked to bring their attention to a component of their dribble the experts' times rose indicating a decrease in efficiency. The authors concluded that expertise is held outside working memory. The automation is interrupted when paying close attention brings the skill to working memory, leading to more time needed to complete the task.

Novices in studies of nursing expertise (Daley, 1999) and springboard diving (Huber, 1997) provided relatively superficial explanations for how they

learned and how they executed a dive, respectively. The experts in both these studies showed more sophistication. Divers associated richer concepts with executing their dives, and nurses had richer narratives about their own learning. In terms of salience, the expert nurses and divers each attended to the more salient components of their experiences. The expert divers narrowed their focus to the most important factors in dive execution: the impact of the wind and their body position in relation to visual markers for example. Likewise the expert nurses were better able than the novices to narrow their focus to the characteristics of a new and challenging experience that were salient.

Anticipation and flexibility are hallmarks of expertise not only for the nurses and divers mentioned above but also for tennis experts. Tennis experts (Rowe & McKenna, 2001) better anticipated the last stroke in a video of a tennis match. The novices could not as easily anticipate.

The ability to anticipate, the automation of skill, complexity in analyses, and attention to saliency can each be attributed to schematization of experiences. Having schematized one's experiences creates interconnections (Reingold et al., 2001). These interconnections lend flexibility to experts' performances that novices lack (Daley, 1999). Experts have these automatic skills while novices do not (Beilock et al., 2002). Complex schemas constructed from vast experience paired with automation of skills allow experts to anticipate what will happen next (Rowe & McKenna, 2001). The richness of an expert's schemas allow them to hone in on salient information (Huber, 1997).

In the studies of teacher expertise most of the researchers who explained their findings used schema theory in some form (Borko et al., 1992; Carter et al., 1988; Livingston & Borko, 1989; Oppewal, 1993; Peterson &

Comeaux, 1987). Schemas, in the studies when a definition was given, were seen as cognitive structures for organizing information. More experienced teachers, having elaborate and well-connected schemas, are able to create contingency plans for lessons based on their ability to consider alternate outcomes of their lesson (Livingston & Borko, 1989), to be flexible during instruction as they take in feedback from students (Borko et al., 1992), and to reflect more richly on their teaching or someone else's by offering alternative interpretations and hypotheses for classroom happenings (Borko et al., 1992; Carter et al., 1988; Livingston & Borko, 1989; Oppewal, 1993; Peterson & Comeaux, 1987). These well-developed schemas allow an expert teacher to excel in the "improvisational performance" that characterizes a teacher's response to "the uncertainty of the classroom" (Livingston & Borko, 1989).

Schema theory is also useful in explaining novice teachers' performances. Novice teachers lack developed schemata, or "frames of reference" (Mostert & Nuttycombe, 1991), therefore plan using detailed written scripts, instruct with little flexibility, and reflect on superficial characteristics of the lesson in a disconnected manner (Jay, 2002; Mostert & Nuttycombe, 1991; Westerman, 1991). Without developed schemata, drawn from years of teaching, novices, using the only frames of reference available, often justify their decisions or interpretations using examples from their own experiences as students (Oppewal, 1993).

With no reference to schema theory or another over-arching principle, the balance of researchers reported results similar to those already mentioned. Expert teachers showed great flexibility in planning as well as in teaching their own lessons (Westerman, 1991). On the other hand, novices had no back-up plans, showed little flexibility in their classroom teaching, and

gave brief descriptions of classroom events (Gonzalez & Carter, 1996). When evaluating other teachers' lessons, experts offered complex and rich analyses, while novices usually presented limited interpretations of classroom events (Carter et al., 1988; Jay, 2002; Lin, 1999; Sabers, Cushing, & Berliner, 1991).

### Research Design Decisions in Light of the Literature

This design section illustrates in detail the existing research on teacher expertise and development, paying special attention to works that shaped the research decisions I have made. I've recapped my literature review as the studies I've selected relate to the sections of my research design. My participant choice, data collection, and data analysis decisions are supported by my review of existing literature on teacher development, teacher expertise and cognitive science research on expertise. While the following sections serve as arguments supporting my decisions, the explicit details of my research design are described in the next chapter, Chapter 3 Research Design. I begin, though, with a description of the role constructivist theory of learning played in this research.

#### *A Constructivist Perspective on Learning*

Constructivist learning theory plays a role in this study in multiple ways. It was necessary to ground this research in a well-developed theory of learning and associated pedagogy, so as to provide a framework for considering teacher responses to the video-clip. The video-clip was selected, in part, because it showcases a teacher's implementation of constructivist learning theory.

The work of Driver and associates provides a perspective on constructivism that aligns well with the images in the video-clip. Their theory is a "general framework theory designed to provide science educators with a

perspective on how learning in science occurs” (Driver, 1997). Driver and associates presented a constructivist general framework theory and regarded teaching as a reflexive process. The teacher is considered “theory-maker and problem solver”. From the data I gather in this research I can compare a participant’s personal theory of learning to the tenants of Driver’s theory of learning and in doing so determine to what extent the participant’s theory resembles a constructivist perspective on learning.

First let us consider the overlap between Piagetian constructivism and Driver and associates’ theory for children’s conceptual understanding (Driver, Asoko, Leach, Mortimer, & Scott, 1994):

- Meaning is made by individuals
- Meaning depends on the individuals’ current knowledge schemes
- Learning comes about when schemes change through disequilibrium
- This requires internal mental activity and results in changing a previous knowledge scheme
- Learning is seen as involving a process of conceptual change
- Teaching approaches based on this perspective provide children with physical experiences that induce cognitive conflict and foster children’s development of new knowledge schemes that are better adapted to experience

Driver (1983) beautifully and extensively describes how children bring their own understandings of how the world works into science classes. They have their own frameworks about components of their world (Driver, 1983). Often a child’s constructed understanding is far from similar to understandings scientists have of the same phenomena, for example, the seasons, or why objects fall towards the ground when we drop them. If students are merely told

to learn the right explanations for the examples given, they, according to Driver, will parrot back the right answers, never having internalized the meaning. This happens because they have not experienced the necessary conceptual change from their “alternative frameworks”. Science teachers, aware of these alternate frameworks, work to provide interactive opportunities for students to reconstruct an understanding of these phenomena. The student has new experiences during science class that they integrate into their existing understanding. Given the opportunity and guidance for experiencing the phenomenon, students will often test their ideas about the phenomenon and construct a different understanding of the phenomenon, hopefully a more disciplinary appropriate understanding given their new experiences.

In summary, all learners need to make sense of learning experiences for themselves and are not “receptacles in a knowledge delivery system” (Driver, 1997). Each child has her own purposes, interests, prior knowledge, and experiences. Teachers should be “responsive to individuals’ concerns and interests while making available the benefits of scientific knowledge and ways of thinking”.

According to Driver the significant difference between Piagetian perspectives and her perspective is that Piaget focused on the personal construction of meaning while the theory Driver and associates describe involves both personal and social construction of meaning (1994). The social component “provides the stimulus of differing perspectives on which individuals can reflect.” These differing perspectives can be the source of cognitive conflict, needed as fuel for modifying existing schemes of understanding. Additionally, Piaget was describing the way children make sense of their world while Driver and associates propose how children make

sense of science so that teachers might change their approach to teaching and might take on a specific role. The role teachers take and the changes they might make in their instruction are for the purpose of supporting lasting conceptual change for students. The goal, for teachers, is to support meaning-making for students from perhaps inaccurate understandings of science to accurate understandings of science. To this purpose Driver highlights several implications for teachers that flow from a conceptual understanding of how children learn science (Driver et al., 1994):

- Teachers need to be aware of learners' current conceptions
- Teachers need to recognize that learners can change their conceptions when confronted with strong enough reasons to do so
- Teachers need to recognize that these processes of change are emotionally and intellectually demanding so classrooms should be supporting environments
- Learning outcomes can not be predicted because each learner interprets new experiences in terms of existing conceptions (though a range of possible outcomes is useful for the teacher to have in mind)
- Teachers need to obtain feedback from students to determine success of pedagogical strategies
- Teachers need to modify teaching strategies if problems and uncertainties remain for students (as identified by the teacher)

From these implications the teacher's role becomes clearer (Driver, 1997; Driver et al., 1994):

- To mediate scientific knowledge for learners by being an authority who introduces new ideas or cultural tools to support students in making sense for themselves



- To help learners make personal sense of the way in which knowledge claims are generated and validated
- To provide physical experiences
- To listen and respectfully challenge children's meanings
- To promote reflection and thought by requesting argument and evidence in support of children's' assertions
- To be a guide mediating the child's world and the science world

Both the teacher and the children's peers then provide the sources of challenge and alternative interpretations so that the child can experience the cognitive conflict that allows for personal conceptual change.

Keiny (1994), as was described earlier, explored the shift from teachers' use of an instrumental instructional practice to a developmental instructional practice. Inherent in both of these are perspectives on learning. All of her results suggest that the developmental strategies are more constructivist while the instrumental practices are the established didactic approaches to education. Stofflett and Stoddart (1994) also explore shifts from more didactic instructional strategies to more conceptual change pedagogy.

Constructivism as a theory of learning also inspires instructional strategies. It is possible the personal learning theories held by participants will be exposed by their discussion of preferred teaching strategies, if not exposed as explicit tenets of their own perspectives on learning. From this research I hope to describe what, if any, alternate theories of learning participants might have as well as how closely personal theories resemble constructivist theories of learning.

In this research I used a lesson designed using constructivist learning theory to elicit insights into participant's personal theories of learning. I

attempted to determine if the participants' personal theories of learning resemble constructivist principles and to describe what is not constructivist. As such, the participants' reactions to the video-clip may include references to the role of prior conceptions on student's understanding of science. The participants may respond with reflections on students' common misconceptions about science concepts. The participants were not explicitly informed of the video-clip teacher's pedagogical approach. However, it was expected that the teachers might respond to the video-clip with specific ideas about constructivist learning theory.

### *Participants*

Describing the novice teacher is a relatively simple task; little to no teaching experience certainly would qualify someone as a novice. Students at various stages in pre-service teacher education programs at universities are often the novice participants in studies of teacher expertise. Methodologically and theoretically relevant studies are surveyed here to justify the decisions I've made regarding which participants to use, and later, to justify my research design. Participants in related studies of teacher expertise range from students in their first year of undergraduate teacher education to students in the midst of student teaching (Borko et al., 1992; Carter et al., 1988; Ethell & McMeniman, 2000; Gonzalez & Carter, 1996; Lin, 1999; Livingston & Borko, 1989; Mostert & Nuttycombe, 1991; Oppewal, 1993; Peterson & Comeaux, 1987; Westerman, 1991). Two studies of teacher expertise examined postulant teachers, that is, teachers who have had no educational training but are experts in their subject area. The postulant teachers were then compared to experts and novices (Carter et al., 1988; Sabers et al., 1991). Postulant teachers usually have several years of field experience in the subject area,

perhaps as lab biologists or industrial chemists. A few studies of teacher expertise involved novices at intermediate stages of experience, such as first year teachers, and teachers with fewer than five years of teaching experience (Carter et al., 1988; Sabers et al., 1991). Several studies looked for distinguishing characteristics between pre-service teachers at different stages of their education, e.g. first year students compared to fourth year students in an undergraduate program (Ethell & McMeniman, 2000; Mostert & Nuttycombe, 1991; Oppewal, 1993). The remainder, from the lengthy list cited earlier, compared teachers who graduated, were certified to teach and, at the time of the study, were working as teachers. These teachers were considered experts and were compared to pre-service students at various stages in teacher education programs.

Defining an expert is a more elusive task than defining a novice. In the cognitive science research on chess, expertise is determined by explicit rankings (Gobet & Simon, 2000; Reingold et al., 2001). In research on athletic expertise, such as soccer, golf and tennis, years of experience and rankings were also used to determine expertise (Beilock et al., 2002; Rowe & McKenna, 2001). In Daley's work with nurses (1999) years of experience determined expert versus beginner. Likewise, in teacher expertise, some researchers defined expertise as proportional to the years a teacher has been teaching (Peterson & Comeaux, 1987). However there is no extant agreed upon evaluation of teachers that would lead us to consider every twenty-year veteran teacher an expert. Within the absence of a universal process for evaluating teaching expertise, researchers used proxy measures to identify experts. Often, convenience played a role: student teachers are novices and their respective cooperating teachers are considered experts (Borko et al.,

1992; Gonzalez & Carter, 1996). This choice is not without merit; mentoring could belie an interest in professional development, but is that all that distinguishes an expert from a novice? Other studies of teacher expertise collect their expert participants based on recommendations from local school boards, and in doing so define expertise as the good opinion of others (Livingston & Borko, 1989). Other researchers rely on their own good opinion of the experienced teachers they have worked with and use this evaluation to consider them experts. There is the combination approach of determining expertise by both local opinion and researcher opinion (Carter et al., 1988; Sabers et al., 1991) or years of experience and researcher opinion (Lin, 1999). In these last three studies the researchers observed the teachers and justified their choices through their own expertise as teacher educators. One researcher makes the statement that the experts in the study were selected because their teaching reflects the teacher education program's goals for pre-service teachers (Westerman, 1991). Another researcher (Jay, 2002) used an existing measure of expertise (Berliner, 1988) and the recommendation of the teachers' colleagues to justify their expert designation. Whether defined as years of experience, praise from colleagues, or approval from a teacher education department, such definitions stop short of giving more concrete criteria for expertise. These measures do not have a fine enough resolution for gaining insight into facets of expertise.

The pools of participants were selected for their prior experiences with constructivist learning theory and/or associated teaching strategies. The National Board Certification process espouses a student-centered approach to teaching and learning. As such, the Master teachers, who are all Nationally Board Certified, should have had experience teaching with student-centered

strategies and might have personal theories of learning from which those instructional choices stem. Additionally, the Novice teachers are students in a teacher education program that explicitly teaches future teachers about constructivist learning theory and uses constructivist pedagogical approaches in teacher education instruction. The Novices, even with these experiences, may not have personal theories of learning that relate to a more constructivist theory of learning because the majority of their schooling was, expectedly, didactic in nature. It may or may not become apparent from the results of this study why Master teachers who practice student-centered pedagogy, but are products of didactic schooling, have more constructivist-based learning theories. Also, it is a possibility that some Novices will espouse a constructivist personal theory of learning. Then, what remains for further study is investigation as to whether these Novices use their constructivist personal theory of learning as a guide for their practice during student teaching and during the early years of their career or whether they will revert to more didactic teaching strategies drawn from to their past experience.

#### *Data Collection*

In designing a study to investigate teachers' personal theories of learning I found inspiration in cognitive science studies of expertise. Specifically, studies of chess expertise where participants were shown images of chessboards (Gobet & Simon, 2000; Reingold et al., 2001) and a study of tennis expertise whose participants were shown a video of a tennis match (Rowe & McKenna, 2001). The chess studies focused on automaticity of memory, while the tennis study investigated attention and automaticity of anticipatory skills. I borrowed from these studies the idea of presenting Master and Novice teachers with a videotaped episode of classroom teaching.

Turning then to studies of teacher expertise, I looked for other studies that used video-tape to help me make decisions as to whether my participants would view and respond to their own teaching or to someone else's teaching. Also, since my background and my research interest center on studying science teachers, at either the middle or high school level, I searched for studies of teacher expertise that would meet those criteria.

Several studies I reviewed involved a science and/or math context at either the secondary or the elementary level (Borko et al., 1992; Carter et al., 1988; Gonzalez & Carter, 1996; Lin, 1999; Livingston & Borko, 1989; Oppewal, 1993; Sabers et al., 1991). Of these studies, two asked the participants to watch and analyze video of another teacher's lessons (Oppewal, 1993; Sabers et al., 1991), while two presented slides, made from another teacher's video-taped lesson (Carter et al., 1988; Lin, 1999). Gonzalez and Carter (1996) asked cooperating teachers to reflect on their student teachers' teaching. The student teachers in this study were asked to reflect on their own teaching. Comparisons were made between the kinds of events the cooperating teachers emphasized versus the student teachers' recollections. The remainder (Borko et al., 1992; Livingston & Borko, 1989) asked participants to reflect on their own teaching. In these two studies the participants were interviewed at various points and asked to reflect on the planning and teaching of their own lesson.

A handful of additional studies of teacher expertise employed analysis of video-taped lessons, although these studies examined teacher expertise in other content domains: English (Jay, 2002; Westerman, 1991) and social studies (Mostert & Nuttycombe, 1991; Peterson & Comeaux, 1987). Each of these studies asked participants to reflect on video-taped lessons taught by

another teacher, except the work of Westerman (1991), who used video-tape of the participants' own teaching as part of a stimulated recall interview about the decisions they made while teaching the lesson.

### *Data Analysis*

For most of the cognitive science research supporting this doctoral work the data existed as time increments: time taken to dribble a soccer ball through cones (Beilock et al., 2002), time taken to recognize the king is in check (Reingold et al., 2001) or to recall the arrangement of pieces on a chessboard (Gobet & Simon, 2000), and time taken to predict the last stroke of a tennis match (Rowe & McKenna, 2001). These protocols were often measured in seconds. Measurements in terms of time to complete a task were not useful to my investigation into personal theories of learning. Associated statistical analyses were not helpful for answering my research questions.

For guidance I turned to the teacher expertise studies for guidance. Most studies of teacher expertise included in the earlier literature review explicitly referred to their methods for data collection and analysis as qualitative: think-aloud protocols, semi-structured or structured interviews, and iterative category development (Borko et al., 1992; Gonzalez & Carter, 1996; Lin, 1999; Oppewal, 1993; Sabers et al., 1991; Westerman, 1991). Several of these studies were explicitly situated in qualitative traditions: case study (Jay, 2002), ethnographic methods (Borko et al., 1992; Livingston & Borko, 1989), and grounded theory data analysis methods (Westerman, 1991). The remainder, though they explicitly referred to their methods as qualitative, did not elaborate on what was interpretive about their research. Few if any of the studies claiming to use qualitative methods provide detail about their data analysis. One study (Carter et al., 1988) did not refer explicitly to qualitative

methods but the description of the analysis methods would ascribe their work to a more qualitative domain of inquiry. Several studies analyzed quantitative data, i.e. number and kind of events recalled from a lesson, in conjunction with qualitative data (Lin, 1999; Oppewal, 1993; Sabers et al., 1991). Two studies used predominately quantitative data, i.e. performance on cognitive ability tests and frequency of critical comments, to analyze differences between participant groups (Mostert & Nuttycombe, 1991; Peterson & Comeaux, 1987). It is my view that investigating personal theories of learning is a research focus best served by qualitative data collection and analysis methods that allow participants to express their thoughts and ideas in their own words.



## CHAPTER 3

### RESEARCH DESIGN

#### Introduction

I've drawn from the three domains of research presented in my literature review: teacher development, teacher expertise, and cognitive science, to design a qualitative research study that investigates differences between Novice and Master<sup>3</sup> science teachers. In the sections that follow I've attempted to explicate the research design decisions I've made to conduct this study. The central research question and sub-questions are reiterated below.

#### Central Research Question

- How do Novice and Master teachers differ in their interpretations of a teaching episode?

#### Research Sub-questions

- How do Novice and Master teachers' perceptions and interpretations of a teaching episode relate to their personal theories of learning?
- How do Novice and Master teachers' personal theories of learning compare?

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<sup>3</sup> Most research on teacher expertise uses the term "expert" to categorize developed or experienced teachers. I have chosen to refer to those teachers who would usually be called "experts" as "masters" instead. I feel that the title "expert" is too often associated with a wealth of factual knowledge. Alternatively, I feel that the designation "master" captures both the advanced skill as well as the craft nature of teaching. When discussing participants in my research I refer to Novice and Master teachers. I've chosen to capitalize "novice" and "master" when I use these terms to refer to the two groups of participants in this research. In cases referring to participants from the supporting literature I retain the lowercase lettering.

## Participants

In this research study of teacher expertise, I designated pre-service science teachers as Novices. The Novices are matriculating from a program that espouses constructivist learning theory both explicitly and implicitly. Each of the seven Novices, by the time of the study, had completed two semesters of field experiences. Two of the Novices had completed their student teaching practicum. All seven Novices are between 20 and 35 years old. Considering that past studies of teacher expertise, described above, struggled to adequately define master teachers, I designated Nationally Board Certified science teachers as Master teachers. The seven Master teachers were each over 45 years of age. One Master teacher was about to retire. Several of the Master teachers had experienced career changes and thus had been teaching for less than fifteen years. The National Board Certification application and evaluation process is guided by criteria directly related to the National Science Education Standards (NSES) and the American Association for the Advancement of Science (AAAS) Benchmarks as well as current educational research. The Master teachers were therefore chosen because we would expect them to espouse reform-based perspectives on learning. Before National Board Certification it was difficult to justify a teacher as a master beyond student and colleague praise. With the availability of National Board Certification, having criteria related to NSES and AAAS teaching standards, it is hoped that this select group will become subject for further study (N.R.C., 1999a).

Choosing to have Novice and Master teachers respond to a constructivist-based episode of science teaching is intriguing because such teaching is highly valued in reform efforts in science education (A.A.A.S.,

1993; N.R.C., 1996, 1999a), yet could be seen as a passing trend and be rejected by others. It is not clear why some teachers support this kind of teaching and others don't. Research suggests that teachers' past experiences of schooling strongly shape their choices as teachers (Bell & Gilbert, 1996; Korthagen, 2001; Stofflett & Stoddart, 1994) Also, research suggests that as teachers develop, their concerns shift from survival to concerns for student understanding (Fuller, 1969). Constructivist-based methods are often associated with more learner-centered instruction (A.A.A.S., 1993; N.R.C., 1996, 1999a). As such, Master teachers might be more likely to espouse constructivist-based teaching methods, while Novice teachers may be drawn to more didactic methods that allow them to better control the classroom environment as they try to stay afloat.

#### Data Collection

Informed by the research summarized in the literature review, I decided to ask teachers to analyze someone else's teaching in the form of a video-clip from a middle school science lesson. Two reasons for this choice are 1) wanting participants to have a common stimulus and 2) expecting participants to be more openly critical of another teacher than they might be of themselves. Videotape preserved the flow of the lesson and the teacher-student and student-student interactions, as opposed to slides, still frames, or silent footage that would remove a sense of continuity and eliminate the valuable dialogue between teacher and students and among students. The video-clip was shown in two segments, Clip A and Clip B, each about six minutes in length. Semi-structured interviews elicited participants' recollections and interpretations of the video-clip lesson. The Clip A interview centered on general reactions to the video-clip as well as recollections about the segment.

During the Clip B interview, participants were focused, by the interview questions, to reflect on learning in the context of the viewed lesson. While the interviews about the video-clip attempted to explore a participant's implicit theory of learning, the follow-up interview, a loosely-structured interview in the days following the video-clip interview, explicitly investigated the participant's theory of learning. The video-clip interviews and the follow-up interview were recorded using a digital voice recorder. I transcribed the Video-clip Interviews verbatim. Using the Transcriva (Padilla, 2004-2005) transcription software allowed for transcription from a digital audio recording.

#### *Video-clip Description*

The two video-clips served as a common stimulus for the participants. Clip A and B are two of seven segments from a lesson on friction. Clip A begins with a teacher inviting the students in a seventh grade physical science class to the front of the room with their chairs and notebooks. The teacher, Robert, shows the students a brick and a block of wood. He asks them to think about how far the brick and wood would each travel if pushed equally hard along the floor. The students share their ideas about what would happen to the brick and block and why. Robert then facilitates a class discussion about how the students think they could make friction more and less, to use his words. Clip A concludes with a brief reflection by Robert outside of the classroom. He scratches his head as he relates that this is Day 3 of the lesson but he is still on Day 1 of his lesson plan.

Clip B picks up with students working in groups as they create posters about different kinds of friction and how they would increase and decrease friction in those instances. Robert moves from group to group. He stops at one group to advise them. They are disagreeing about whether there is friction in

air. He validates their disagreement and suggests that they present both views because other students might share either view. Each group then presents their poster with their ideas about friction. The students field questions from their peers. One group is discussing their understanding of rolling friction. Their perspective brings probing questions from students about carnival games and bowling. The class gets caught up in a debate about the reasons why, as they've experienced in bowling, a gutter-ball slows down. Clip B ends with several different explanations from the students about the science behind rolling friction.

The design and implementation of the lesson is consistent with constructivist learning theory (Driver, 1983). In Clip A the teacher begins by eliciting student ideas. In Clip B the students begin to articulate and later defend their ideas. Driver describes how students' preconceived alternate frameworks about science are difficult to change unless the student has direct experience with the scientific principle and the opportunity to explore their own ideas. It is this comparing one's own ideas to more scientifically acceptable understandings of the principle that leads to reconceptualization of one's framework towards a more scientifically orthodox understanding.

How the teachers react to the video-clip should shed light on their personal theory of learning from an implicit perspective. The follow-up interview, on the other hand, explicitly addressed their personal theory of learning as well as past experiences of constructivist based teaching strategies. Considering the research mentioned in the literature, past experiences may alone explain differences in the results. For the follow-up interview I chose questions that could be presented in any order as the conversation progressed. This more open-ended approach let the

conversation naturally develop. I informed the teachers that the follow-up interview was all about them and how they thought about learning. We created an educational narrative as they talked about memorable teachers, what kind of student they were in school, and discussed critical incidents in their understanding of how people learn.

All of the Master teachers have achieved National Board Certification. Part of the intensive application process involves submitting videos of their teaching for analysis by others. They might also have written about their own interpretation of their video. Thus, viewing and analyzing the clips may be a familiar professional experience.

I chose consecutive clips so as to maintain continuity between the parts of the lesson. These two particular clips were chosen because they juxtapose two different images of the teacher. In Clip A the teacher is at the front of the class and is doing most of the talking. In Clip B the teacher hardly speaks, moves from group to group, and stands in the back during the presentations, offering encouragement but no clarification. However, though the teacher's role changes, in both clips the students' ideas are central.

Robert is neither a highly experienced teacher nor is he a pre-service teacher. He has several years of teaching experience, but is new to this class of students. Though he designed the lesson, this is his first time teaching the lesson. Some of the interactions we see between Robert and the students are those of a less experienced teacher while at other moments we see a more experienced teacher. Robert reflects on being behind in his lesson plan. These reflections provide opportunities for the Novice and Master participants to identify with him, give him advice, admonish him, etc. Additionally, Robert does not correct student's views about friction. This withholding again provides

opportunities for the participants to react with support or criticism. Both clips are edited so they are able to span several days of interactions. Being an edited compilation there are ample opportunities for the participants to work out what they think happened between Clip A and B. All of these qualities, in addition to others discussed in this section, make the two clips excellent choices for eliciting differences between the Novice and Master teachers and to reveal their personal theories of learning.

### *Interview Guides*

As described above, the participants viewed the video-clip in two parts: Clip A and Clip B. Clip A of the video-clip lasted approximately 6 minutes. The Clip A interview involved broad questioning while the Clip B interview focused on student learning. Both are structured interviews. Discussion of the purpose behind the questions in each interview and hypotheses about participant reactions, when relevant, follow below.

#### *video-clip a interview guide.*

The Clip A questions are intended to be broad and not leading. The purpose of these questions is to cast a large net for interpretations of and reactions to the video-clip. The teachers' initial frames of reference for interpreting the video clip may in fact have very little to do with learning. Beginning with such a broad set of questions allows for other, unanticipated differences between and among participants to surface.

#### **1. What do you recall? About the students, teacher, lesson?**

I would expect Novices to attend to issues related to classroom management and control as is seen in the literature, i.e. (Fuller & Bown, 1975). I expect the Masters to be more concerned with student learning rather than classroom control. Additionally, it will be interesting to see if Master teachers recall more

or different events from Clip A as compared to Novices as was seen in studies of both chess experts (Gobet & Simon, 2000; Reingold et al., 2001) and expert teachers (Borko et al., 1992; Gonzalez & Carter, 1996).

**2. What would you say was happening during this part?**

**3. From what you've seen, what would you say were his goals or objectives?**

Questions 2 and 3 ask participants to move from a general interpretation to a more specific interpretation. Asking participants to first summarize what they saw prepares them for abstracting from observations, and for making inferences about Robert's goals and objectives for the lesson. The Novices may not be able to abstract and put themselves into the teacher's shoes while the Master teachers may make this leap easily.

**4. Do you think he was successful?**

Asking the participants to evaluate Robert's success at meeting his objectives and goals provides some insight into how the participants define success. This is the first question that also gives a glimpse into the participant's personal theory of learning.

**5. What do you think will happen next (in the lesson)?**

**6. What would you do next?**

Questions 5 and 6 are linked in that they both ask the participant to reason forward based on what they've seen so far. Question 5 asks participants to anticipate, based on what they have seen so far, where the lesson will go next. Considering both research on expert teachers (Borko et al., 1992; Livingston & Borko, 1989; Westerman, 1991) as well as tennis experts (Rowe & McKenna, 2001) I expect the ability to anticipate will be more developed in Master teachers than Novice teachers. Question 6 asks them to be the teacher and



consider where they will take the lesson. Novices, lacking flexibility and highly interconnected schemas, may not be able to speculate about where they would go with the lesson. Question 6, like Question 4, also gives a glimpse into the participant's personal theory of learning because they are sharing what teaching choices they would make and perhaps what teaching strategies would be comfortable for them.

### **7. Were there any other thoughts you'd like to share?**

This question provides an opportunity to gather ideas and insights that may not have been prompted by the previous interview questions. Participants can comment on any issue/topic they find important or noteworthy.

*video-clip b interview guide.*

The interview after participants watch Clip B focuses them on issues of lesson design and student learning. With this more focused approach I am attempting to specifically get at a participant's personal theory of learning. The questions in the Clip B interview build on each other to achieve a single end, moving the focus from the teacher in the clip, Robert, to the participant. As we progress from Question 8 through to Question 13 there is a natural development, moving from describing the reasoning behind Robert's actions in terms of student learning to describing the participant's preferred style of teaching and their own reasoning.

### **8. What do you think the teacher was trying to accomplish here?**

Question 8, like Question 1, asks for a summary. The second clip is structurally different from the first clip, though it would be expected that the participants would recognize how the design of the second clip is intended to achieve the same goals as the first clip. There may be differences between Master and Novice teachers' abilities to conceptualize someone else's lesson

design. Master and Novice teachers might also differ in their ability to recognize lesson goals other than content learning, such as notions about scientific inquiry, in addition to the typical science content of the lesson.

**9. From what you saw, what would you say the students were learning?**

Question 9 asks participants to infer from their observations whether learning was happening. This question strongly focuses the participants on student learning. Hopefully it will lead to participant reflections about what learning looks like and the evidence on which such claims can be made.

**10. Why do you think he's organized his teaching this way?**

**11. Do you think this organization supports student learning or interferes with student learning?**

Questions 10 and 11 ask the participants to speculate on Robert's reasoning for the lesson structure and to take a position as to the effectiveness of the lesson in terms of student learning. The justifications the participants offer for both questions will reveal additional insights into their personal theory of learning.

**12. Would this lesson/teaching style have worked for you?**

**13. What would you have done differently?**

Both Questions 12 and 13 allow the participant's views on teaching and learning to become central. These two questions are the culmination of the interview, bringing to light their own teaching style and the reasoning behind their choices.

**14. What advice or feedback would you give Robert?**

With Question 14, I attempt to determine what qualities the participant values for both teachers and teaching style. The Novices may have more superficial

suggestions regarding mannerisms, vocal style, or classroom organization. The Master teachers may focus on lesson design or student understanding.

**15. What do you think is Robert’s level of experience?**

This question developed from one of the pilot interviews I conducted. The experienced teacher independently offered her own ideas about how long Robert had been teaching as well as her reasoning behind those ideas. I began to wonder if there would be differences in how the Novice and Master teachers evaluated Robert’s level of experience, so I added the question to the interview guide.

**16. Did you notice the clip titles?**

There are two subtitles that run at the beginning of each clip. The first says “Eliciting student ideas”, the second “Students present and defend their ideas”. I was very curious to know whether the participants registered these titles. One explicit way to find out is to ask them outright. Another way is to look at the language they use as they respond to the questions. If they use similar language as the titles, it might suggest that they registered the title and used that knowledge to answer the questions rather than providing an original response.

**17. Were there any other thoughts you’d like to share?**

This question is, again, one that allows participants to bring up any issues they would like.

*follow-up interview guide.*

A loosely-structured follow-up interview was conducted in the days after the participants watched the video-clip. These interviews were conducted in person. The time between viewing the video-clip and the follow-up interview allowed the researcher to review the video-clip interview for salient comments

regarding learning for the participant to elaborate on in the follow-up interview. Because of this the questions below were modified once the researcher included alternative questions based on the video-clip interview. For example, after listening to Master Teacher Mercedes' video-clip interview I returned to her comments about X-ing out wrong ideas. I asked her how she gets rid of student wrong ideas. I also pressed her to explain in more detail the role misconceptions play in her teaching and her students' learning. The intention of the follow-up interview is to explicitly explore a participant's personal theory of learning.

Because a person's existing ideas will form the conceptual ecology that will allow them to assimilate, or accommodate, new information (Strike & Posner, 1992) teachers' previous experiences of teaching and learning will strongly influence their beliefs about how people learn. With this in mind, the follow-up interview included questions about the participants' past experiences of teaching and learning. Below are questions that were used and conjectures about possible variations in Novice and Master teachers' responses to each question. These conjectures, along with those from the video-clip interview, helped shape the anticipatory context (Huberman & Miles, 1994) for data analysis presented in the next chapter. Potential responses, below, were derived from the teacher development literature, research studies of teacher expertise, and cognitive studies of expertise, and are so noted. In line with the more open-ended nature of the follow-up interview, the order of the questions varied from participant to participant.

**1. Begin with questions developed out of the video-clip interview.**

Some participants made comments during the video-clip interview that were particularly salient for the insight they gave to their personal theory of learning.

I asked participants to clarify what they meant, or to begin by describing again the situation they mentioned. In each case the comment provided the opening for the follow-up interview.

**2. In your experience with students, how do you know that a student has learned something?**

Question 2 speaks directly to the participants' understanding of learning. We would predict that a Novice teacher would consider student engagement as a sign of learning and that a Master teacher would emphasize the student applying what they've learned to a new situation. Both of these examples fit within the established literature about novices being more focused on classroom management (Fuller & Bown, 1975). The Novice teachers may not yet show concerns for student learning (Borko et al., 1992; Westerman, 1991). Master teachers may also refer to student wrong ideas as sources of insights into current student understanding and learning, while the Novice teachers may view these only as mistakes.

**3. How do you learn best?**

- a. How do you know that you have learned something?**
- b. Suppose you got interested in X. How would you go about learning about X?**
- c. How did you figure this out?**

I expect answers to Question 3 to vary by participant. The Novice teachers' responses may relate to recent learning experiences such as how to prepare for a college course final exam, with heavy emphasis on memorization and dependence on textbooks. Master teachers, like expert nurses (Daley, 1999) may rely on colleagues as well as their own past experiences rather than on textbooks as they approach various teaching challenges.

**4. How do your students learn best? What do your students need in order to learn?**

Question 4 asks the participant to describe their students' learning. Novices have had limited classroom experiences and will not be able to answer this question. This question may or may not reveal differences in how the Master teachers conceptualize learning.

**5. How do you think people learn? Can you support your perspective with examples from you own teaching?**

Master teachers' language may involve aspects of constructivist learning theory such as preconceived ideas, past experiences, or misconceptions. Novice teachers may concentrate on classroom management as they haven't yet moved to focus on issues of student learning (Borko et al., 1992; Kagan, 1992; Lin, 1999; Oppewal, 1993). Novice teachers may be more didactic in their view of the role of the teacher in the learning process (Bell & Gilbert, 1996; Keiny, 1994). Master teachers may describe the teacher's role as more facilitative.

**6. Was there a critical incident in your understanding of how people learn? What was that incident?**

The Master teacher is more likely aware that not everyone learns the same way, mostly from experiences in their classrooms, perhaps specifically from lessons that did not go well, while the Novice teacher may base their perspective on what they have learned about how they themselves learn best.

**7. What kind of student were you in college, high school, middle school, and elementary school? Did you have a favorite teacher?**

Again, the answers to this question will likely vary from participant to participant. The answers may or may not be valuable in helping to

characterize the participant's theory of learning. There may be some connection between a beloved teacher's teaching style and the participant's preferred learning experience; then again, there may not.

**8. What led you to become a teacher? How did you decide to go into teaching? Why did you become a teacher?**

Question 8 clarifies a portion of the participant's history. Learning about the participant's past and their motivations could be valuable to understanding how they think about learning.

**9. Why did you pursue National Board Certification? What was the experience like?**

This question, only for the Board Certified teachers, was included merely because of my curiosity about the certification process. Answers could also serve to elucidate some of the motivations that guide my participants.

**10. Some people say that teachers teach the way that they were taught. Others say we teach to suit the way we learn. Do you agree with either of these statements? Why or why not?**

Wording this question to lead the participant towards two opposing views was purposeful. Question 10 was intended to be provocative. I expect the Novices will take a position, siding one way or another, while the Master teachers may delineate a middle ground, perhaps disagreeing or agreeing with both statements. This question asks the participant to make a connection between views of learning and views of teaching. Responding to Question 10 involves making a metacognitive jump from how the participant thinks about learning to the reasons teachers, as a whole, teach in a particular style.

The above questions were designed to elicit the following notions: the teacher's past experiences with constructivist pedagogy or other constructivist

learning theory, the teachers' prior experiences of science classes, the kind of student they were, the kind of instructional strategies they like, and their personal teaching and learning style. Taken together, these qualities were used, in addition to data from the video-clip interview, to characterize the participant's personal theory of learning.



## CHAPTER 4

### DATA ANALYSIS

#### Introduction

In designing this research project, I drew from qualitative inquiry methods for both data collection and analysis. Significant attention was given to the iterative process of data analysis so as to make the data analysis procedures as explicit as possible (Constas, 1992). Both the video-clip and follow-up interviews are the data sources for comparing how Novice teachers and Master teachers think about learning. The interviews were transcribed and analyzed using both deductive as well as inductive analysis tools. Deductive tools included: anticipated data reduction using the conceptual frameworks that bound this research (Huberman & Miles, 1994) using categories the researcher brings to the data, considered sensitizing concepts (Patton, 2002). Huberman and Miles (1994) suggest conducting data reduction in an “anticipatory way as the researchers choose a conceptual framework, research questions, cases and instruments.” As such, potential categories and responses to the video-clip and follow-up interview were anticipated from the theoretical frameworks supporting this research. According to Huberman and Miles, anticipation has a “focusing and bounding function, ruling out certain variables, relationships and associated data, and selecting others for attention.”

I used grounded theory data analysis procedures for inductive analysis. I let the data speak, as I attended to emergent themes recognized through open-coding (A. L. Strauss & Corbin, 1990). Open-coding, from the grounded theory tradition, and anticipated categories, from the case study traditions, represents a mixing of two qualitative data analysis traditions. Both emergent

themes and anticipated categories are organizational constructs that allow the researcher to represent groups of data drawn from participants' comments (Constas, 1992) and at times are conducted side-by-side (Patton, 2002). To achieve this side-by-side construction I looked for overlap between the data-derived codes and the literature derived codes. I began with the inductive analysis so that data-derived ideas would set the tone for the analysis in total. Once I had completed one pass of the inductive analysis, I then turned to the literature to conduct the deductive analysis. To reflect this sequence the inductive analysis is presented first followed by the deductive analysis, in the chapter that follows. Please note that the theoretical frames bounding this work (and that likewise contributed to the deductive analysis) were established at the onset of the research. As will be discussed in the next chapter, there is considerable overlap between the theoretical frames developed in the literature review and the data collected.

Three main categories were developed from the inductive/deductive analyses: schema, focus, and theories of learning. The diagram below describes the deductive and inductive processes that, side-by-side, led to the three categories. I conclude the chapter with descriptions of the categories along with exemplars. In this research codes are organizing phrases or words that represent a related group of data.

A category is an umbrella for several codes that flesh out the bounds of the category. In the case of the category 'theory of learning', the code onus, which I developed from the transcript analysis, captures comments that place the onus for learning on the teacher as well as comments that place the onus for learning on the student. Both types of 'onus' are critical in describing the participants' personal theories of learning.

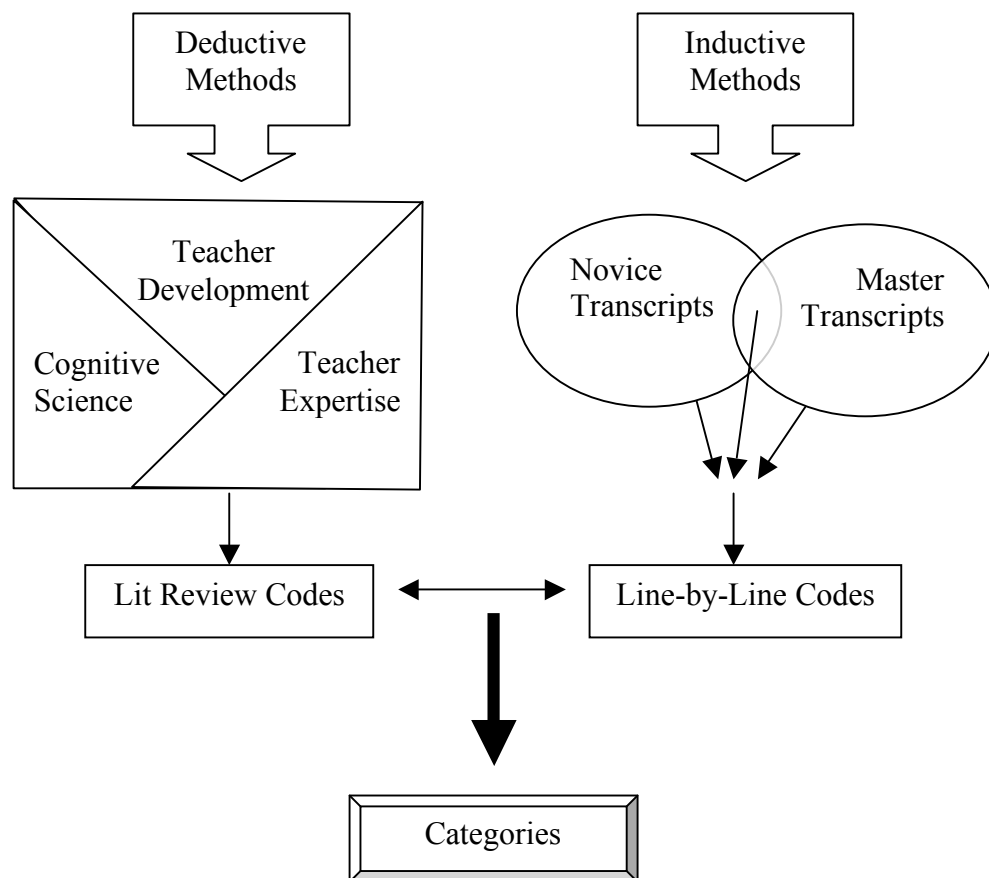


Figure 4.1 Overview of Data Analyses Procedures

The preceding figure summarizes the data analysis procedures used to generate the three main categories and their supporting codes. I began with reading and line-by-line coding of the Master transcripts. Having delineated several codes from these transcripts, I attempted to code the Novice transcripts with these codes. I found little to no overlap. The Master codes were, overall, not useful for organizing the data from the Novice transcripts. I read the Novice transcripts, aiming to generate Novice-relevant codes. I then applied these codes to the Master transcripts with little success. From the two sets of codes I identified the few codes that were common between the two

sets of transcripts. Several divergent codes were also included because they represented significant differences between the two sets of data. I also conducted an analysis of the supporting literature looking for common themes in the results and conclusions of the three theoretical frameworks. I then compared the codes, from the literature, to the codes from the data. A clear overlap resulted in the three main categories: schema, theory of learning and focus for each participant.

### Inductive Analysis Procedures

#### *Getting My Feet Wet*

I began to familiarize myself with the data by reading the Master Video-clip Interviews and looking for similarities. The codes I developed allowed me to begin to get a sense of the landscape of the data and helped me see distinctions within a large amount of data. I then moved on to perform a similar familiarization with the Novice data. The consequences of this ‘getting my feet wet’ are a set of early codes derived from the Master data and the Novice data, all from the Video-clip Interviews.

#### *Master Codes*

I started by coding paragraph-by-paragraph for the Master teachers' Video-clip interview and then moving to a line-by-line analysis. The table below summarizes the plethora of early codes arising from this process. Some of these codes I originally noticed during transcription. I've paraphrased the kinds of participant comments that describe each code. These descriptions are taken from the participants' comments and serve as examples of each code. Notice that each of the codes below is a distinct entity with no organizing category. I started noticing early relationships between codes, as evidenced by the sub-codes for the “Wisdom” code described below.

Table 4.1 Master Codes

<b>Master Code</b>	<b>Description</b>
O: Onus	The student is not the teacher. The responsibility for learning/thinking is on the student.
D: Do something	The students need to do something with the materials they've been asked to think about.
G: Gender	The teacher didn't call on equal numbers of girls. He called on more boys.
P: Puzzlement	I don't know why 'X'. I'm wondering why he did 'X'.
X: Implanted ideas	Take care to avoid dissemination of wrong ideas. Wrong information can become implanted in students' minds. When do we as teachers address misconceptions?
(X): Ok to be wrong	It is ok for students to be wrong. Students will have wrong ideas and it is ok because they are students.
Mi: Multiple intelligences	Students have different learning styles. I do a multiple intelligences survey at the beginning of the year and I use the results to design my lessons.
R: Role	The role of the teacher is that of a facilitator. The teacher is supposed to be the bearer of knowledge and must give the correct information to the students.
W: Wisdom	Students at this age need social experiences. The teacher should be careful with his pacing. This is just like what I did with inertia . . .

After further consideration I separated Wisdom into several components based on the kinds of language I saw in each piece: judgments, knowledge, and future/creative. Judgments involved evaluative comments about the teacher from the video. His instructional strategies, his tone, his mannerisms, and his interactions with students were included in these kinds of statements. The knowledge code involved sharing knowledge about teachers, teaching, and science. All of these statements were stated with authority. I considered these guiding principles from a participant's knowledge base. I'm most

intrigued by characterizations of students in terms of what experiences are age-appropriate as well as identification of knowledge that is grade-specific. Lastly, the future creative sub-code for wisdom included statements either of ideas for the future, on the spot creative contributions for what the teacher from the video could do, or recollections of creative decisions the participant has made in a similar situation. As appropriate as it was to distinguish these sub-codes within the Wisdom code, I eventually realized that Knowledge and Future/Creative were actually linked as parts of narratives or stories told by the participants.

Table 4.2 Wisdom Sub-codes

<b>Wisdom Sub-codes</b>	<b>Description</b>
J: Judgments	What he should do is . . . I wouldn't do what he did. His introduction was good.
K: Knowledge	Kids at this age need to be involved in the learning. Eighth graders need to manipulate the materials. Teachers are . . . Teachers will . . . Discover learning works because . . . Rolling friction and friction in air are similar because . . .
FC: Future/Creative	What he could do would be . . . What he might do . . . Maybe he could do . . . then he could do . . . What I do is . . . What I've done is . . .

### *Novice Codes*

The next stage in my inductive analysis was to try to apply the Master codes to the Novices Video-clip Interview. As I expected, several substantial codes from the Masters were rare or absent in the Novices' Video-clip Interviews. Other Master codes were appropriate for the Novices. It seemed that novices only rarely, understandably, said what they had done, but also

they rarely speculated about what they would do. Nor did they mention any principles of practice. Only a couple of the Novices shared their knowledge about teachers, teaching, and specifically about students. They did not say “Kids at that age need . . .” or “You have to be careful when teaching like Robert is teaching because . . .” I decided to analyze the Novice Video-clip Interviews as a group to develop codes that were unique to them alone. The Master codes did not extend to them; they did not characterize their interpretation of the video clip. The following section is a description of the Novice codes generated from the Novices Video-clip Interviews.

Table 4.3 Novice Codes

<b>Novice Codes</b>	<b>Description</b>
I: I . . . therefore . . .	I find that kind of thing more helpful . . . [so others must].
B: Being the teacher	I have trouble “being” the teacher.
E: Engaged	The students looked very engaged. They were all paying attention and being quiet.
CM: Classroom management	I’m really concerned about classroom management.
CO: Classroom organization	The kids were having trouble writing on their laps. I liked that he had the kids bring their desks up.
LD: Lesson design	What did he do for assessment? When did he introduce formal science ideas?
TIMING: Pacing	This is a long lesson. He seems to be stuck. He needs to move on.
COMFORT: Being comfortable	I don't think I'd be comfortable with that the first year I'm teaching. He seems really comfortable with the students.

### *Aligning the Filters*

After generating the Novice codes from the Novices Video-clip Interviews, I then coded the Master Video-clip Interviews using the Novice

codes. There was some overlap but not much. The following chart summarizes whether each code from my initial pass is predominately a Novice code, a Master code or both. I've also noted, with asterisks, which codes are more intriguing. Some of these codes are interesting because they relate to both my central/sub research questions and to the literature framing this research. Other codes are interesting because they are specific to the Novice or to the Master teachers.

Table 4.4 Code Origination

Origination		Code
N		Class management*
N		Classroom organization
N		I . . therefore*
N		Engaged*
N		Comfort
N		Lesson Design
N	M	Onus*
N	M	Do something*
N	M	Gender
N	M	Timing
N	M	Puzzlement
N	M	Role*
N	M	X-out wrong ideas*
	M	(X) Wrong ideas are ok*
	M	Knowledge*
	M	Judgments*
	M	Future creative*
	M	MI, learning styles*

Next I purposefully returned to my research questions and to my literature review to begin the deductive analysis process.

#### *Deductive Analysis Procedures*

The dual purpose of the video-clip interview and follow-up interview is to consider differences among the participants and to get at participants' understanding of how they think people learn. Similarities and differences



between novices and experts, as presented in the literature on teacher development, teacher expertise and cognitive science expertise studies, are natural starting places for data analysis. After generating the deductive codes from the literature I saw clear groupings, resulting in categories. These anticipated categories developed from the literature are: focus, perspective, personal theories of learning, and schemas. Below is a summary chart of the anticipated categories and codes developed from the literature as well as more detailed descriptions of the categories.

The chart below summarizes each anticipated category and related codes as well as providing a brief description of the category. A detailed discussion of each category follows below. These categories align to the key concepts highlighted in Chapter 1 Introduction.

Table 4.5 Anticipated Categories

<b>Anticipated Category</b>	<b>Codes</b>	<b>Description</b>
Focus:	on student learning on self-preservation	There is a shift during teacher development from focus on self to focus on student learning. There is a shift during teacher development from focus on control in classroom to the intricacies of the teaching process, often linked to student learning.
Perspective:	image of self as student image of self as teacher	Pre-service teacher identity is aligned with the students in classroom. Master teacher identity is aligned with being the teacher in the classroom.
Personal theory of learning:	role of science teacher onus for learning	Teachers have conceptualizations about how students learn and how teachers should teach. The science teacher is a facilitator and guide. The science teacher is the bearer of knowledge. The onus for learning is on teacher. The onus for learning is on student.

Table 4.5 (Continued)

Schemas:	superficiality and simplicity depth and complexity automaticity anticipation saliency flexibility	Schemas are central to development of expertise. Schema development, or lack there of, results in: - Novice analysis is more superficial; analyses are simpler. - Masters exhibit more depth and complexity, characterized by interconnections, in both their analyses and breadth of knowledge. - Masters exhibit great mental flexibility and strong anticipatory skills. - Novices lack mental flexibility and have weak or absent anticipatory skills. - Masters have automated skills. - Novices lack automated skills. - Masters have the ability to identify salient info during planning and teaching.
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*Focus and Perspective*

An obvious category, because of its prevalence in the literature, involves a focus on student learning as opposed to a focus on classroom management. The more experienced the individual is the more focused they are on student learning. Less experienced individuals are more focused on self-preservation. The best instantiation of the concepts characterized by this category are described by Fuller and Bown (1975) as shifting concerns new teachers experience as their focus changes from centered on survival to centered on student learning and achievement. Survival encompasses concerns about classroom management, control of the classroom, student engagement, preparation of detailed scripts for lessons, etc. Supporting examples are drawn from Westerman's (1991) study in which expert teachers' decision making during lesson planning focused on student learning while novices' planning focused on prescribed lesson plans.

Another well known distinction between novices and expert teachers is the shift in identity as a teacher negotiates the culture shock of moving from one side of the desk to the other (Kagan, 1992). Other instances supporting this distinction involve novice teachers using their own experiences as students to justify their judgments rather than taking a teacher's perspective in making judgments (Oppewal, 1993). I'll take a brief tangent to explore an important nuance in evaluating this category. Though both novice and master teachers use, at times, language that puts them in the student's shoes, they do it very differently. A novice teacher, such as one from Oppewal's study above might take a student's perspective when evaluating the teacher's choices, "I wouldn't like that." I've at times heard master teachers say, "If I were that student I wouldn't like that." At first I was puzzled because here was a master teacher taking a student's perspective. I've thought of some ways to distinguish between these two, as I consider, distinct perspectives. The novices are using a student's perspective, drawn from their past experiences as a student (novice), their own perspective. The master is taking a student's perspective, not their own. Often a master will take someone else's perspective: "one of them" from a specific student population. The master takes on the perspective of a particular student or a generic student from any of their classes. It is more difficult I imagine to take the perspective of a particular student, especially when that student's context differs greatly from one's own. We would expect the master teachers to be better at taking on another's perspective than the novices, and more experienced master teachers to be better than less experienced master teachers. Perspective taking may relate to more well-developed schemas. The ability to consider alternate explanations might also be a hallmark of expertise. We would expect

teachers with this notion of perspective taking to be more constructivist in their theory of learning because constructivism is grounded in personal construction of meaning. Someone espousing this belief would therefore be strongly aware that other perspectives exist.

### *Schemas and Personal Theories of Learning*

Considering the superficial discussion of schema theory or the generalized theoretical frameworks used by existing studies of teacher expertise, I drew from well-developed applications of schema theory. Korthagen and Lagerwerf (1995) describe a learning theory that is used to analyze the participants' understanding of how people learn. This choice, of a constructivist-based approach to understanding learning, is particularly reasonable considering the strong emphasis in the literature on the constructivist nature of learning for all learners, children as well as adults (Bell & Gilbert, 1996; N.R.C., 1999a; Stofflett & Stoddart, 1994). Researchers in teacher education are charged by the National Research Council to study teachers as learners, as well as to design and evaluate teacher education programs and professional development programs using the lens of the science of learning, as described by the National Research Council (1999a; , 1999b).

Korthagen and Lagerwerf's (1995) theory of levels suggests that people have developed gestalts or bare images from their experiences that shape their reactions to events. These gestalts are amalgamations of situations they've encountered before. Sometimes, people will develop schemas from multiple related gestalts that allow them to approach similar situations from the point of view of their schema for such situations. Lastly, and most rarely,

people can develop theories from their schemas that make explicit the reasoning and complexity involved in approaching certain situations.

Using Korthagen's ideas of gestalt, the Novice teachers may operate from their gestalts while the Master teachers may have schemas or even theories that shape how they interpret the video-clip. Novice teachers may lack the ability to describe the reasons behind their answers to the interview questions, operating from a gestalt framework while Master teachers may have richly developed schemas or even detailed theories. Some of the misconceptions evident in the Novice teachers' understandings will relate to raw and unexplored gestalts. Master teachers may also have gestalt level understandings of how people learn, but after years of exploration and experimentation, they may have experienced a level reduction from theory to gestalt, in so much as their use of their theory becomes automatic. Upon questioning though, they should be able to expand their gestalt to describe the theory that drives their lightning speed decision-making.

Eraut's description of private theories also suggests explanation for how people interpret events. These private theories, which may or may not be influenced by well-documented academic theories, are, like Korthagen's gestalts, strongly influenced by people's past experiences (Eraut, 1994).

#### *Meshing Deductive and Inductive Analyses*

Below is a table describing the overlaps between the codes derived from the deductive analysis of the three literatures and the codes inductively derived from the Video-clip Interview data. Not all the codes from the inductive analysis are included, only those that were most relevant to the research questions and that could be related to the literature. I've attempted to match the inductively derived codes with their counterparts from the literature. The

inductive codes in the Schema category would be useful for identifying in the participant transcripts characteristics of schemas, such as described by the anticipated codes. Likewise, coding for “X-out wrong ideas” in the participant transcripts, would give insight into a participant’s personal theory of learning, as would comments about role and onus. The literature also supports that role and onus are notions that shape a participant’s view of learning.

Table 4.6 Code Overlaps by Category

<b>Categories</b>	<b>Anticipated Codes</b>	<b>Inductive Codes</b>
<b>Schema</b>	Schemata Superficiality/simplicity Depth/complexity Automaticity Saliency Flexibility	Knowledge Future Creative Judgments
<b>Theory of Learning</b>	Personal theories of learning	Do something X-out wrong ideas (X) Ok to be wrong MI/learning styles
	Role Onus	Role Onus
<b>Focus</b>	Student learning Survival	Engaged/comfort Classroom management Lesson design Timing
	Perspective as student Perspective as teacher	I . . . therefore Being the teacher

From these overlapping codes I developed the three main categories, above, and related codes that were subsequently used to characterize each participant’s schema, theory of learning and focus. The first column in table 4.7 below indicates whether the code originated from the data, from inductive methods (D) or from the literature through deductive methods (L). The second column indicates the initial code name. The third column reflects the final name of each code or consolidation of codes.

Because Knowledge and Future creative were inextricably linked in the stories told by the participants, I eventually decided to code for Storying/knowledge. Only select questions were helpful in determining the schema development. Flexibility and automaticity cannot be coded for in the text of the data. However, by looking at certain patterns, such as the progression of ideas, I could make claims about the mental flexibility of a participant. Progression of ideas is described in the next section.

Table 4.7 Schema Codes

<b>Schema Category</b>		
<b>Origin</b>	<b>Initial Code Name</b>	<b>Schema Code</b>
D	Judgments Knowledge	Evaluate Storying/Knowledge
L and D	Future creative	
L	Flexibility Automaticity Salience	Progression of ideas

Both Role and Onus, in table 4.8 below, originated from the data and the literature, and could easily be coded. Often a participant's acceptance of student ideas, right or wrong, was evidenced by the role of student misconceptions in their teaching. Thus Ok to be wrong and X-out wrong ideas were consolidated under misconceptions. Do Something was often mentioned in response to acknowledgement of the variety of Learning Styles held by the participant's students. However, Learning Styles was a code specific to certain participants, while Role, Onus and Misconceptions were pervasive among the participants. This code was used to characterize personal theories of learning for those participants who emphasized Learning Styles in their responses to the interview questions.

Table 4.8 Personal Theory of Learning (TOL) Codes

<b>Theory of Learning Category</b>		
<b>Origin</b>	<b>Initial Code Name</b>	<b>TOL Code</b>
D	Ok to be wrong X-out wrong ideas MI/Learning styles Do something	Misconceptions
D and L	Role Onus	Role Onus

Several of the codes from the data were consolidated under Classroom Management. The engagement of the students, the lesson design, and timing, for example are all related codes dealing with survival in the classroom and mastery of classroom logistics. Perspectives of Being the Teacher were associated with the I . . . therefore code.

Table 4.9 Focus Codes

<b>Focus Category</b>		
<b>Origin</b>	<b>Initial Code Name</b>	<b>Focus Code</b>
D	Classroom Management Engaged Comfortable Lesson Design Timing Student Learning	Classroom Management     Student Learning
D and L	I . . . therefore Being the teacher	I . . . therefore
L	Perspective	

*The Product of Combined Inductive/Deductive Analyses*

The inductive/deductive analysis resulted in three main categories, each with two states. The diagram below summarizes each category and identifies its codes. Exemplars are given and discussion of the coding prepares the reader for interpreting the results described in the next chapter.



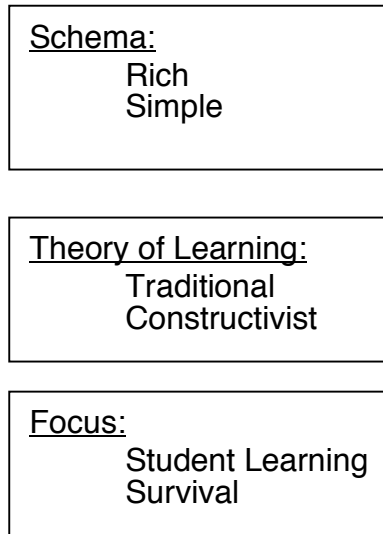


Figure 4.2 Category Overview

Schema identification was characterized using the amount of storying and knowledge shared by the participants. The Master teachers used stories much more than did the Novices. They also imbedded principles of practice in their stories. Their stories served as illustrations of principles of practice. The Master teachers also more freely evaluated Robert, the teacher in the video clip. By contrast, the Novices did not evaluate Robert to the same degree. I posited that storying and evaluating are evidence of well-developed schemas with rich connection. Likewise, the Master teachers tended to jump ahead of the questions I posed, often answering two or three questions related to the question at hand, but without prompting. The Novices did not exhibit this to the same degree. Again, I suggest this progression of ideas is evidence of more rich schemas held by the Master teachers and more simple schemas held by the Novices.

Three codes that were useful for describing a participants' theory of learning were their view of how student misconceptions should be used during teaching and learning, their view of the role the science teacher plays in the classroom ('guide on the side', or 'sage on the stage'), and where they place

the onus for learning (on the teacher or on the student). For example, when participants talked about misconceptions I coded that section and then considered their comments about the role of the teacher, to get a picture of their perspectives on learning. Participants' personal theories of learning fell along a continuum somewhere between a traditional theory of learning and a constructivist learning theory.

Lastly, three codes were particularly helpful in characterizing the participant's focus. Dialogue about classroom management and classroom control were both coded as focus on survival. At times the Novice's also justified their opinions by expressing that if they were the student they would prefer a particular instructional strategy, this focus on self as student is also typical of not having transitioned to see oneself as teacher, but rather as student. Master teachers, though an atypical characterization, showed concern for survival issues, but as a mentor might. Master teachers' concern for student learning was evidenced with concern for reinforced misconceptions, as well as, discussion of student conceptualization and understanding. To illustrate the categories I have included excerpts from participant transcripts. I then describe how each quote serves as an exemplar for a state.

*Focus: Student Learning versus Survival*

Some examples of each of the categories follow below. The bracketed comments are the interviewer's questions. Colleen's excerpt illustrates a teacher whose focus is on student learning. Her comments about student conceptualization and ability to explain their thoughts support this interpretation. Here is an excerpt from a Master teacher, Colleen,

*“{What do you recall?} Um I thought that he, the young teacher Robert was doing a good job and presenting the information, getting the kids to think about their ideas um having them write them down. He was focusing in on trying to get them to conceptualize something and to come up with an idea . . . I thought that he was doing a very good job of connecting – trying to connect concepts with the kids, trying to get them to understand cause and effect and having them think about why that would be true. So I liked that he was doing that – the writing exercise is always a good thing because it makes them pull their thoughts together in a cohesive way to get them to be able to then turn around and \_explain\_ what they were saying . . .” [Colleen Video-clip Interview]*

By contrast, Jessy, a Novice teacher, offers this response,

*“{What do you recall?} um . . . I think the first thing that stood out was actually the classroom management things coming from a really hectic classroom um from my fieldwork observations so you know I was . . the first things was watching him you know telling them to pick up the chairs that it was a big deal but they shouldn’t drag them on the floor and make noise and also initially he asked them a question and after having them write things down get their own ideas but then saying ‘Hands, hands, hands’ so like those things . . I was sort of clued in at least sort of to feel . . to classroom management – to having come from a sort of hectic classroom.” [Jessy Video-clip Interview]*

Jessy classifies her own concerns as focused on classroom management, and by extension, survival. She is, though, clearly aware of her bias and even explains the reasons behind this strong concern.

*Theory of learning: Traditional versus Constructivist*

Mercedes, a Master teacher, illustrates some of the surprising results I've seen in this study. Considering she is a Nationally Board Certified teacher we would expect her responses to be heavily constructivist. Here she responds to a question about what the students were learning,

*"{What would you say the students were learning?} What each other thinks. Right and I don't [know] whether it's right or wrong. They are learning that people have a lot of different ideas about friction and they were learning what each other thinks . . . You do want to hear what people think but I think you want to do that once at the beginning of the lesson and then I think you need to guide them to where they need to be at the end of the lesson . . . I don't know what day this is but they seem to be still brain-storming and being allowed to write anything they want and it feels like it's too far in the lesson to be at that stage. I just feel like that's the role of the teacher -- is to clarify and correct . . ."*

[Mercedes Video-clip Interview]

What is noteworthy about this excerpt is the role Mercedes sees for the teacher, "to clarify and correct". She places the onus for learning on the teacher. The teacher leads the students to correct understanding. In other excerpts she emphasizes that wrong ideas should be "X-ed out". This conception, of removing wrong ideas and replacing them with right ideas, is not antithetical to Master teacher characterization, but her approach to reforming wrong ideas is.

By contrast, Luscien, a Novice teacher, has this to say,

*"{Why do you think he's organized his teaching this way?} . . . you know just teaching I don't know deductive methods of science is not a*

*great way to have knowledge stick in students. For them – the best way is for them to make sense of it within themselves and then um kind [of] take on a more – kind of work through their misconceptions and take on a more, a formal scientific um understanding of things, not just learn someone else’s version of how the world works and transcribe that into their own brain – kind of make sense of it within themselves, I guess.”*

[Luscien Video-clip Interview]

He does not ascribe to a traditional theory of learning. He says that to achieve learning students should not transcribe someone else’s ideas into their brain. Luscien’s emphasis on student preconceptions and the active role played by the student in learning supports the suggestion that Luscien has a constructivist theory of learning.

*Schema: Rich versus Simple*

Schema development cannot be illustrated by one quote alone. Rather, several features of the interviews contribute to the drawing of a participant’s schema as rich or simple. As was described earlier, the progression of ideas, illustrated by Master teachers, supports an interpretation of a richer schema for teaching and learning. Likewise, the storying and knowledge sharing evidenced by Master teachers and lacking by Novice teachers also supports differences in schema development, as do responses to the video-clip. One example of a response to the video-clip involved unprompted reactions to Clip B. Three of the seven Master teachers jumped in at the close of Clip B, before I began the Clip B interview. They expressed excitement and curiosity about the student actions and the teacher’s choices. Only one Novice gave this

unprompted response. This Novice simply expressed how overwhelmed he was by what he saw and how difficult it was for him to keep up with what was happening.

## CHAPTER 5

### RESULTS

The Video-clip was a 10-minute selection from a seventh grade physical sciences classroom. The lesson, taught by intermediate teacher Robert, was designed using constructivist learning theory. The topic of the lesson was friction. Two groups of teachers participated in this research study. The Novice group was composed of seven pre-service teachers, five pre-student teaching and two post-student teaching. The five had had two semesters of fieldwork experiences and were at the close of their coursework for certification plus a Masters degree. All seven were seeking certification to teach 7-12<sup>th</sup> grade physical sciences courses. The Master teachers were Nationally Board Certified middle school physical science teachers from either New York State or Massachusetts. The results are organized into four sections: general interpretations, personal theories of learning, focus, and schema development. The general interpretations serve to introduce the data, as well as the participants, to the reader. I summarize the results in a last section, Summary, that describes the range of responses, discussing what was expected compared to what was observed.

#### General Interpretations

The general interpretations results address the central research question for this work, "How will the participants' responses to the video-clip differ?" As discussed in the literature review, prior research suggests that novices and expert teachers will interpret representations of classroom events differently. It would be expected that Novices in this study would be more focused on survival, i.e. classroom management, student behavior. Master teachers, alternatively, would be expected to be more concerned with student

learning (Fuller & Bown, 1975). Experts in other fields, including teaching, exhibit more complexity and richness in how they make sense of events. From existing literature, we would expect the Novice teachers in this study to exhibit less complexity and more superficiality in their interpretations of the video-clip. Their focus should be on more logistical issues. Master teachers, on the other hand, would be expected to show greater flexibility and interconnections in their interpretations. We would expect them to focus on pupil learning and show a complexity in how they relate what they see to their own rich experiences.

To represent the data for the general interpretation section I've organized the participants' responses into tables, for easy comparison. **M** represents the Master teachers, while **N** represents the novices. Two questions were added to the Video-clip interview after I had already completed the first couple of interviews. Cells with "n/a" indicate a question that was omitted from a participant's interview.

#### *Video-clip A Interview*

##### ***Q1. What do you recall about the teacher? Students? Lesson?***

Do Master teachers recall more or different events from Clip A? Does "what" they attend to differ? Table 5.1 below summarizes the participants' responses to Q1. In the case below, participants' recollections varied from focused on student learning (Learning), student engagement (Engagement), to classroom management (Management). These codes were common in the participants' responses and directly relate to differences in teacher development. Each of these codes originated from the inductive and deductive analysis that is detailed in Chapter 4 Data Analysis. The "Reported Out" column indicates a particular way of answering Question 1 that will be



described later. If a participant answered in this form, a “yes” was recorded. If they did not answer in this form, a “no” was recorded.

Table 5.1 Question 1 Summary

<b>Participant</b>	<b>Focused on</b>	<b>Play-by-Play</b>
Emilio ( <b>M</b> )	Management	Yes
Samuel	Learning	No
Rachel	Learning	No
Colleen	Learning	No
Ann	Management	No
Mercedes	Engagement	Yes
Donovan	Learning	Yes
Luscien ( <b>N</b> )	Learning	No
Audrey	Engagement	Yes
Dexter	Engagement Learning	No
Jessy	Engagement Management Learning	No
Garrett	Engagement Learning	No
Clare	Management Learning	Yes
Pierre	Engagement Learning	No

I should explain the conventions I have used for presenting quotes.

Comments made or questions asked by the interviewer are included in curly brackets, i.e. {}. Capitalized words, i.e. LAUGHS, indicate the person speaking is at that point laughing. When a participant begins a new thought in the middle of their current thought a dash, i.e. –, is inserted. Bar brackets [ ], are added when a participant’s thoughts are obscured by a grammatical omission. The correction has been added in bar brackets. A string of two periods indicates a pause in the participant’s thoughts. A long pause of three periods or more indicates where I have left out extraneous thoughts. When

participants emphasize a word, an underscore flanks the word, i.e. *\_explain\_*, as in Colleen's quote below. To clean up the quotes, such as in "he he the novice teacher", I removed repeated words. I also removed repeated or superfluous "uh's" and added punctuation when needed to make the quotes more readable. The source of the quote is in bar brackets at the close of the quote.

According to the literature, the Novices would be expected to focus more on issues of survival, such as classroom management. Many Novices focused on student engagement. They were quite concerned with whether the students were paying attention, or were on task. I argue that this attention to student engagement is related to survival in the classroom including classroom management, and thus is a typical novice response to the video-clip. An example of a response focused on student engagement included Garrett's (N),

*"Umhhh, I don't know, they definitely seemed to be engaged . . . They were all kind of sitting there . . . they all seemed to be paying a decent amount of attention and asking questions. They all seemed to raise their hand and listen to what everyone else was saying."*

[Garrett Video-clip Interview]

and a response focused on classroom management included Jessy's,

*"um . . . I think the first thing that stood out was actually the classroom management things, coming from a really hectic classroom from my fieldwork observations. So you know I was . . . the first things was watching him telling them to pick up the chairs that it was a big deal but they shouldn't drag them on the floor and make noise. And also initially he asked them a question and after having them write things down get*

*their own ideas but then saying ‘Hands, hands, hands’ so like those things . . . I was sort of clued in at least . . . to classroom management – to having come from a sort of hectic classroom.”*

[Jessy Video-clip Interview]

The Master teachers would be expected to focus on issues related to student learning, yet we see several of them focusing as well on student engagement or classroom management. We also see the Novices, all but one, attending to student learning while also focused on survival issues.

Not only were there interesting things to see in the content of the participants’ responses, but how participants answered Question 1 also differed. One way of answering Question 1 stood out, the play-by-play approach. In each of these cases the participant reiterated events from the video-clip. Much as a reporter might relay the events they see during a sporting event, participants gave a play-by-play of what they had seen, rather than expressing their thoughts on what they saw. For example, Audrey’s response illustrates a play-by-play approach to answering Q1,

*“Um . . . there were three in the corner who were kind of sitting there looking awkward but other than that the rest of them seemed to be really into what was going on and you know lots of heads nodding, lots of hands going up, lots of writing, pretty engaged except they keep on showing this one group, I think it was three students who were like, ‘I don’t know’, not really participating and just kind of sitting there . . . {Do you recall anything else about the teacher?} Um . . . I liked the fact that he had students writing down their answer to the question rather than letting one student answer verbally and then maybe not giving others time to think about it.”* [Audrey Video-clip Interview]

In contrast, Colleen's response is a more analytical approach to answering Q1,

*"I thought that he, the young teacher Robert, was doing a good job and presenting the information, getting the kids to think about their ideas having them write them down. He was focusing in on trying to get them to conceptualize something and to come up with an idea . . . I thought that he was doing a very good job of connecting – trying to connect concepts with the kids, trying to get them to understand cause and effect and having them think about why that would be true. So I liked that he was doing that – the writing exercise is always a good thing because it makes them pull their thoughts together in a cohesive way to get them to be able to then turn around and explain what they were saying"* [Colleen Video-clip Interview]

For Question 1 we would conclude that the Novices were typical in their responses in terms of being focused on issues of survival. We would also conclude that several of the Master teachers were typical in that they focused on student learning and not on survival in the classroom, but likewise, several were more novice-like in their responses, including a less sophisticated approach to answering Question 1 by way of a play-by-play response. Also unexpected were the Novices' equal concerns for student learning. Perhaps because all the Novices had completed their coursework in teacher education their concerns had begun to shift. Interestingly, those participants who gave a play-by-play answer to Question 1 also focused, at least in part, on classroom management and/or student engagement.

**Q2. What would you say is happening here?**

**Q3. What do you think are Robert's goals and objectives?**

How capable are the teachers at abstracting what they've seen in clip A into a few words? Can Master and Novice teachers conceptualize someone else's goals based on what they've seen? Can they work backward from what they see in the lesson to the possible goals and objectives? Question 2 asks the participants to summarize what they saw in a few words. Question 2 prepares participants for Question 3 by asking them about specific goals and objectives that Robert is trying to achieve. Thus it makes sense to consider the responses to these Questions 2 and 3 together. Column one, as in the previous table, lists the participants. Column two and three summarize the participants' responses to Questions 2 and 3, respectively.

Table 5.2 Questions 2 and 3 Summary

<b>Participant</b>	<b>Q2 Summary</b>	<b>Q3 Goals/Objectives</b>
Emilio ( <b>M</b> )	Science info Habits of mind	n/a
Samuel	Science info	Science info Prior knowledge
Rachel	Science info	Science info Prior knowledge
Colleen	Science info	Science info
Ann	Science info	Science info
Mercedes	Science info	Prior knowledge
Donovan	n/a	n/a
<hr/>		
Luscien ( <b>N</b> )	Habits of mind	Habits of mind Onus
Audrey	Habits of mind	Science info Prior knowledge Highlight right ideas
Dexter	Habits of mind	Habits of mind Onus Prior knowledge

Table 5.2 (Continued)

Jessy	Science info Habits of mind	Science info Habits of mind Onus
Garrett	Science info	Science info
Clare	Science info	Science info Prior knowledge
Pierre	Lesson design	Science info Onus Implant ideas

Looking first at Question 2 there is an interesting pattern. The Master teachers summarize the lesson in terms of the science information the teacher is presenting. Samuel suggests, *“An entry level discussion of learning what friction is and how to increase or decrease it.”* [Samuel Video-clip Interview] The Novice teachers, in contrast, summarize the lesson more in terms of habits of mind (Bybee, 2000) rather than traditional science content. Specifically, the novices referenced habits of mind such as students making predictions or solving problems. In addition, many participants recognized that Robert was ascertaining the students’ prior knowledge about friction.

It is interesting to look at the summaries the participants give in Q2 and then compare them to the goals given in Q3. It is not so much that there are discrepancies between some of the answers to Q2 and Q3 but what was added or changed in the Q3 response. New ideas are shaded in gray. It is here in Q3 that we see glimpses into personal theories of learning. One novice, Pierre, says one of Robert’s goals was to implant ideas. Another, Audrey, says Robert was trying to highlight right ideas. Three Master teachers identified Robert’s goal as to access prior student knowledge as did three Novices. We also see the emergence of a significant code, the notion of onus. Onus is a code developed from both the literature review as well as from the

data, its development was detailed in the data analysis chapter. In each case that onus was coded, the participant suggested one of Robert’s goals was to place the responsibility for learning on the student. Luscién’s response is an example,

*“I think he was trying to help the students wrestle with their ideas about . . . something in nature – try to just have them wrestle with it in a more scientific and directed way. I’m sure all these students have thought about friction . . . it seems like his job is not to tell them about friction but try to just help them explore their own ideas and to guide them and think about it in kind of a more directed way. {And what did you see that made you think that?} Um . . . well . . . again asking them . . . ‘What do you think will happen in this scenario and why?’ so trying to just get at what their prior conceptions are of this occurrence of friction not so much ‘Here’s my conception . . . this is dogma.’ But, ‘What are your conceptions of it?’” [Luscién Video-clip Interview]*

**Q4. Do you think he was successful?**

What does a successful lesson look like? What characteristics mark a successful lesson? Will the participants use their own criteria or will they link success to the goals they suggested Robert intended? Each participant will likely differ in his or her opinion of what a successful lesson involves. Question 4 asks participants to evaluate Robert, to have an opinion. No Master teachers mentioned management while only one Novice mentioned learning.

Table 5.3 Question 4 Summary

<b>Participant</b>	<b>Successful</b>	<b>Process</b>	<b>Focus</b>
Emilio (M)	Not sure	Yes	Teacher actions
Samuel	No	Yes	Student learning

Table 5.3 (Continued)

Rachel	Yes to a point	No	Student learning
Colleen	Not sure	No	Student learning
Ann	No answer	Yes	Student learning
Mercedes	Not sure	Yes	Teacher actions
Donovan	n/a	n/a	n/a
Luscien (N)	n/a	n/a	n/a
Audrey	Yes	No	No indication
Dexter	Not sure, Yes	No	Management
Jessy	Not sure	Yes	Student learning
Garrett	No yet	Yes	Management
Clare	No answer	No	No indication
Pierre	n/a	n/a	n/a

I would have expected either a “yes” or a “no” answer to the question of Robert’s success, but most participants responded with very vague responses. This hesitancy is justified by the often-linked reference to the process nature of teaching and learning. For example Emilio says,

*“ . . . I can’t judge, it seems unfinished, I mean of that six minute clip it’s very hard to say – if I saw more of it, saw how he wrapped it up I might be in the end, ‘This guy missed the whole point. He missed a great opportunity.’ or maybe he’s going to tie it together where it was super but I just don’t know. It’s just too much of a snapshot without resolution of what he did accomplish . . . So it’s just really hard based on this to say.”* [Emilio Video-clip Interview]

In some cases participants explain their hesitancy by noting that they would like more information, such as to hear from other students besides those that spoke in class or to assess at a higher level than what was shown. Clare



doesn't answer the question. Ann, also, doesn't give a direct answer to the question but alludes to the process of teaching and learning with,

*"He was beginning to get it through them. It's not going to end there. He had some of them, but the last little bit when that one student said something about 'Break the brick', he hadn't succeeded with that one."*

[Ann Video-clip Interview]

In a few cases, the responses focused on classroom management or teacher actions, both of which I considered to be issues of survival. Looking closely at the transcripts, the Master teachers focused their ideas of success to student learning. Only one Novice linked success to student learning. Two Novices linked success with classroom management.

***Q5. What do you think will happen next (in the lesson)?***

***Q6. What would you do next?***

Can the participants reason forward based on what they've seen? Can they predict a reasonable outcome? How do Robert's choices differ from choices they would make? I would expect that the Novices would be less able to anticipate what might happen next, whereas the Master teachers would be quite able to both anticipate what Robert might do next and describe what they would do next. The Novices might not be able to put themselves in the teacher's shoes and think quickly on their feet to choose a reasonable conclusion to the lesson. Question 6 is significant because what each participant would do next begins the transition from a focus on Robert to a focus on the participant's ideas about teaching and learning.

Table 5.4 Question 5 Summary

<b>Participant</b>	<b>What next?</b>	<b>What I would do</b>
Emilio (M)	Something experimental	Do inertia first
Samuel	Something hands-on	Assessment

Table 5.4 (Continued)

Rachel	I'm not sure Something experimental?	No indication
Colleen	Something experimental	No indication
Ann	Something experimental	No indication
Mercedes	I'm not sure Something experimental? Assess?	No indication
Donovan	Formalize ideas	No indication
Luscien (N)	I'm not sure Formalize ideas	No indication
Audrey	Something like an activity	No indication
Dexter	I'm not sure Something experimental	Something experimental
Jessy	Something hands-on Formalize ideas	No indication
Garrett	Something experimental	No indication
Clare	Something experimental Formalize ideas	No indication
Pierre	I'm not sure	No indication

Two different responses stand clearly from the data: something experimental versus formalize ideas. The Novices as a group are more interested in formalizing ideas than the Master teachers. By formalizing ideas, participants referred to lectures where traditional ideas about friction were presented along with typical diagrams and arrows. Both the Master and Novice teachers expect to see something experimental or hands-on. In these cases the participants expected the materials Robert has shown the students, a block of wood and a brick, to be put in the students' hands so they can try out their ideas. Three Novices are unsure of what they will see, with Pierre alone giving no suggestions. Two Master teachers are unsure but offer possibilities.

Interestingly three participants jump ahead by offering a description of what they do or would do next. Two Master teachers and one Novice teacher show this anticipation.

Below is a table comparing both answers to Q5 with answers to Q6. In each of the three cases when a participant mentioned in Question 5 what they would do there was consistency in their answer to Question 6. Differences between answers in Questions 5 and 6 are shaded in grey.

Table 5.5 Question 5 and 6 Comparison

<b>Participant</b>	<b>Q5 Summary: Next he'll do</b>	<b>Q6 Summary: I would</b>
Emilio (M)	Something experimental	Something experimental
Samuel	Something hands-on	Something hands-on Assessment
Rachel	I'm not sure Something experimental?	Something experimental Assessment
Colleen	Something experimental	Something experimental
Ann	Something experimental	Something experimental
Mercedes	I'm not sure Something experimental? Assess?	Something experimental
Donovan	Formalize ideas	Something experimental
Luscien (N)	I'm not sure Formalize ideas	Formalize ideas
Audrey	Something like an activity	Something experimental Formalize ideas
Dexter	I'm not sure Something experimental	Answers with science concepts
Jessy	Something hands-on Formalize ideas	Something experimental Formalize ideas
Garrett	Something experimental	Something experimental Formalize ideas
Clare	Something experimental Formalize ideas	Answers with science concepts
Pierre	I'm not sure	Something experimental Assessment (formative)

In most cases there was a direct correlation between what the participant thought they would see next and what they would do next. Many even mentioned, with a bit of surprise, that what they would do was exactly what they expected to see happen next. Novices Clare and Dexter were unable to

answer with concrete examples of actions they would take and answered only with the science concepts they would teach, as indicated in the table “answers with concept”. Both gave only conceptual outcomes drawn from the subject matter. Taking Questions 5 and 6 together, all the Novices, save Dexter and Pierre, included ‘formalize ideas’ as part of what could be next. All the master teachers included something experimental in their plan or Robert’s plan for what might come next. The justifications for what the participants would do next were highly useful for characterizing their personal theories of learning. Those reflections are analyzed later alongside other comments from the interviews regarding personal theories of learning.

***Q7. Were there any other thoughts you’d like to share?***

Question 7, a catchall, did not provide significant data for analysis. The lack of focus in the question resulted in a wide range of answers that are difficult to compare. Some master teachers referenced logistical concerns, while others focused on student learning. On the surface the Novices seem to focus more on logistical concerns. But the Novices, for example Audrey and Dexter, were actually focused on learning more than on the logistics of running a classroom. Audrey takes the position that being behind in one’s lesson plan is not bad. She later justifies this by mentioning that sometimes the students need more time to process what they are learning. Likewise, Dexter’s interest in the context of the video-clip is motivated by his concern that Robert would be handicapped if he didn’t have knowledge about prior lessons. If Robert wasn’t the students’ regular teacher then he would have a hard time preparing the lesson and anticipating their pre-conceptions. All in all, this question was not helpful in determining novel differences between the two groups.

*Video-clip B Interview*

***Impromptu Responses.***

After watching Clip B several participants had immediate reactions. Each of the responses by the Master teachers is a detailed analyses of the content of Clip B. Their analyses reference student understanding, the complexity of lesson design, and probing questions about what they saw.

Table 5.6 Master Impromptu Responses

Colleen	<i>“The last student really understands the concept. He wasn’t reading off the poster, he’s conceptualized what the girl’s asked him. He can explain because he understands very well. I’m wondering how much the other students understand as opposed to reading off their posters.” [Colleen Video-clip Interview]</i>
Samuel	<i>“That was brilliant. I love putting the kids in the teacher’s shoes and having them teach each other. I do that often. I would like to see where they’re getting the information. Are they copying, assimilating? Was it getting in there deep? They had trouble with the questions because it wasn’t in there deep. This banter between the kids is a level up from the group discussion because they were tapping a certain level of prior knowledge.” [Samuel Video-clip Interview]</i>
Rachel	<i>“The end discussion was just a dream come true. Everyone has an opinion and they start analyzing. They’re discussing it among themselves, which is the truest sense of a good classroom. I didn’t like his posters. A poster to me is a graphic. I limit the number of words that can be used. If you let kids choose their path in an investigation you can’t say, ‘I don’t like your choice.’ His idea is good but it takes more practice to pull it off better. I’d like to hear him reflect on the lesson.” [Rachel Video-clip Int.]</i>

In contrast, the only Novice who responded spontaneously gave no analysis and expressed a sense of being overwhelmed.

Table 5.7 Novice Impromptu Response

Dexter	<i>“There were a lot of ideas in the four minutes. It’s hard to keep up with the students. They said a lot of things.”</i> [Dexter Video-clip Interview]
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**Q8. What do you think the teacher was trying to accomplish here?**

Like Question 1, Question 8 asks for a summary. The second clip differs significantly in structure. However, both Clip A and Clip B are contiguous attempts to achieve related goals. Clip B though, reveals more detail about what Robert was trying to accomplish. Will the participants recognize the relationship between both clips? Will the participants change their opinion about this lesson’s purpose?

Table 5.8 Question 2/3/8 Comparison

Participant	Q2/Q3 Summary	Q8 Summary
Emilio (M)	Science info Habits of mind	Habits of mind
Samuel	Science info Prior knowledge	Science info Onus
Rachel	Science info Prior knowledge	Assess
Colleen	Science info	Science info
Ann	Science info	Science info Habits of mind
Mercedes	Science info Prior knowledge	Science info
Donovan	n/a	Science info
Luscien (N)	Habits of mind Onus	Communication skills Onus

Table 5.8 (Continued)

Audrey	Habits of mind Science info Prior knowledge Highlight right ideas	Play-by-play Communication skills
Dexter	Habits of mind Onus Prior knowledge	Onus
Jessy	Science info Habits of mind Onus	Play-by-play
Garrett	Science info	Play-by-play I don't know
Clare	Science info Prior knowledge	Play-by-play
Pierre	Lesson design Onus Science info Implant ideas	Habits of mind Onus

Two significant responses stand out from the table above. The grayed responses are novel for that participant. The Masters are relatively consistent with few new ideas about the purpose of the lesson. The Novices, on the other hand, emphasized the communication skills they saw. While this is not necessarily lost on the Master teachers, they clearly see these skills used to foster learning science at the heart of the lesson. Additionally, several of the Novices answered not with abstract analyses but by reiterating events they saw in the clip. On occasion a Novice would begin by listing the facts as they saw them and then build up to a more abstract statement about what was happening. The science and habits of mind that the Novices associated with the first clip are mostly absent in their summaries of the second clip. Pierre is the exception,

*“And also there’s the presentation aspect he was getting at. Getting his students to present their findings, their thoughts, in front of the class.*

*And I thought it was great, the question/answer segment there between the students and their peers. I thought that was really great. {Why?} Because it's very student-centered. It's letting the students come up with the question and them ask—instead of asking the teacher . . . And it's very hard when you know you have to defend your thinking like that you obviously have to be confident in your thoughts and have thought them through thoroughly and understand the concepts behind them and it just presents all sorts of wonderful opportunities to learn and deepen your understanding of the subject.” [Pierre Video-clip Interview]*

**Q15. What do you think is Robert's level of experience?**

This question developed from one of the pilot interviews I conducted. The experienced teacher in the pilot interview independently offered her own ideas about how long Robert had been teaching as well as her reasoning behind those ideas. I began to wonder if there would be differences in how the Novice and Master teachers evaluated Robert's level of experience, so I added the question to the interview guide.

Several different factors surface repeatedly as the participants assessed Robert's level of experience. Most of the characteristics straddle both groups of participants: age, use of contemporary methods (as opposed to didactic methods), degree of classroom control, his being behind or being perplexed about being behind, and that this was a lesson he hadn't taught before. One characteristic was strictly used by the Novice's to determine his experience level: his attitude. Both Clare and Audrey noted how comfortable Robert was in front of the students, and ranked him as having 2-5 and 2-4 years experience, respectively. Dexter noted his confidence as well as his nervousness at moments in his assessment of Robert as a student teacher.



Both Colleen (M) and Samuel (M) addressed Robert’s lesson design, though in opposite ways. Colleen ranked him as a student teacher in part because of his poor lesson design. Samuel said he had been teaching a while because of his middle school-appropriate methods.

Four of the six Master teachers thought Robert was a new or student teacher. Both Samuel and Rachel thought he had more experience teaching, but according to Rachel, not too much. Of the five student teachers to answer this question, two estimate his experience in the 2-5 year range, one in the 5-6 year range. One estimated that Robert was a student teacher and one Novice didn’t know.

Table 5.9 Question 15 Summary

<b>Participant</b>	<b>How experienced?</b>	<b>Why?</b>
Emilio (M)	New teacher	Contemporary methods
Samuel	Teaching a while	Classroom control Student-appropriate methods
Rachel	Not brand new, not too experienced	Contemporary methods Timing New lesson Classroom control Age
Colleen	Student teacher	Perplexed at timing Poor lesson design
Ann	Student teacher	Age
Mercedes	n/a	n/a
Donovan	New teacher	Perplexed at timing
Luscien (N)	n/a	n/a
Audrey	2-4 years	Age Comfortable Contemporary methods
Dexter	Student teacher	Age Nervous Confident New lesson
Jessy	Don’t know	Classroom control (engaged)
Garrett	n/a	n/a

Table 5.9 (Continued)

Clare	2-5 years	Comfortable Classroom control (authority) New lesson
Pierre	5-6 years	Contemporary methods Perplexed at timing (anxious)

*Summary*

From the general interpretations the Novices hold true to being concerned about survival. Their responses also indicated potentially simple schemas for interpreting classroom events. However, several novices are also focused on student learning and show glimmers of more complex schemas. As for the Masters, their overall focus was more on student learning but they showed interest in addressing classroom management and other survival issues. Some appear to have complex schemas for interpreting teaching and learning while others seem to have more Novice-like schemas.

The next section will allow us to investigate these findings further. In the next section I dig deeper into the interpretations of three Novices and three Masters from the participant groups. These participants illustrate the diversity of interpretations exhibited in the two groups. Master Teacher Ann represents the middle ground as three other Master participants responded in ways similar to her, demonstrating moderate theorizing about learning from a constructivist vein. Master Teacher Rachel and one other Master participant represent one end of an extreme with strong constructivist personal theories and well-developed schemas for teaching and learning. Master Teacher Mercedes represents an alternate interpretation of constructivist learning theory that maintains a traditional image of the teacher as bearer of knowledge. From the Novices, Audrey is a typical Novice in her lack of theorizing about learning, as were three other Novices. Novice Jessy stands

out for both her persistent concern for survival issues as well as her rich schemas (compared to the other Novices) for teaching and learning. Novice Luscién stands out because of his more developed theorizing about learning.

I present each exemplar's personal theory of learning, focus, and the complexity of schema for teaching and learning, using their responses to the video-clip interviews as well as the follow-up interview. I present the Novice teachers first, followed by the Master teachers. For each group in the Theories of Learning section, the first participant is typically the most simple, the next two participants represent two extreme cases. I adopt the same order of participants in the Focus section as a convention and where applicable in the Schema Development section as well.

### Theories of Learning

#### *Novice Teacher Audrey*

Audrey is an example of a typical novice teacher who is preoccupied with lesson design and who does not connect formal theories of learning with actually teaching practice. She uses current terminology but seems to think about learning and teaching as another subject to be learned, rather than as guiding principles. She reveals a very thin theory of learning, perhaps in part because of her preoccupation with lesson design rather than student learning. She has her own views of learning that seem to shift in an amorphous way. Her theorizing is quite underdeveloped. It is difficult to reconcile that she has just completed student teaching with her simple understanding of how people learn.

#### *old models vs. new models.*

I chose this title for this section because Audrey creates a dichotomy between old models of instruction and new models of instruction. The primary

difference, for Audrey is the move to more student-centered teaching. Audrey conceptualizes differences in teaching styles as the old ways compared to the new ways. Her perspectives on learning are hinted at but nearly absent from the video-clip interview. From the quote below we are led to believe that teacher education instruction is a slave to changing trends rather than informed by research, at least to Audrey. When pressed to explain her classification of Robert as a new teacher she says he is *“trying new stuff”* so he must be a new teacher. She explains why the instruction she saw is new,

*“I’m not sure, I don’t know I guess because you hear of the \_old model\_ of teaching being the teacher in front talking and then you hear of the \_new model\_ of teaching being student-centered and all of that so that’s what I’ve heard a lot of through all of my classes like, ‘We want you to do things the new way’ and he’s doing things the new way.”*

[Audrey Video-clip Interview]

She ties these models of teaching to her teacher education program but doesn’t identify her own perspective. Her textbook response is similar to novice nurses who relied on textbooks rather than personal experience (Daley, 1999).

During the follow-up interview we see a picture of Audrey’s theorizing about learning that is shallow and based primarily on how she learns. She is good at school because she can learn in ways other than the ways that she prefers. She characterizes a typical school situation for her as the teacher presents the information and the student receives it. Though this is not how she prefers to learn she emphasizes that she’s actually very good at learning in this format. From her own experiences as a student teacher she places the onus on the student to volunteer information about his learning. As a teacher

she provides several kinds of experiences so students can absorb that input and process it for themselves. There is a distinct absence in Audrey's ideas of teaching for understanding or taking responsibility for students' lack of understanding.

Audrey's initial response to the question, "How do you know a student has learned something?", implies a very simple understanding of learning with little to no theorizing. She responds, "*Sometimes I don't*" [Audrey Follow-up Interview]. When pushed for an example she offers that fact-based information is easier to assess than conceptual understanding. She indicates that learning a fact, such as a vocabulary word, is different than understanding a concept.

Part of the reason Audrey wants to be a teacher is because she enjoys when students "get it". So we returned to the topic of how she knows a student has "got it".

*"As it is now I know that they've got it when they volunteer that and sometimes I can ask the right questions or design the right thing that lets me know but often it's just when they volunteer that they've gotten it or ask a question that lets you know that they've understood something else in order to ask the question."* [Audrey Follow-up Interview]

She does not base her assessment on demonstration of understanding but instead on whether a student volunteers their awareness. Audrey does add that she gets insight into learning when students can ask more complex questions. She does say that she could "*design the right thing*" to determine if understanding has been achieved but doesn't go on to explain what that means, implying a glimmer of connections between the teacher's role and student understanding. On the whole, Audrey does not connect her role as a teacher with establishing evidence of student learning through assessments,

neither formative nor summative, or even teacher-student dialogue. We can hope that she will eventually get there.

*onus.*

This section is titled *onus* primarily because Audrey touches on placing *onus* for learning on students. Audrey's explanation for Robert's lesson design begins to indicate some of her own perspectives. Notice in the quote below that her reasoning is based on her own experiences as a student, essentially based on what works for her.

*"I think a big part is getting the ideas to come from them rather than from him because it is, I think, often more valuable when that 'aha' moment comes from inside you rather than from someone else explaining something and then you understand what they're explaining."*

[Audrey Video-clip Interview]

She continues to ponder about what the students in the video-clip were doing in their groups but ties her observations not to learning but to lesson sequencing.

*extracting information.*

Audrey's approach to teaching and learning is one of extracting information. She describes lesson design as imbedding information in a lesson that students then extract. Her critical incident for understanding how people learn involved designing lessons for four-year-olds. She was struck by how the four year olds learn through playing with materials. She said she had to work hard to not use her comfort zone of imbedding information into a lesson for students to extract. She explains this shift to play-learning as developmentally based. She contrasts learning from one's experiences (playing) with the way adults learn. Audrey emphasizes that later in development people don't learn

by playing. She backtracks to say that people can learn by dabbling but that adult learning is different than four-year-old play-learning. There is a clear disconnect with a constructivist approach to education, considering that Piagetian constructivism can describe infant learning through adult learning and does not consider adult learning as extraction.

Audrey describes that she prefers to learn via auditory and visual information. She also prefers to learn from other people. Though she is very good at learning in traditional environments, she prefers the realness of the outdoors and even majored in earth science because of its tangible nature.

*"I really learn best from other people, from seeing things, from hearing things rather than reading them. Being able to ask questions and have someone answer them. I guess I'm good at school. I'm good at taking knowledge from class. I'm very good at that model of having an expert there and learning from the expert."* [Audrey Follow-up Interview]

Interestingly, her view of teachers is that they are the experts. This fits well with her desire to share her knowledge with others, and her fear of not being able to hold back from telling students the right answers. Her willingness to ask questions also relates back to her expectation that students will volunteer questions, showing their understanding or lack thereof.

Audrey has a strong belief that how people learn best varies depending on the content that they are learning and if they are having fun. When asked about a critical incident in her understanding of how her students learn things, she describes an end of the year survey she gave. The survey revealed to her that there were groups of student who preferred different instructional strategies. Some of her students said they learned best by seeing so they liked the animations. From this evidence she concluded, *"It was pretty solid*

*evidence that you should do a variety of stuff.*" [Audrey Follow-up Interview]

She goes on to express surprise that some students prefer bookwork. Her surprise stems from the emphasis placed against bookwork's effectiveness during teacher preparation. I observe that her evidence is not based on student achievement or evidence of student understanding. I believe she conflates effectiveness with preference. Her students like bookwork so it must be effective. She assures me that the teacher education curriculum lacks emphasis on bookwork most likely because it is such a staple that teachers will fall back on it anyway. She describes later that she will probably fall back into her comfort zone of traditional instruction when teaching.

Audrey explains that when she is planning she first thinks about what worked for her and then she has to "*stretch that*" [Audrey Follow-up Interview] to include people that don't think like her so it will work for them as well. It is Audrey's perspective that all teachers revert to their comfort zone, based on the way they were taught, when they don't have enough time to plan or when they don't have a good idea for a lesson. When asked why a teacher should ever try a new strategy she responds that teaching with different strategies is important not just to keep the students' interest but so they have an opportunity to learn from a variety of contexts. Most teachers, I think, would agree with this last statement. But what will Audrey's instruction look like during her career?

*what's a theory good for anyway.*

Audrey has some specific beliefs about the individual nature of learning. She eschews formal theories of learning as speculations about how people learn. She seems unsure if learning is idiosyncratic or if there are some commonalities among how people learn. When asked how her students learn



she offers, *"I think the process is different for every student."* [Audrey Follow-up Interview] She describes two groups of students. Some students add on a little each day to their conception of something while others pile stuff up and let it sit for a while and then it somehow comes together for them at the end.

When asked explicitly how she thinks people learn she reiterates that, *"I think it depends on what they are learning"*. [Audrey Follow-up Interview]

Earlier she had described her own learning as situation-specific. This situation-specific learning doesn't match either of the two scenarios she gave about how her students learn best, the fermentation versus the pile up descriptions.

She characterizes the learning theories she learned of during her teacher education program as tools to help her plan. She has little belief in their explanation of cognition.

*"I can remember all different theories about how ideas in your brain are rearranged and I don't know if I think any of them really explain what's going on."* [Audrey Follow-up Interview]

*"I guess I see theories of how people learn as being predictions of how you can help them learn . . . being useful as that rather than being this explanation for what's going on in there. Sort of like gravity is a prediction that the apple is going to fall from the tree but you know later on, you find out it may not work exactly the way it does."* [Audrey Follow-up Interview]

After this example, involving gravity, I began to question her conceptualization of a theory in the scientific and social scientific use. Though she considers theories useful for making predictions she does not address the availability of data to confirm the theory's predictive power. I am not surprised that in her interviews she did not describe assessments she designed to test her theories

about student learning. Her ideas about learning appear to have an “n” of one, herself. Where else does she get evidence?

Following her tool metaphor for learning theories she’s introduced I ask her to explain whether these tools have been helpful. She says she’s used them automatically,

*"Especially since it is so imbedded in this program, thinking that 'Ok well I need to know where they're starting from and then I can't be too many steps ahead of where they're starting at. There is a theory right there. [I] forget the guy's name, starts with a V."* [Audrey Follow-up Interview]

Trying to establish whether these theories/tools she uses are completely external to her personal conception of how people learn I ask whether she’s come across individuals who thought differently than her or if she knows of such individuals because the theories predict it. Her reaction is mixed. She distinguishes between people who have preferences for how information is received but the actual process of turning that information into understanding, she thinks, is similar but could also be different from person-to-person.

*"I don't know. It depends on what you mean [by] learning differently. There's 'I learn best by looking at things or I learn best by hearing things' but once that information is given to you in a certain way is the same process going on when that information turns into understanding?"* [Audrey Follow-up Interview]

For her, there's a difference in how people prefer to get information. But according to her gut that information leading to understanding is different. She is not able to explain further. She gives evidence to support that something is happening, because *"learning is tiring"* [Audrey Follow-up Interview], but no

one, not even experts in learning psychology know what is happening, she says. She illustrates her point with examples from her teaching that distinguish between input and process.

### *Novice Teacher Jessy*

Jessy represents the classic novice teacher, highly concerned for issues of survival such as classroom management. We see very little theorizing about learning. Her perspective is strongly based on her own preferences. She does seem, however, aware of this standpoint.

*what's my role?*

Jessy's video-clip interview yields very little insight into her personal theory of learning. What becomes clear from her comments is a real question about the role of the teacher. In fact as we see later she verbalizes such questions.

Jessy primarily focuses on issues of classroom management and control. We get inklings of her perhaps developing perspective,

*"Active learning was going on and especially that sort of importance of problem solving . . . Solving that gutter-ball problem right there and playing it out in their minds which is I think really important."* [Jessy Video-clip Interview]

When pressed though to explain what was important about active learning she begins to theorize about learning by discussing the role of the teacher in the science classroom, specifying the teacher's actions,

*". . . what I seemed to notice was he wasn't speaking at all which definitely stood out so he didn't jump in initially with the gutter-ball question which was interesting."* [Jessy Video-clip Interview]

Again, pressed for why it was interesting she simply reiterates what she saw and that it was good.

*sum of my experiences.*

What sets Jessy apart from Audrey is her strong awareness that her perspectives on learning originates from the sum of her life experiences. Jessy describes herself as a visual learner, though she explains she likes to get information in a variety of ways. She has a strong awareness of the nature of scientific knowledge in the domain of earth science and geology. She says she values presenting information in a way that students can grasp. For her though, visual information is a necessity. She calls herself a layperson in regards to science. She was not a strong student; on the contrary she struggled through middle school and high school. It wasn't until college that she connected with science. She attributes this connection to the freedom she was given in some of her geology courses as well as the increased challenge the classes presented.

*"You give me a little bit of freedom and some interesting classes and I did fantastic and blossomed after that . . . Going into college, having professors really make connections for you and show you and illustrate things visually and make real-world connections made a huge difference for me." [Jessy Follow-up Interview]*

Jessy is unique in that she is cogniscent of where her understanding of how people learn comes from,

*"I think that my understanding of how people learn is probably very much related to how I learn. Identifying things that have helped, ways that things have been presented to me by other teachers that have clicked things in for me. And then my own experience trying to teach*

*relates to that but I think where I come from has to do with how I like to learn." [Jessy Follow-up Interview]*

I asked Jessy to explain how she knows a student has learned something. She explained that what she looks for are the same signs she herself shows when she has learned something. When Jessy has learned something she tends to verbalize the connections she's seeing and to ask questions that extend her knowledge. When she does not understand she tends to stop asking questions and moves on unsatisfied.

*"I recognize that I take that from my learning style, from my perspective. I know plenty of people who are super bright, when they say 'Uh, uhh, I get it' or 'It's just like such and such', they really do get it." [Jessy Follow-up Interview]*

When I pressed her to speculate about how these people learn she said she didn't know and wished she knew. She admitted that she can't decipher these kinds of people. Interestingly she continues to view these individuals as fellow students. She doesn't make the connection that she, as a teacher, might have students like "these people" and she might need to figure them out to meet their needs as learners.

Jessy had a difficult time explaining how she thought students learn. She first answered in terms of how she could observe that learning occurred, and with how she knows she has learned something. With a little pushing she summarizes her perspective,

*"I think they learn through experience and they learn by explaining things to each other or by explaining them on a piece of paper [in] some other situation; by being able to wrap their mind around something and kind of explore it." [Jessy Follow-up Interview]*

Jessy asserts that asking people to repeat what was learned without providing opportunity to apply that knowledge to a novel situation does not test for understanding. In order to create a definition for themselves Jessy says people need both experience and information. But as we continue to see with Jessy, her perspective is strongly driven by her own needs.

*"I think I will of course teach from my learning. I won't dive in and do a straight experiential learning curriculum where there's no explicit instruction. I feel like I learned through explicit instruction, every class I've taken has been taught pretty much through explicit instruction and I will certainly do that. I will address both of those as a teacher, teaching the way I was taught and teaching the way I learn best. But I don't only learn through explicit instruction, I need experience. I need real-world connections."* [Jessy Follow-up Interview]

Jessy's self-awareness of her development extends, as we saw in the video-clip interview, to her focus on classroom management, to her teaching style, and to her personal theory about how people learn.

*"It's interesting, we talk about different theories of learning and it does seem to fall back to, I mean I take all of that information in and it gets sort of buried in there and is being accessed but I think is sort of overridden by my experiences because I've been a student for so long."* [Jessy Follow-up Interview]

*Bloom's Taxonomy.*

At first, Jessy explains she will ascertain learning through assessment, *"I think the most important way for me to gauge how the students are learning is to give them questions stepping up on Blooms taxonomy."* [Jessy Follow-up Interview] She doesn't connect her actions during the lesson or experiences

students have during the lesson as related to learning. She initially sees her role as making observations rather than shaping learning. Interestingly, she mentions Bloom's taxonomy again in regards to the teachers she enjoyed during college and high school. When asked about teachers that stand out in her memory she juxtaposes two geology professors, one who asked questions that *"got a littler further on Bloom's taxonomy"* [Jessy Follow-up Interview] and the other who expected strict recall of his notes. It's clear something about Bloom's Taxonomy stuck with Jessy, but no other construct, or theory, appears in her interview data.

*popping the misconception balloon.*

One of the most interesting comments Jessy made about misconceptions was likening them to an out-of-control, ballooning idea that the teacher pops. This phrase was just too insightful to ignore. Though Jessy thinks the lesson style in the video-clip supports student learning, she once again ties learning back to survival issues of lesson design. She asks if there is any formal instruction and for detail about how Robert deals with misconceptions. Jessy thinks misconceptions can be stopped and corrected. With this approach I might think she holds a more traditional perspective on learning and teaching. She later expresses concern for the classroom management implications of working in groups and the possible propagation of misconceptions.

When asked the role misconceptions play in teaching and learning Jessy framed her answer, once again, in terms of differences between herself, a novice, and an experienced teacher. She fears losing control of the misconceptions,

*“The thing I’m not comfortable with as sort of the novice, not even yet a novice teacher, is that there’s no way to control it and so it’s this wild thing, wild card out there that if you let it go, if you’re teaching in an experiential way it could balloon into something much bigger. An experienced teacher would know how to let it blossom for a while and then pop that balloon or clue them into something having taught the lesson before, and ask them just the right question that would send them down a path to address that misconception.” [Jessy Follow-up Interview]*

For Jessy, how a teacher addresses misconceptions is in some way determined by the instructional style. She describes two styles: either fully experiential or as she implies, less experiential. In spite of the dichotomy that she introduces, she ends with a strong argument that learning cannot be assessed without some knowledge of student understanding before the learning takes place.

*“If you’re not talking about an experiential setting for learning I think that misconceptions are still important and need to be addressed. The idea is to pre-test or [have a] pre-unit/lesson discussion to figure out where people are at. They’re powerful. If you’re really going to teach for understanding without knowing where your students are at to start, how do you know they’ve learned anything at the end of the lesson?” [Jessy Follow-up Interview]*

#### *Novice Teacher Luscién*

From the video-clip interview we learn that Luscién is a novice teacher in transition. He struggles to reconcile his conclusions about how students learn best with the role of the teacher in a classroom centered on student



ideas. He has learned first hand that without student ownership of their contribution to the lesson real learning will not likely occur. However, he wonders what the role of the teacher is, if not to correct misconceptions.

*inquiry-based or something.*

I've drawn this section title from the first quote below where Luscién shows haphazard use of buzzwords. The value of inquiry-based instructional strategies, for Luscién is that they allow students to communicate their understanding of ideas, primarily to contribute to the meaning-making in the class. He describes inquiry-based strategies as,

*“allowing students to explain things in many different ways, in the fact that they can use words, they can use pictures, they can use diagrams in this poster, really gets at however the students can describe their concepts. That seems more inquiry-based . . . multiple intelligence-friendly or something.”* [Luscién Video-clip Interview]

He continues to explain that this variety allows students to have ownership over their contribution to the lesson.

Luscién explains he prefers to learn by seeing a demonstration and by doing. He emphasizes that he can force himself to learn by reading, though he struggles with meaning-making from the typical “dry physics textbook”. He cautions that *“the boat’s still out for me”* [Luscién Video-clip Interview], as far as whether learning styles and preferences resonate with his opinions of how people learn.

*teacher: mosaic builder.*

Luscién is shifting his perspective on learning as he considers the role of the teacher. From Luscién’s descriptions I’ve coined the phrase, mosaic builder, to describe what Luscién sees as the teacher’s role. Luscién’s

response to the question, “What will happen next?” and “What would you do next?” are the same. He expected Robert to introduce more formal terminology and to connect the science knowledge to the student’s knowledge. He clarified his perspective by tying his thoughts back to the teacher’s role,

*“I guess that’s where a teacher is more than just a mediator but has content knowledge and can bring that to the students you know, helping them formalize their thoughts – taking what they already know and giving things labels and kind of filling in loose ends.”*

But Luscién, himself, recognizes he is a novice teacher in transition,

*“I guess I’m in the middle of an overhaul with my style of teaching. I’d say ninety-nine percent of my education has been in more of a lecture, note taking, more rote learning style. It’s kind of hard to break out of that mode. So much of it is imbedded within you as a future teacher. The experience I have had teaching is to just put out the solution, put out the answers, help students understand how things work in terms of you. After all you’re the one that went to school for so long, you’re the one that’s been like this physics whiz so it’s your job to tell them how things work. So I think it takes a lot of self-control and taking a step back and allowing students to work through things themselves.”*

[Luscién Video-clip Interview]

Luscién is clearly in transition; caught up in the tension between his image of a teacher and his beliefs, from his own experiences, about how people learn through ownership.

*“When is direct teaching necessary and when do you let students kind of figure things out for themselves and take a step back and let them operate with slightly incorrect misconceptions of how things work? . . .*

*What is your purpose in the classroom if not to at some point help them confront these misconceptions?” [Luscien Video-clip Interview]*

In other quotes from Luscien, he also emphasizes the necessity of letting students confront their misconceptions and work through them. Luscien admits that his conflict is part of his development and that he will struggle with these decisions for a while.

*ownership.*

Luscien was one of the participants to strongly emphasize the concept of “ownership”. His exploration of ownership is tied to his lack of ownership for some of his college class experiences. He seems to realize, and regret, that for some courses he performed well by memorizing information to do well in the class, but didn’t own the information. Consequently, he has no connection to the subject matter and can’t remember much from the courses.

*“It’s really sad to me that this knowledge that was in my brain three years ago is not here anymore and it’s kind of sad and depressing and I wish it was there. With all that time I put into that class – I attribute a lot of it to [that] I never really own[ed] it. It was just in my brain, passing, and eventually it went through and it’s been replaced with something else. . . . I didn’t do anything with my own ideas in that class and because of that I don’t have much to show for it now. So because of that I value more student-centered activities where students get to make meaning of things and have some relevance to themselves. ‘See this was my concept. I came up with this.’ Because of that I think it’s more likely to stick with them.” [Luscien Video-clip Interview]*

According to Luscien, there is a distinction between traditional and more contemporary views on who “owns the knowledge” in the classroom,

*“Traditionally the teacher would own the knowledge and they would dish it out and you were lucky if you got to have a little bit of it. . . Why should the teacher have the sole ownership of the ideas in the classroom? Why can’t the students come up with these ideas themselves? The teacher allowed for students to facilitate their own explanations and their own ideas as to why these things occur?”*

[Luscien Video-clip Interview]

In the above quote we see the contradiction between the teacher owning the knowledge and his early struggle with his image of the teacher as owning knowledge. From Luscien’s experiences both as student and teacher, students who contribute will take pride and ownership of the co-created knowledge. This viewpoint places the student closer to equal standing with the teacher. For Luscien, his own less than satisfying experiences of rote learning lead him to value experiences when student ideas are centrally tied to making meaning.

*misconceptions: wallowing or brilliant ideas?*

At times Luscien sees Robert’s lack of involvement as letting the students wallow in their, sometimes wrong, ideas. This is something he would find it hard to do. Alternatively, Luscien also sees value in students’ ideas. In fact, for Luscien, meaning-making must start with student ideas,

*“Deductive methods of science is not a great way to have knowledge stick in students. For them—the best way is for them to make sense of it within themselves and then work through their misconceptions and take on a more formal scientific understanding of things, not just learn someone else’s version of how the works. And transcribe that into their own brain – kind of make sense of it within themselves I guess.”*

[Luscien Video-clip Interview]

Again, we see a real conflict between the role of the teacher and the desire to facilitate student learning. This is a common tension in constructivist-inspired teaching and experienced teachers have managed this tension. Luscién, a novice, is beginning to explore, and theorize, about the balance he seeks. Below Luscién recognizes his urge to correct and clarify misconceptions. In the second quote he acknowledges the transition he's making to valuing student ideas.

*"I guess he's allowing even more time than myself to let them wallow in figuring [it] out themselves. I don't know if – I would find myself –it'd be hard for me not to jump in when a student brought up a misconception or wrote something down on the poster that wasn't quite right. I guess I'd probably have a tendency to bring that up right away."* [Luscién Video-clip Interview]

*"When I was a TA in college I would TA calculus. I'd basically just go through things, you know, empty my brain out onto the white board and say, 'There it is. Do you get it or do you not get it?' And now, I'm really trying to listen to what the students have to say. I realize that the students have brilliant ideas; that they have ideas that I haven't had yet; that I can learn from them. It's just a little more give and take than how I think I would have originally approached helping someone learn."* [Luscién Video-clip Interview]

*those who need more.*

Luscién describes a student from his critical incident in understanding how people learn who needed more than what the typical classroom instruction offers. From this student Luscién learned a valuable lesson about

students' motivations, especially those that differ from his own motivation to do well in school.

Putting together the data from his Video-clip Interview with some of his insights during the Follow-up Interview, we see that Luscién prefers to be actively involved in learning. Putting together his strong sense of ownership with the value of involving students in lessons, we can see how ownership and participation contribute, in Luscién's mind, to learning. Overall, Luscién's perspectives on learning appear strongly constructivist. Though he has had little experience with more constructivist instruction, his experiences with traditional instruction were negative enough to strongly impact his perspectives on teaching and learning. However, when faced with being the teacher in the classroom, such as his long-term substitute experiences, he attempts traditional instruction.

The critical incident Luscién recalled involved a student from a long-term substitute teaching position he held. Bill lacked the motivation to learn and was considered a "problem-child" in school. For Luscién, encountering Bill provided a first encounter with someone who was not at all motivated to succeed in the traditional school environment.

*"I came to a realization then that . . . all students in high school aren't like me. To me you know, 'All you have to do is X, Y and Z and you'll do well in this class' and for some students they really they don't care. They don't have that drive to get back the A's on their report card or get that reinforcement somehow. They have no desire to succeed in school for one reason or another. All students don't come in with self-motivation and I had to find other ways besides 'You need to do this to*

*do well.' It's not just about doing well. They need more. They need it to be interesting."* [Luscien Follow-up Interview]

I asked Luscien how his encounters with Bill changed his teaching. He responded that to interest the students he designed experiments where they were participants in data gathering and analysis. He also designed lessons that had a strong relevance for the students. Consequently, he described the differences in Bill and the connection to the role of the teacher.

*"This kid who was the biggest trouble maker was totally into this lab and he was like sprinting up and down the stairs and counting it and calculating his heart rate and you know graphing his heart-rate over time. My heart went out to this student that in the traditional setting he was going to be the troublemaker, no matter what. Only in activities where he was allowed to, I don't know, take a different path in as far as you know the typical teacher-student, 'Sit down. Listen to me' relationship. If that didn't change he wasn't going to succeed in school."*

[Luscien Follow-up Interview]

I pressed Luscien to explain why these redesigned lessons were so effective. I asked him to describe in more detail the value of the lesson he designed. He responded,

*"Well I think a lot of kids will remember that lab for a while, and they'll -- what will they remember? 'Well this kid won, or this kid had great horsepower because he was fat and fast. Like if you have weight and you're fast you know that's what does it.' And so I think that will stick out in their heads. You know they could remember the formulas, work over time. Well what is work? It's the force you're applying against gravity*

*over time. So they'll remember it in their own terms . . . for a longer period of time than you know  $P=W/T$ .” [Luscien Follow-up Interview]*

Luscien’s “litmus test” for the effectiveness of a given teaching style is linked to the long-term impact of the instruction and originates from ownership as co-creators of understanding. How students think about their world years after the instruction is the telling factor of the lesson’s effectiveness. A student’s contribution of their own words and their own ideas builds the memories that the student will have of the lesson; students are seen as co-creators of knowledge.

*thinking about thinking.*

Luscien’s response to the last Follow-up Interview question reveals his complex awareness of teacher development as linked to metacognition. He explains that a teacher will recognize different needs in their students if they take the time to think about how they themselves learn and subsequently teach.

*“If you never stop and reflect upon that then sure, how else are you going to teach except for how you've learned it -- how you learn and how you were taught? But if you stop and think about things then I think you can stop and make changes . . . I mean if you learned by looking at the board and taking notes -- maybe that is how you learn best. I don't know. But if you stop and say, 'Well I did really well in this system because that's how I learn best but there are a lot of students out there [for whom] that isn't working for them. I need to integrate other means of teaching into my classroom.' There's no reason why you can't do that and do demonstrations and other methods.” [Luscien Follow-up Interview]*



Luscien explains that he only recently experienced metacognition into his own learning preferences as part of his teacher education program. Luscien's perspective is evidence of the value for novice teachers to reflect on their own learning and teaching preferences.

*Master Teacher Ann*

From both the video-clip interview and the follow-up interview Ann appears to be a moderately constructivist teacher. Her use of misconceptions for diagnosis and her desire to have students play with their ideas and recognize inconsistencies in their data supports this claim. In addition, her belief in and evidence for learning styles, and her awareness that her preferred learning style should not and does not drive her instructional choices, also support this claim.

According to Ann, learning styles (her terms) play a central role in her personal theory of learning. She doesn't speak very much about constructing ideas from past experiences, though her awareness of common intuitive misconceptions of physical sciences exemplifies her rich pedagogical understanding for her field.

*student ideas and onus.*

Ann is comfortable using student ideas to explore science topics. She also is flexible because of her ability to proceed in a lesson based solely on student ideas about a topic. She thinks it is important to use student ideas in teaching. She places the onus for thinking on the student. When asked what she thought would happen after video-clip A and what she would do next she said,

*“He needs to do a lab where either they try ideas he sets up for them or ideas they’ve come up with . . . he needs to let them try or at least demonstrate some of those ideas.” [Ann Video-clip Interview]*

*“I would have a lot of stuff hanging around and I do have closets full and as they talk I would start bringing things out and ‘Let’s try a few of these things.’ I might have a goal down the line of actually doing a lab that I prepared. You want them to try a few things and maybe you’re not prepared to have a whole class do them because you don’t have enough equipment . . . It’s a spur-of-the-moment thing . . . Get the kid with the idea up there and have him try a few things and that way you’re going to generate a lot of interest . . .” [Ann Video-clip Interview]*

The challenge, though, is for the new teacher to maintain the interest of the whole class when centrally involving just one or two students. Ann expresses how impressive it was that the students in the video-clip are discussing with each other rather than turning to the teacher for direction. She calls this segment, *“a very advanced level of teaching”* [Ann Video-clip Interview].

*don’t lead them astray.*

Ann balances addressing student misconceptions in a way that allows students to explore their own ideas while at the same time she is cogniscent of being a good guide, one that doesn’t lead students astray. Student conceptions play a strong role in Ann’s teaching. She needs to get at student preconceptions so she can plan where to go with her lesson, with the purpose of addressing student misconceptions. However, she takes great care to reinforce correct understandings and avoids leading the students down wrong paths through her own lack of content knowledge. It is noteworthy that Ann

appreciates the time and effort it takes for students to change their conceptions.

With solid content knowledge she said, *“I can avoid certain traps. I don’t want them to walk down those lanes and start getting misconceptions because I’ve led them slightly astray.”* [Ann Video-clip Interview] When asked what the students in the video-clip were learning, she expresses that some misconceptions were still held but *“for the most part they had learned . . . very sophisticated ideas about what changes friction . . . and obviously the difference between their original ideas”* [Ann Video-clip Interview], their preconceptions.

She is not strongly concerned with the obvious student misconceptions in the video, *“We still have a little bit of density confusion but not too bad and all in all I think he’s [Robert’s] gotten a pretty good idea into their heads about what’s going on.”* [Ann Video-clip Interview] When pressed about the misconceptions she identified regarding friction and density she said, *“it’s very difficult to get a misconception like that through their head or to have them actually use correct terms. They feel more comfortable especially in front of a group using common everyday terms and not trying to show off.”* [Ann Video-clip Interview]

When asked why Robert organized his teaching this way she expresses complex reasons for his actions,

*“Organized it in that he’s gone from a discussion led by him to a discussion led by the students? Because first he was getting ideas of what they were thinking so he’s seeing their misconceptions. He’s seeing their good ideas, he’s seeing where he’s got to go with this topic. Now at the end he gets to see what they’ve learned and really pick it out of their brains. It’s not just a paper test, he’s actually seeing them*

*respond to questions and try to answer other kids' questions. I thought it was a great way to do it.*" [Ann Video-clip Interview]

Her praise, preceded by an explicit justification for his reasons, show her leanings toward a constructivist approach to introducing a topic and assessing understanding.

When asked whether this lesson would have worked for her she responds that it would. Though she doesn't do lessons like this often, because of the time constraint, she decides what topics should be taught like this.

*"I like that it gets them involved. It helps me know what they're thinking and then I can deal with their misconceptions. As an experienced teacher I know most of the misconceptions now but in any one class it helps them to listen to each other."* [Ann Video-clip Interview]

When asked to describe the role played by student misconceptions in her teaching, she describes them as central.

*"We do about three or four different labs with density and they have to have their hands on it. We're doing better on that now that we're spending more time with it. You cannot just give them the formula for it. Mass over volume does not do it in their heads . . . it takes doing it and redoing. It also takes analyzing their data . . . . . because they started to see inconsistencies in their data they started to see that the one that weighed more really didn't necessarily sink."* [Ann Follow-up Interview]

She addresses misconceptions by returning to problem concepts in a variety of ways throughout the year. Her decisions about lesson structure and sequence flow directly from a desire to teach for understanding, to meeting her students' needs. She also realizes that students need time to grasp and grapple with conceptions.

*reaching past the comfort zone.*

Ann's advice to teachers is to reach past their comfort zone. Her awareness of different learning styles, as she describes them, is an ever-present impetus for a teacher to never get comfortable with how she teaches. Ann is aware that learners are different and need a variety of instructional strategies in order to learn. In response to questions of what she recalls,

*"Somewhere they were used to writing it down and he encouraged them to do pictures. That was a good thing because you are dealing with different learning styles and I didn't see any pictures being drawn but there might have been that happening."* [Ann Video-clip Interview]

She sites her critical incident in understanding how people learn as her interaction with a learning skills teacher at the middle school where she teaches. Her in-service experiences that introduced her to learning styles became central to both her planning and instruction because she began to see evidence supporting that people learn in different ways. How does she know a student has learned something? She looks to the connections they make between ideas on concept maps as truly indicative of understanding. However she wishes she could probe each student's brain in a one-on-one discussion of ideas.

When asked to describe how her students learn she says, *"That's a horrible question to ask about a whole class. Because they have such different learning styles . . . I can't say how a class learns best. I can say how a child learns best if I talk to them."* [Ann Follow-up Interview] She sees the diversity of learning styles in each class and uses strategies to meet the diverse needs of her students.

An important justification supporting her constructivist perspective is her awareness that the way she learns is different from the ways her students learn. She describes herself as, *"I can read a manual to figure things out. I can swallow things whole."* [Ann Follow-up Interview] However, her teaching style differs greatly from how she herself prefers to learn.

Her advice to novice teachers illustrates well her awareness that one's preferred way of learning cannot alone influence your teaching strategies. She asserts before a teacher can teach a group of students she has to have the ability to command their attention when she wants it and to the degree that she wants it. Only then can learning happen. But, she says, new teachers have to understand that people learn very differently than them.

*"The statistics say that 20% of people learn like teachers learn. So 80% of your kids are not going to learn like you learn. . . you really have to look at different ways to teach than you were comfortable with. You can't stay comfortable . . . ever."* [Ann Follow-up Interview]

According to Ann, no matter where you are in your career you have to keep listening to other people and changing. New teachers should force themselves to teach to different learning styles, she says. They can take exemplars from how they learn or how others teach but new teachers must realize that some kids are going to learn differently and thus need to be taught differently. Ann points to teacher education as the place and time to instill this ability in future teachers.

#### *Master Teacher Rachel*

Rachel's perspective on learning exhibits strong constructivist tendencies: students should be doing something to explore science ideas, student ideas can drive lesson structure, students' misconceptions have to be

explored and confronted with data to guide student thinking towards correct science ideas. Additionally, she recognizes that taking ideas and transferring them from mind to paper can reinforce connections. This awareness of cognition shows itself in her instructional choices. During the follow-up interview Rachel's constructivist ideas are clarified. She uses questioning to challenge misconceptions. She places onus for learning on the student and she sees her role as facilitating thinking.

*thinking takes time.*

Like Ann, Rachel is aware that students need time to process information, especially if it contradicts their own perspectives. Rachel characterizes Robert's lesson as an example of discovery learning. She explains his slow pace as indicative of such a lesson design.

*"Discovery learning takes longer. When you tell kids what to think it's quick but if you \_ask\_ them to work through a problem then you've got to give them time to think and that takes time."* [Rachel Video-clip Interview]

Discovery learning should involve "doing it". Rachel is very serious about students playing with their ideas and testing those ideas out; gathering and analyzing data is important for students to create understanding of concepts.

*keeping the students in control.*

A common theme for Rachel that illustrates a more constructivist perspective is her desire to keep the students central to the learning. They are in control to a large degree. This is tied to Rachel's idea of the role of the science teacher as facilitator and guide but not leader. Very early on Rachel connects the lesson she watched to teaching for understanding. For her what stood out was the centrality of student ideas,

*“He’s really asking them about their ideas. He’s making it so that they are coming up with the ideas rather than him and I think that’s a good thing.”* [Rachel Video-clip Interview]

For Rachel the lessons she’s seen Robert teach are about *“letting the child learn on his own and in his own way.”* [Rachel Video-clip Interview] She used to do more discovery learning but now combines direct teaching with discovery learning. She doesn’t explain why she thinks a combination is better. Valuing student ideas seems central to her teaching.

Rachel’s emphasis on placing the onus for thinking on students extends to teacher development as well. When asked what advice she would have for Robert she said she would not tell him what he should do but would ask him thought-provoking questions centered on student understanding so he could come to conclusions about having the students *“do something”* himself. Rachel’s preferred instruction involves putting students in positions to recognize patterns. They’ll conduct an experiment and she’ll ask them, *“Do you notice that pattern in any place else? You know what are the words? What are the easiest and best words to use to describe that pattern? Ok now let’s see what the science book says about the pattern.”* [Rachel Follow-up Interview] She characterizes this approach as going from a broad perspective to the specific but emphasizes, *“\_they’re\_ really doing a lot of the direction of it.”* [Rachel Follow-up Interview].

Rachel’s discovery learning, where students must have materials in their hands to play with, contrasts to other methods of instruction, *“Direct teaching is not a learning strategy because the learner is not active in it.”* [Rachel Follow-up Interview] Though she employs direct teaching from time to time, she emphasizes strategies she uses to keep the learning centered on



the students. I could not characterize Rachel's perspectives on learning without mentioning the importance of confidence in her teaching. For Rachel, believing in oneself is the critical piece necessary for learning. In its absence learning is sabotaged. Also, being a parent of five children, she attributes her perspectives on learning to a large extent on the experiences she had raising five very different children. Her critical incident in understanding how people learn is drawn from her working individually with her children as they struggled with mathematics. Those experiences also reinforced for her the role confidence plays in learning.

*to teach does not equal to learn.*

This section's title is taken directly from Rachel's comments below. They capture an awareness that teachers cannot learn for a student. The onus is placed on the student. What the teacher can do is orchestrate opportunities for learning to happen and provide a reason for the student to invest in the learning.

When I suggested that confidence alone might not help students develop understandings about mathematics, she replied that the teacher must tie the concept to the child's world. If not, the child has no reason to invest in the learning. The teacher must, according to Rachel, begin with a vision of where she wants the students to go. Along that journey the teacher provides opportunities for the student to develop that vision. According to Rachel a teacher must have room in her lesson for the student's vision to develop in a different direction from what the teacher envisioned. Her advice to pre-service teachers captures her rich student-centered perspectives on learning and the role the teacher should play,

*"To teach does not equal to learn. Many things are taught, that does not mean that they are learning. Only the learner can learn. The teacher cannot learn for the learner. The teacher doesn't have anything to do with the learning in a way, in a way. Teaching is like cooking. I make dinner and I put it on a plate and I give it to you. If you don't pick up your fork and you don't eat from that plate you're going to die of malnourishment. So what the teacher puts on the plate . . . but the teacher can't eat for the kids."* [Rachel Follow-up Interview]

For Rachel, *"The goal of the teacher is to find the key that unlocks the child's interest in learning. And because everyone of them is different it just takes a long time to figure out what those keys are."* [Rachel Follow-up Interview]

When asked whether teachers teach the way they were taught or teach to suit their learning preferences, she replied that she does not do either of those two perspectives nor believe in either choice. She is cautious not to teach to her own preferences for visual information. She describes herself as less kinesthetic, but because several of her students are more kinesthetic she includes such instruction, out of fairness. According to Rachel, as a teacher encounters students with different learning styles and tries new ideas she broadens her repertoire. For Rachel, seeking National Board Certification allowed her to closely examine her own teaching and try new ideas. In addition, Rachel's self-confidence was bolstered.

Rachel's perspective on her role includes such ideas as *"My job is to provide opportunities for you to think"* and *"My students make me a better thinker even though I'm a facilitator of thinking."* [Rachel Follow-up Interview] She clearly sees herself as providing experiences that foster student thinking. Tied to the discovery-learning model of instruction for Rachel is a particular

role for the science teacher. The teacher is a facilitator who leads students to knowledge. But along with taking that role the teacher must know when to stop students from reinforcing wrong ideas.

*putting the brakes on.*

Rachel's approach to learning highlights an appreciation but not a fear of misconceptions held by students. She uses this image of braking to describe how she reacts to students' misconceptions. She balances exploration of student ideas with care to not reinforce misconceptions. When misconceptions become apparent she questions the student to engage their thinking as they compare their ideas with the data they have available.

*"Except that their observations can be wrong, and can be skewed and unless you're saying to them, 'Well that happens in that situation, you're right but is that something that is always happening? Would you say that that's true all the time?' Either they can support it or they can't."*

[Rachel Video-clip Interview]

However, there is a tension between exploring student ideas and developing accurate science ideas. Rachel emphasizes the struggle with discovery learning as deciding when to employ discovery learning and for how long. She feels it is important to pick which topics to teach directly and which to let students explore. She illustrates this concern with criticism of Robert's timeline,

*"I would have a problem with that because that's fine on day one and day two but by the time you make your poster you should have it. They're not your ideas. Now what you are doing is you have discovered some natural laws of nature that hold true in a wide variety of situations"*

*and you should be able to express those and they should be accurate.”*

[Rachel Video-clip Interview]

How students present these scientific ideas is up to them, but she is concerned that Robert told the students they are presenting their ideas about friction on their posters. For Rachel, students should be stopped if they begin to cultivate a wrong idea. It is important for her that students not write wrong ideas for fear that doing so will reinforce them.

Rachel, from her video-clip interview, comes across as having a bit of a traditional perspective on wrong ideas. She had said not to let students write wrong ideas. When asked for clarification she responded,

*“What is the sense of drawing an incorrect picture and explaining it? Finding the words to explain it and it's wrong. It doesn't make any sense. So what you do is you say, ‘Draw the picture and let me check it.’ If I check it and the worst that can happen is you're half way through. And I go, ‘Wait. Put the brakes on. Hold up. Don't cross it out, just draw a line and start again.’ So a lot of times a kid will misinterpret a question or he will follow his logic down a bad path. And all he needs is a question. He's got his logic to here. And you can be reinforcing him building his confidence, you can be saying, ‘You're right to there.’ and then when he starts to go wrong say ‘Ok, let's go back to that spot. And let me ask you a question about that.”* [Rachel Follow-up Interview]

Rachel feels responsible to guide student thinking but does not try to replace wrong ideas with right ideas. Her directive is to challenge the student's thinking with questions. She determines when is the time to step in. Rachel uses a lot of questioning in her teaching. I asked why this was the case. She explained that without a question that is relevant to the student's life they won't

have a reason to invest. Without investment, the students have no motivation to learn.

For Rachel, students are in school to learn about their world. She does not expect them to come in with accurate perspectives on science. Her classes provide opportunities for students to rethink ideas. Her lessons are collaborative, involving the students in creating and sharing knowledge. When misconceptions become evident she relies on questioning to help students confront their less accurate ideas. Her comments to students might include the following exchange,

*"'Would anyone like to make corrections?' Sometimes it goes from right to wrong. But then you just keep with that strategy, you don't freak on it. You just stay with that strategy. 'Would anyone like to go up and make a recommendation on that?' And then every now and then if no one does, then I'll go and get them back on track. You just have to keep it light. 'If I wanted you to get everything right I would just go ahead and teach you something you already knew. But I'm teaching you things you don't know so of course you're not going to know it because you don't know it. And if you did I wouldn't be [needed].' The other thing is the interesting things are complicated and complicated things can be misleading but that's what makes them interesting. I mean we can talk about easy things but they're just not interesting. Want to talk about the weather? Well that's pretty darn complicated. 'So if you've missed that little section which throws off the entire thing, who could blame you, of course there's only 25 variables.'"* [Rachel Follow-up Interview]

*Master Teacher Mercedes*

*the having of right ideas.*

Having right ideas is so different from Duckworth's notion of having wonderful ideas (Duckworth, 1996). Mercedes, like so many teachers, is interested in student's knowing, and I would venture, understanding right ideas. However, the emphasis throughout her class is one of reward for right, perfect ideas. She even uses a bad odor in one's house as a metaphor for having a misconception.

Mercedes shares that at one time she used to employ direct teaching methods, then shifted to an open-inquiry strategy, and now uses, what she calls, "guided-inquiry". As she describes her style, though, it seems there is more guiding and less inquiry.

*"I no longer let them go off and try things that are really far a field. I don't do that as much because of time and I now believe that it reinforces incorrect ideas. Letting people free at that age I feel actually reinforces incorrect ideas. I want them to reinforce correct ideas so I've got to get rid of incorrect ones before we go into a testing mode . . ."*

[Mercedes Video-clip Interview]

When pressed to describe how she gets rid of wrong ideas, she explains that she presents the students with "the facts". Her battle with wrong ideas stems from the following belief,

*"If they liked one young man's explanation . . . and they thought that made sense, that's the answer their brain's got right now and I don't know if they're going to give that up that easily."* [Mercedes Video-clip Interview]

Her biggest critique of Robert, the teacher from the video-clip, was his instruction to the students that there were no wrong ideas because they were their ideas.

*“You can have something wrong on that board but you wrote it . . . neatly. You decorated it. You drew a diagram of it. If it’s wrong, that is definitely implanted on that group’s brain. No doubt in my mind. I don’t think I’d do boards until you get rid of everything that’s wrong. If you’re going to brainstorm wrong stuff, you should not do it in a way that makes a strong impression on your brain, which is graphically, colors. Talk with your group not knowing if it’s right yet. Then when you’re sure you got it, that’s when you decorate it and then you implant it in your brain.”* [Mercedes Video-clip Interview]

As fixed as her ideas are about how students learn, how ideas are implanted, she does not explain how to get rid of wrong ideas. When asked what she does when misconceptions persist she responds time after time that students’ wrong ideas need to be gotten rid of.

Mercedes has very strong ideas about how students learn. Because of these perspectives, she handles wrong ideas in a very particular way.

*“If there was something on that chart that was misleading I would have had it crossed off with a big X. But after the first week nobody minds in my room. If there’s something in front of those kids that’s wrong you need to X it out. Because if they don’t, that stays up there as a potential right answer to the kid that was only half paying attention when you said it was wrong. ‘It needs to be black and white. That’s got to come off there because I don’t want you thinking that. You know it’s not personal. It’s just got to be right or you can’t leave here thinking it . . . I respect*

*what you think but you know if it is wrong I'm going to cross it out.' . . .  
And they do buy into that. They absolutely do not take it personally."*

[Mercedes Video-clip Interview]

At one point Mercedes asked students to draw their ideas of a physical science concept. From the drawings she realized she was not assessing their understanding thoroughly enough because the written explanations they gave were right but the drawings revealed misconceptions. She now includes drawing as an assessment form. However, armed with this information that students had persistent wrong ideas she did not change her lesson design to create opportunities for students to construct more accurate understandings or to confront their misconceptions. Instead, she devises alternate assessments, drawings, to reveal their wrong ideas. She then tells them the right ideas until they can show evidence of knowing the right ideas. She does instruct in three ways: notes, drawings, and explanations, so as to provide multiple opportunities for students to learn right ideas. To further illustrate this perspective, students in her class divide their notebook in half. The first half is for right information, the second half is for them to work out their own ideas. They are instructed to study only from the first half of their notebook. Mercedes emphasizes that ideas are not recorded in the first half unless they are right ideas.

I'm surprised by the responsibility Mercedes places on her students for identifying their own misconceptions. She expects that they will contrast their way of thinking to the way of thinking they hear or see from her. Just by this process they are expected to volunteer that their thinking doesn't match the right way to think about science,



*"And then every time I'll start a concept I'll say, 'You know what. You might [have] misconceptions. The minute you see one, the minute you find one you think you knew and you now know you are wrong, I want you to share that with me.' And the kids will raise their hand and say, 'You know I always thought seasons, I always thought that the sun was closer during the summer and further away in the winter. That's what I thought was the right answer.' And I said, I know, how are we going to get rid of that because next year when I'm gone you're going to think that again." [Mercedes Follow-up Interview]*

I pressed Mercedes to explain where misconceptions come from. She responded,

*"I think a lot of misconceptions make sense. Unfortunately they are logical. They're based on real life experience, when you get closer to heat it's hotter, when you move back it's colder. Or maybe it wasn't explained very well or maybe it wasn't explained in a way that was able to unseat the misconception. So I think they take their logic that they had since they were a little kid, maybe parents and inexperienced people told them an answer anyway. They [parents] revert to logic, which might not always be correct. You can pick out the kids whose parents tell them the way it is carefully and truthfully; they understand it." [Mercedes Follow-up Interview]*

With this response, Mercedes introduces the notion of truth. This perspective fits with her dichotomy of right and wrong. If we were to ask Mercedes I think she would say that science is the truth. It would be interesting to further explore her understanding of the nature of science and the origin of scientific knowledge.

*bad odors and emptying the trash.*

When challenged about how she unseats misconceptions that have formed she likens the student's brain to a house and the misconception to a bad odor that must be rooted out and thrown away.

*"There's something stored somewhere in your house that's giving off a bad odor, but you need to go find it. So let's say you spray a good smelling spray around, does that make it go away? {No} So you need to go find it, take it out of the house and get rid of it, put everything in a new place and get it right and then you won't have the problem again. So we talk about taking out what you don't understand and getting rid of it. We do peer editing for that purpose."* [Mercedes Follow-up Interview]

Peer editing allows the students to respond to each other's work. Often the responses include recognizing wrong and right information, *"That part's not right. I know it's not right, I heard the teacher say it the other day."* [Mercedes Follow-up Interview] Students then tell Mercedes, who checks the work and the student *"is supposed to cross it out. I know it sounds simplistic; it's almost like a physical motion and I actually say to them, 'Picture throwing it away.'"* [Mercedes Follow-up Interview] I challenged Mercedes by asking her how she deals with misconceptions that persist even after students have "thrown away" a wrong idea. She tells a student that they may have to throw away the wrong idea three or four times. In fact, it might not be until high school that the student, she says, will get the right idea after revisiting the concept.

*personal learning space.*

When asked how she learns best, Mercedes replied, *"By doing it myself"* [Mercedes Follow-up Interview]. Mercedes introduces this concept of personal learning space which she applies to herself and to all her students.

She explains that she became aware of her need to do things herself from learning how to use computers from her husband, *“If he takes the mouse and clicks through a sequence I will never learn it myself.”* [Mercedes Follow-up Interview] However, she emphasizes that she doesn’t want to aimlessly wander in wrong directions. She applies this approach to teaching. She sees her role as facilitator. To her that means she may tell a child how to wire a light bulb, but she won’t do it for them.

*“My job is to make sure they're going in the right direction. I don't let them flounder, but they get there themselves. My job is to keep redirecting them every time they go off in the wrong direction. And that is a facilitator.”* [Mercedes Follow-up Interview]

Letting students flounder is something Mercedes has strong feelings about. She is very impatient and considers it a great waste of time to investigate what she calls wrong paths. She credits her own impatience with not wanting to let students explore wrong ideas. Again we see this distinction between wrong and right ideas. She is trying to avoid frustration among her students that, she believes, would certainly interfere with learning for the class as a whole. *“You withhold an answer from the wrong kid at the wrong time and you could lose the whole class.”* [Mercedes Follow-up Interview]

Mercedes introduces the notion of personal learning space. She does not invade the learning space of her students, nor do her students invade each other’s learning space. Her attitudes about learning space originate she says, from her own preferences and are manifest in her beliefs about learning.

*“If you write it for me I'm not sure I can do it. I can watch you do it. I need to do it myself. When I do it myself and it's right then I know*

*[that] I know how to do it. And that's the \_only\_ time \_I\_ know how to do it."* [Mercedes Follow-up Interview]

*"Learning is the same way. Your learning is yours, not somebody else's. I can help you, I can advise you, but I shouldn't be touching your pen or anything. I don't do that for you."* [Mercedes Follow-up Interview]

Her thinking about learning as spatial ties into her perspective on how people learn,

*"I think learning is spatial. It has a place it belongs. If you put it in the wrong place you can't go get it again. It isn't connected to anything. It doesn't make sense. If it's out there all by itself you can't go back to it because there is no link to it."* [Mercedes Follow-up Interview]

A critical incident in Mercedes' understanding of how people learn involved asking students to draw what sugar dissolving in water looked like. She found that the words they'd used were correct but the drawings revealed significant misconceptions,

*"I thought, 'They'll have to draw everything because I'll have to know what they are thinking.' They don't express themselves well enough for you to figure out whether they're right or not. I think I filled in a lot of words [for them] without meaning to because they hesitate and they falter."* [Mercedes Follow-up Interview]

Again, we see the emphasis on being right or not. For Mercedes, the one person who should be right is the teacher.

*teacher: bearer of knowledge.*

A recurring theme for Mercedes is the image of teacher as the keeper of knowledge. Mercedes feels very accountable for student's incorrect ideas

about science. She sees her role as clarifying and correcting wrong student ideas to accurate science ideas.

*“I just believe now that people learn their wrong ideas . . . when you don’t guide them enough. I think teachers need to guide more. All those years where they said you need to be the facilitator, don’t be the sage on the stage, be the [guide on the side]. Well you know what? You need to be the guide on the stage. That’s what you need to be. You need to be the center.”* [Mercedes Video-clip Interview]

In fact, her reasoning for why Robert’s style could support learning is that the students are engaged and interested, *“It’s as if they’re the teachers”*.

[Mercedes Video-clip Interview] She offers strong criticisms that Robert’s style can interfere with learning because the students are learning what each other thinks, not what are the right ideas. And later she offers,

*“When push comes to shove, I’m the teacher. I’m the one that’s supposed to know it. I should be the one that gives them what to study. That’s the truth. It’s not supposed to come from them. They’re the kids. The thinking is supposed to come from them. The process should come from them, but the answer should come from me.”*

[Mercedes Video-clip Interview]

Mercedes’ perspective on onus for learning is interesting because it is split between the process and the answer, between the students and the teacher. It remains unclear how the process coming from the students supports learning the answer that is given by the teacher.

We see this idea of “Teacher as Bearer of Knowledge” in so many of her responses, even in her comments about Board Certification and content knowledge. National Board Certification (NBC) reinforced for Mercedes that

she understood how people learn. National Board Certification also proved to Mercedes that a teacher without enough knowledge on a topic shouldn't be teaching the subject. She concluded this after scoring poorly on a content section of the National Boards in an area where her background was weak. She explains that a teacher who only understands slightly beyond the students' understanding will not be able to teach for understanding,

*"It's virtually impossible to catch up on a topic you don't understand. How do you know your students don't understand if your depth of understanding is only a little deeper than theirs?"* [Mercedes Follow-up Interview]

The classes throughout Mercedes' education did not resemble how she teaches. Her high school and college courses that were hands-on, such as biology, did captivate her. She assures me though that she doesn't teach as she was taught. Her classroom experiences, as a student, involved mostly memorization. She teaches to some extent, she explains, as she prefers to learn. However, she instructs the same concept in three different ways: notes, drawing, and explanation. She believes that in this she is addressing the needs of her students. She asks her students and they respond with what should come next or if they feel ready for a quiz.

Her approach to teacher education, not surprisingly, resembles her approach to classroom instruction. For teachers to move from novice to master they should watch and mimic a master teacher. She even equates this approach to letting the teachers do it by themselves, much like she needs to do for herself. Teacher education should involve showing a novice what mastery looks like and then having them do it exactly the same way. Her idea of mastery is a direct corollary to how she teaches. She is a master in her

mind and emulating her in deed and action will lead a novice to mastery faster than any kind of philosophical (her word) discussion in a teacher education classroom. I intuit from her reaction that she might have some disdain for teacher education programs. This is surprising since she has such a respect for experts, unless of course she doesn't consider teacher education programs as sources of expertise.

### Focus

To characterize the participants' focus I conducted a global analysis of participants' comments in both the interviews. Participants' mention of classroom management issues, classroom organization, lesson design, student engagement and timing were associated with a focus on survival. These logistical problems, part of the fears beginning teachers have, are coupled with a fear of losing control in the classroom.

#### *Novice Teachers*

Also helpful in determining focus is the participants' self-image. According to the literature and supported by my research, Novices typically see themselves as students in the class and don't identify as the teacher. When participants referred to their own preferences as justification for a teaching choice I called this the "I . . . therefore" code. This was entirely a Novice code. No Masters justified their choices by personal preferences. Some participants came flat-out with acknowledgements that they didn't see themselves as the teacher yet.

#### *audrey.*

Audrey lacks clear concern for student learning and is more focused on survival. Audrey manifests her concern for issues of survival with her attention to lesson design and student engagement, not so much classroom

management. Her recollections about the students involved their attentiveness to the lesson,

*“The rest of them seemed to be really into what was going on. Lots of heads nodding; lots of hands going up; lots of writing; pretty engaged except they kept on showing this one group who were not really participating and just kind of sitting there.”* [Audrey Video-clip Interview]

Audrey justifies the lesson style as supportive of student learning based on how engaged the students are. In other words, if the students are engaged then they are learning,

*“I would say it’s very supportive of student learning because they seem to be incredibly engaged.”* [Audrey Video-clip Interview]

During several of the Video-clip interview questions she focused on Robert’s lesson structure,

*“If I were sort of imagining his sequence, it would be they all talked as a class about basic friction stuff and now they’ve opened it up to this group work, coming with their ideas and I’d almost imagine they would then be designing some sort of investigation to figure stuff out.”* [Audrey Video-clip Interview]

Though Audrey takes the voice of the teacher in this quote above, on several occasions she justifies her conclusions based on how she would feel if she were a student in the class.

*“I think it can be frustrating if you don’t have any prior knowledge of it and you’re not given very much. Say someone had no idea what friction was, didn’t know what the word meant, just had no concept of it. I would find that a very frustrating situation, then to be thrown in. But hearing*



*your peers' ideas and working in a group would probably help with that."*

[Audrey Video-clip Interview]

When asked if this lesson would work for her she thinks not. Audrey explains how uncomfortable she is with the idea of *"being the teacher"*,

*"I think I'm not comfortable enough with myself as a teacher, you know comfortable \_being\_ 'the teacher'. I think this kind of approach really takes some solid guidance and you have to suppress your urges to tell students the right answer . . . and I don't know that I'm there yet."*

[Audrey Video-clip Interview]

I am left wondering if this above quote is some indication of transition.

However, the bulk of her feedback for Robert involves praise for his lesson design and his classroom management skills.

In conclusion, Audrey's focus is strongly on survival, perhaps in part because of her deeply rooted image of self as student.

*jessy.*

Of all the Novices, Jessy stands out as the one most concerned with issues of survival. Classroom management is a recurring and persistent theme in her Video-clip interview. From her response to the first question through to the last question, Jessy emphasizes her concern for how to manage the classroom.

*"I think the first thing that stood out was actually the classroom management things coming from a really hectic classroom from my fieldwork observations. So the first thing was watching him telling them to pick up the chairs, that it was a big deal but they shouldn't drag them on the floor and make noise and also initially he asked them a question and after having them write things down get their own ideas, but then*

*saying 'Hands, hands, hands'. I was sort of clued in to classroom management having come from a sort of hectic classroom."* [Jessy Video-clip Interview]

Her concerns with using more open-ended classroom instruction are motivated from concerns about how to keep control of the class as a novice teacher.

*"As a novice teacher I'll want to stay more regimented and try and stick with things. [I would] not feel comfortable with things being quite so free-form".* [Jessy Video-clip Interview]

When asked how much experience Robert had, she suggested he was not a novice because he has *"exceptional classroom management skills"* [Jessy Video-clip Interview]. Not surprisingly both Jessy's praise for Robert and her questions for him centered on classroom management skills and the logistics of lesson design.

*luscien.*

Compared to Jessy and Audrey, Luscien lacks concerns for survival and focuses almost entirely on student learning. His response to the Question 1, what do you recall, is a good example of his concern for student learning.

*"I liked how when he asked questions he gave everyone time to think about it and write things down. That kind of eliminates the phenomenon in classes where one or two kids raise their hand, constantly answer and part of the class is left never having to really think about it or answer. Everyone had to write it down and he left it very open whether you could use words or pictures, 'Whatever you can do [to] try to think about what this is and why.' So I thought that's something I see myself*

*doing a lot is making everyone answer. Sort of giving a way for everyone to think about it.” [Luscien Video-clip Interview]*

From the above quote we see that not only does Luscien connect lesson design with student learning, but he also puts himself in the role of the teacher. Unlike other Novices, Luscien argues that Robert’s lesson design was motivated out of helping students learn science. But with all of this reflection Luscien struggles to fit his image of self into a different teacher mold than he has seen before. He explains that he is overhauling his image of the science teacher and how hard it is to break out of that old mold.

*“So much of it is imbedded within you as a future teacher. The experience I have had teaching is to just put out the solutions, put out the answers, help the students understand how things work in terms of you. After all you’re the one that went to school for so long, you’re the one that’s been like this physics whiz so it’s you’re job to tell them how things work.” [Luscien Video-clip Interview]*

In this example Luscien does not see himself as a student in the class but as the teacher. He has even jumped ahead of most to consider the changing role of the science teaching in today’s reform-based classroom. He is having trouble reconciling his image of science teachers from his own education with the image of the constructivist science teacher.

However much Luscien struggles with this tension much of his views on student learning are derived from his own experiences of learning. Luscien is so interesting because he does focus so clearly on student learning with a complete absence of concerns for survival. But he also seems to have a student’s perspective for seeing classroom events as evidenced in his theory

of learning. His own experiences as a student, frustrated with rote learning, bear heavily on his perspectives about teaching and learning.

### *Master Teachers*

In contrast, neither Ann, Rachel, nor Mercedes offered any justifications based on their own preferences as students. During their Follow-up interview they each drew connections between their past experiences as a student and their teaching style to some degree. They emphasized, however, that their teaching style does not favor their own preferences but rather addresses the needs of various learning preferences. Let us consider to what extent their individual foci were centered issues of survival.

*ann.*

On the whole Ann is less preoccupied with student learning and more concerned with decisions Robert made about the lesson. Ann focuses on logistics and lesson design primarily out of concern for what she considers the poor pacing of the lesson. She is critical that Robert's lesson took seven days to complete. Ann shares her concern for Robert's survival and offers him advice. Ann shares that some topics require more time than others. She advises Robert to consider his timing when designing the lesson.

*"If he's a student teacher he wanted to try some techniques. He wanted to try pulling the ideas out of them. He wanted to try letting them figure out their own labs. He wanted to try the poster ideas and evaluating – wonderful student teacher stuff. Wonderful things to do as a teacher too, but as a practicing teacher you need to balance your year and know where you're heading and know how much time you can spend on each topic."* [Ann Video-clip Interview]

Ann's reflections are more about teacher learning than student learning. She speaks from a place of experience in recognizing that he is a beginning teacher and has lessons to learn about survival in the classroom. None-the-less her comments lack a strong focus on student learning.

*rachel.*

For Rachel, the issue of poor pacing is also linked to the instructional style and student learning.

*"It is not surprising to me at all that he's in the third day and halfway through the first two days' lessons. That is not a surprise. {Why?} Because that's what happens when you – discovery learning takes longer. When you tell kids what to think it's quick but if you \_ask\_ them to work through a problem then you've got to give them time to think and that takes time."* [Rachel Video-clip Interview]

Master teacher Rachel attends to lesson structure and design, much like Mercedes, in that changes Robert could make might impact student learning. Rachel confesses she is big on *"doing something"* [Rachel Video-clip Interview] with her classes. She puts considerable time into describing how fruitful it is in terms of student learning if the students have materials they can manipulate. Hence, her discussion of lesson design focuses on this theme,

*"I think they needed to try it themselves, like in small groups with the different materials and actually try it themselves . . . He's got the discovery piece down I just don't think he's got quite all the components there {and the missing pieces would be like manipulatives?} Yep, doing something. Giving them cars or letting them bring things or changing the incline of it."* [Rachel Video-clip Interview]

Rachel goes on to reason that students are activated and excited by these kinds of experiences. So again we see a connection to student engagement.

*“I thought the end discussion was just a dream come true. Really it was great. From a question that no one could answer they start really analyzing exactly what happens on a topic that everybody’s interested in and everyone has an opinion. They’re discussing it among themselves and that is the truest sign of a good classroom. They’re staying on topic willingly, they’re listening, they’re quiet ‘cause they want to hear what the other guy’s saying. Different people are responding.”* [Rachel Video-clip Interview]

Rachel does focus a little bit on classroom management in so much as she recognizes that the students respected Robert as evidenced in their behavior. In fact she attributes his classroom control to the respect the students have for their teacher. She evidences their willingness to wait to see the purpose of his lesson evolve.

*mercedes.*

Mercedes blends a focus on classroom management, classroom organization and lesson design with concerns for student learning. When asked what she recalled from Clip 1 she answered with concerns that Robert had designed his lesson in such a way as to reinforce wrong ideas. Her suggestions and justifications pointed to a more structured approach to instruction that would result in students learning more accurate science ideas. Likewise her praise and criticisms of Robert’s classroom management are tied to student understanding,

*“If he can have them bring their chairs and sit that closely together without fooling around then I would guess that he has good rapport in*

*his classroom so the students looked focused and interested. That's a \_huge\_ thing. If the audience isn't listening you might as well stop teaching because it's not happening. They \_looked\_ like they were listening."* [Mercedes Video-clip Interview]

Mercedes offers a lot of advice to Robert, focusing on classroom management and student engagement. It is her persistent criticism of Robert's lesson design that reveals her strong attention to student learning. When asked why she thought Robert organized his lesson as he did she responded,

*"It engages them. They're interested. It's as if they're the teachers. That's what it feels like, that they're learning what each other thinks. Really it can support incorrect thought . . . So I think this is not supporting of student learning of correct ideas. It's supporting that kids have ideas but they're not all right. And those ideas are being freely discussed as if they were right and I think they shouldn't be freely discussed until they're proven to be right."* [Mercedes Video-clip Interview]

During most of Mercedes' Video-clip interview she explains her own ideas about what students need to learn. She describes how her ideas are manifest in the structure and design of her lessons.

#### Schema Development

I used three approaches to determine Schema development. I looked at the progression of ideas in part one of interview one, the storying participants did during the interview, and a question-by-question read of the data. Each tool was applied to the more structured video-clip interview. From this analysis I draw out a sketch of each participant's schema development.

### *Progression of Ideas*

During data analysis I recognized that some participants tended to jump ahead of the question at hand in the Video-clip Interview. If I asked what they thought would happen next, some participants would not only answer this question but add what they themselves would do next. This happened for a few select questions and seemed to be exhibited more by the Master teachers than by the Novices. To evaluate this pattern I tallied which participants jumped ahead, exhibiting a natural progression of ideas, a logical association from one aspect of teaching and learning to another. This Summary Table for Progression of Ideas, A.1, can be found in the Appendix.

The question remains as to whether certain Novice or Master teachers consistently reasoned ahead of the interviewer. I am particularly interested to answer this for the six exemplars described earlier so I can look at possible relationships between their personal theory of learning, their focus and their schema development. For this I must consider each exemplar separately. I would expect the Master teachers to give unsolicited answers and the Novice teachers to answer as questions were asked. The summary tables for each exemplar can be found in the Appendix.

Master teacher Ann did not anticipate any questions. In fact, for Question 13 she gave no answer. These results would support a more Novice-like approach with no progression of ideas. Her summary is presented in the Appendix, Table A.2. Mercedes' anticipation is precisely found in two of the questions that distinguished the participant groups. Most resembled Mercedes' results and thus won't be described in detail. Rachel answered three questions before they were asked: Questions 6, 12, and 13. One other Master teacher showed more progression of ideas than Rachel. Master Teacher Rachel was,



by comparison, much more anticipatory than Ann and a bit more than Mercedes.

Novice Teacher Audrey’s progression of ideas is less than that seen by the Master teachers, and as we will see, not out of the ordinary for the Novices. She exhibits anticipation only on Q10. For Novice Jessy there is persistence in addressing the goals of the lesson, Q3, as well as the reasoning behind Robert’s lesson organization, Q10. Novice Teacher Luscién shows some anticipation but not much, like Audrey in one question only, Q3.

From the above analysis, we could place each participant on a continuum of complexity in progression of ideas. Master Rachel would be at one end of the continuum while Master Ann would be at the opposite end. Novices Audrey and Luscién would be at the same location, closer to Master Ann than to Novice Jessy. Below is a sketch of the continuum constructed from the above data as well as from the other participants.

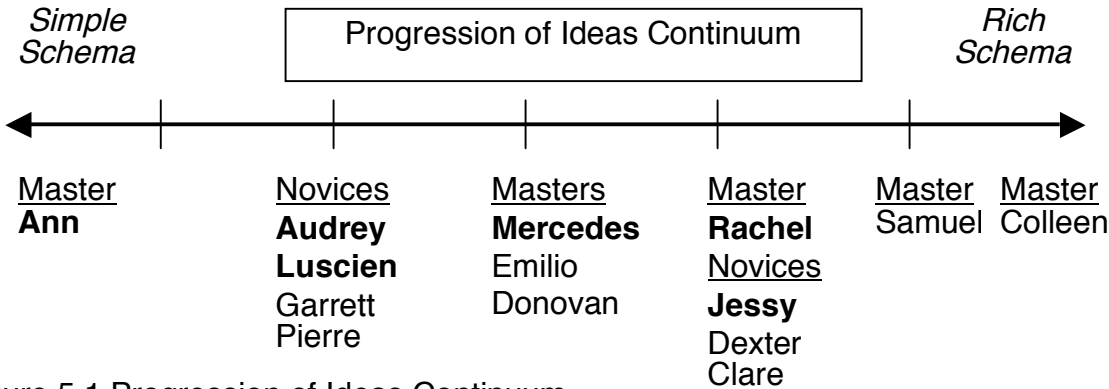


Figure 5.1 Progression of Ideas Continuum

I’ve bolded the six exemplar-participants, showing how they represent the breadth of results. The Novices are clustered at the center of the continuum, while the Master teachers, except Ann, are clustered at the middle and right of the continuum. These data will be combined with the storying and

the question-by-question for each of the six exemplars to create a composite of their schema development.

*Storying/Knowledge*

In their responses to both Clip A and Clip B the novices overall tended to be less lengthy, the one exception being Novice Clare who will be discussed later. One of the early codes I developed from the Master transcripts was “knowledge”. This code represented principles of practice embedded in stories told by the Master teachers, and occasionally by the Novice teachers. Eventually, I coded for storying/knowledge. This is a subjective coding leading to four designations of storying/knowledge: none, little, some and lots. I associate storying/knowledge with well-developed, rich schema because of the complex nature of the stories, often linking reflections of the past and present to the future. I assigned a numerical value to each of the four designations: none =0, little =1, some =2, and lots =3. For each participant I summed their storying/knowledge score. Below is a table of the storying from one of the participant exemplars, Master Teacher Ann.

Table 5.10 Master Teacher Ann Storying

Q#	Storying Score	Q# (con't)	Storying score (con't)
Q1	3	Q9	0
Q2	0	Q10	3
Q3	1	Q11	3
Q4	1	Q12	0
Q5	0	Q13	0
Q6	1	Q14	0
Q7	3	Q15	0
IMP	0	Q17	3
Q8	1	<b>Total</b>	<b>19</b>

With this numerical description of the code we can compare the Novices to the Master teachers. The table below summarizes each of the

participants in terms of how extensive their storying was. The participant exemplars are bolded. I've listed them in ascending order with the participant storying the most at the top and the least at the bottom.

Table 5.11 Master/Novice Storying Comparison

<b>Master/Novice</b>	<b>Participant</b>	<b>Storying Total</b>
<b>Master</b>	<b>Rachel</b>	<b>31</b>
Novice	Clare	26
Master	Donovan	22
Master	Samuel	21
<b>Master</b>	<b>Ann</b>	<b>19</b>
Master	Emilio	17
Master	Colleen	15
<b>Master</b>	<b>Mercedes</b>	<b>12</b>
Novice	Dexter	11
<b>Novice</b>	<b>Audrey</b>	<b>7</b>
<b>Novice</b>	<b>Luscien</b>	<b>7</b>
Novice	Pierre	7
Novice	Garrett	7
<b>Novice</b>	<b>Jessy</b>	<b>3</b>

From the table above we see the Novices clustered at the bottom and the Master teachers clustered at the top. We might venture to claim that those with well-developed, rich schemas would be at the top of the table while those with simple schemas would be at the bottom of the table. Oddly, Clare, a Novice is second only to Rachel, the top-scoring Master teacher. I should note that though Clare told extensive stories, the content focused on her own past experiences. She was the central figure in each of her stories. The stories told by the rest of the Novices and Masters had students, other than self, as the central figures in their stories. Again, the participant exemplars span the breadth of the results.

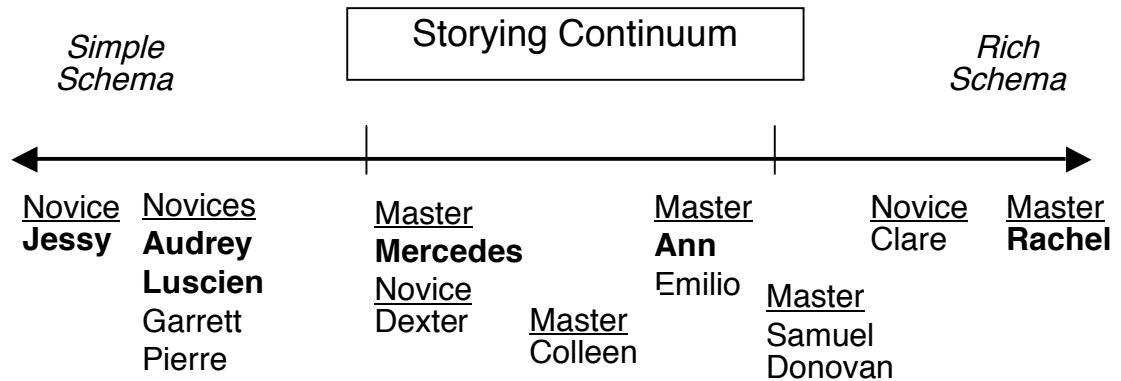


Figure 5.2 Storying Continuum

*Question-by-question*

Participants' responses to particular questions provide insight into their schema development. Together with their "progression of ideas" and the extent of their storying, a clearer picture of their schematization takes shape. I've focused on the three Master teachers and three Novice teachers who are serving as my exemplars.

Those who gave a play-by-play response to Question 1 were considered to have given a more simple, though not necessarily short, response. Both Mercedes (M) and Audrey (N) gave a play-by-play response and also focused at least in part on issues of survival. This pattern may relate to the participant's schema development in terms of a less analytic interpretation of the video-clip, rather than analytic. In Question 4 Ann (M), Mercedes (M) and Jessy (N) refer to the process-nature of teaching and learning, so when asked whether Robert was successful in achieving his lessons goals, they said they needed more information since they've seen too little of the lesson. This awareness of the complexity of a teaching and learning speaks to a richer schema for making sense of teaching and learning.

When asked to speculate about what would happen next, Question 5, both Mercedes (M) and Luscién (N) expressed that they didn't know; they couldn't or wouldn't speculate. Based on the research in cognitive science we would expect those with simple schemas to lack this anticipatory ability.

Immediately after watching Video-clip B several participants jumped in, unprompted, with reactions. Rachel (M), like two other Master teachers, commented about the interactions between the students, how deep learning was happening and connecting what they saw to their own experiences. Her response was rich and connected to her own experiences, exemplifying well-developed schemas for teaching and learning. Of the seven Novices, only one had a comment. He expressed how overwhelmed he was by what he saw and how difficult he found it to follow the students and their ideas. This response may speak to a simpler schema. Jessy (N), Luscién (N), or Audrey (N) all gave indication of naïve schemas for teaching and learning as they had no impromptu response.

When asked to summarize what was happening in Clip B, several participants shifted again to a play-by-play response instead of giving a higher-level analysis, or perhaps even linking their analysis to the prior clip. Novices who responded, "I don't know" were also revealing a simple schema for teaching and learning. None of the Master teachers had any trouble summarizing what they saw.

Question 10 provides much detail to illustrate participant schema development. Rachel (M) and Luscién (N) connected theoretically grounded phrases to the lesson structure they saw in the video-clip. Both included descriptions in their own words of the theory they had mentioned, perhaps indicating a rich schema. Responses from Ann (M), Audrey (N), Mercedes (M)

and Jessy (N), such as a play-by-play response or the “I don’t know” response, were considered simplistic.

Interestingly in Question 13, Ann (M) wanted more information about the lesson before deciding what she would do differently. Responding that she would like more information before detailing what she would do next once again points to a rich understanding of teaching and learning. Mercedes (M), Rachel (M), and Audrey (N) each gave detailed explanations of the lessons they would conduct in lieu of Robert’s lesson. This quick thinking is indicative of rich schemas and is so noted. Jessy (N) and Luscien (N) did not give detailed information about their lesson. They each picked one facet of instruction that they addressed. In Jessy’s (N) case she focused on a classroom management issue, while Luscien (N) addressed the role of misconceptions in teaching and learning. This difference illustrates a consistent focus, on survival and student learning respectively, for each of them throughout the interview process.

Question 14, advice for Robert, illustrates some rather rich schemas about teaching and learning. Rachel (M) would ask Robert some thought provoking questions, which as Rachel puts it, should have the ideas coming from him because teachers are learners too. In addition, Jessy (N) wants more information to help them give Robert advice. Their awareness of the complexity of teaching and learning implies rich schemas. Audrey (N), Mercedes (M) and Ann (M) each gave rather perfunctory advice. Audrey (N) focused on often focusing on classroom management and lesson design. Mercedes (M) focused on the importance of State tests and Ann (M) gave suggestions about pacing. The table that follows summarizes these interpretations.

Table 5.12 Question-by Question Schema Summary

<b>Master Participant</b>	<b>Q1 Schema</b>	<b>Q4 Schema</b>	<b>Q5 Schema</b>	<b>Impromptu</b>	<b>Q8 Schema</b>	<b>Q10 Schema</b>	<b>Q13 Schema</b>	<b>Q14 Schema</b>
Rachel	Rich	Simple	Rich	Rich	Rich	Rich	Rich	Rich
Ann	Rich	Rich	Rich	Simple	Rich	Simple	Rich	Simple
Mercedes	Simple	Rich	Simple	Simple	Rich	Simple	Rich	Simple
<b>Novice Participant</b>	<b>Q1 Schema</b>	<b>Q4 Schema</b>	<b>Q5 Schema</b>	<b>Impromptu</b>	<b>Q8 Schema</b>	<b>Q10 Schema</b>	<b>Q13 Schema</b>	<b>Q14 Schema</b>
Jessy	Rich	Rich	Rich	Simple	Simple	Simple	Simple	Rich
Luscien	Rich	n/a	Simple	Simple	Rich	Rich	Simple	n/a
Audrey	Simple	Simple	Rich	Simple	Simple	Simple	Rich	Simple

Rachel (M) stands out from the three Masters showcased. She leans towards a more rich schema for teaching and learning. Ann (M) represents a Master teacher with moderately complex schema while Mercedes (M) leans, from this analysis, towards a more simple schema. Jessy (N) and Luscien (N) represent Novices with moderately well developed schema for teaching and learning while Audrey (N) leans toward a more simple schema, from this analysis. Looking to the continuum that follows, the Master teachers, except Mercedes (M), are once again clustered to the right while the Novices are clustered from the center to the left. The participant exemplars are bolded. Their location on the continuum speaks once again to their representing the breadth of response.





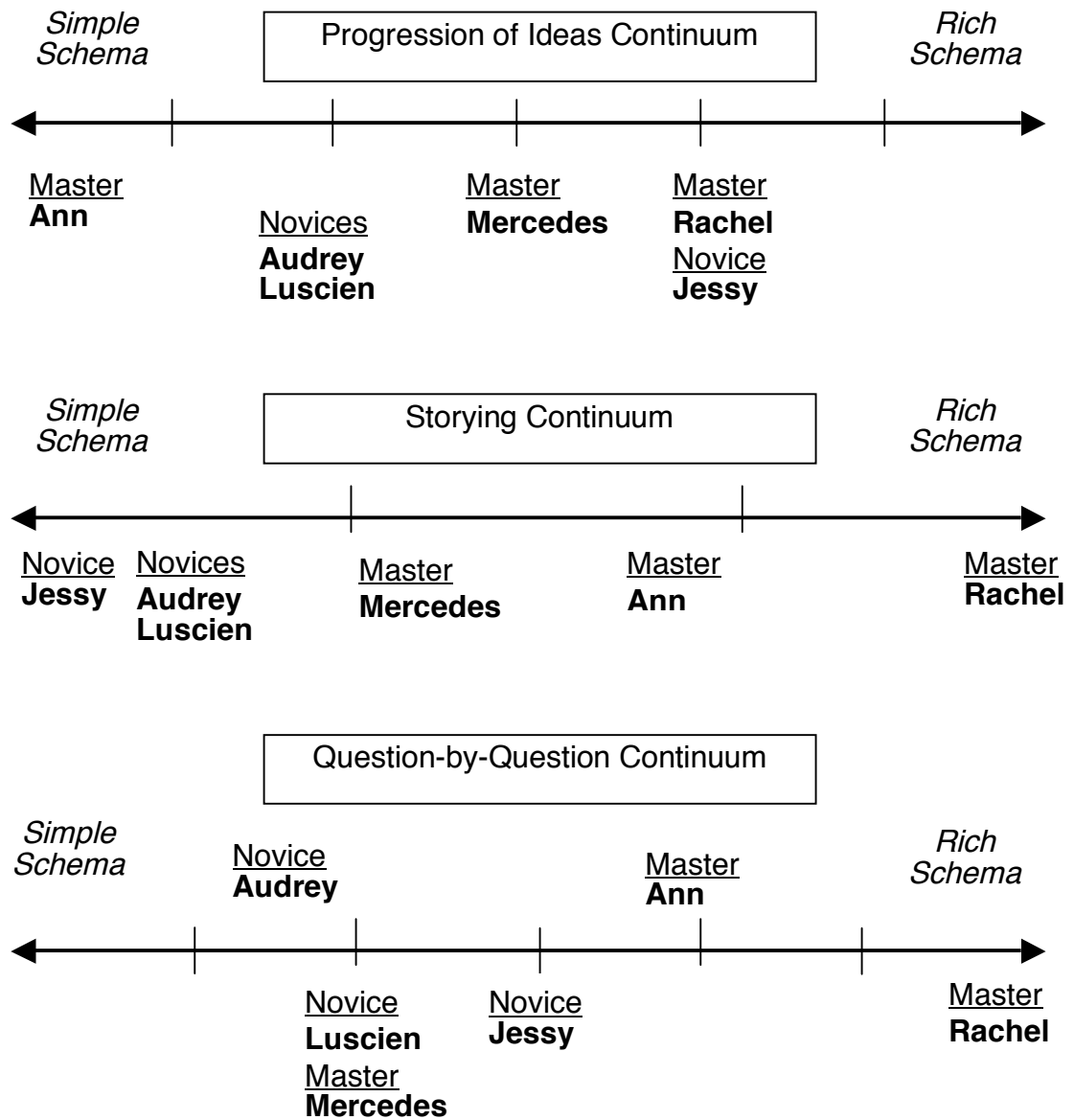


Figure 5.4 Trio of Continua for Schema Development

Mercedes (M) falls into the lower third of two of the three continua. For the third she sits in the middle. Ann (M) is at the extreme left end of one continua and in the top third of two of the continua. The Novices Audrey (N) and Luscién (N) seem to cluster together, consistently in the lower third of each continuum. Jessy (N) falls in the middle of one continuum, then at the

bottom and top of the remaining continua. Based on the criteria for each analysis Rachel (M) clearly has the more rich schema for teaching and learning. Following Rachel (M) the other obvious categorizations might be made for Luscién (N) and Audrey (N), with Luscién pulling slightly ahead of Audrey in the bottom third of a composite continuum. Mercedes (M) would likely occupy an area nearer the middle of the continuum while Jessy (N) and Ann (M), more complicated cases, would also fall around the middle of the continuum.

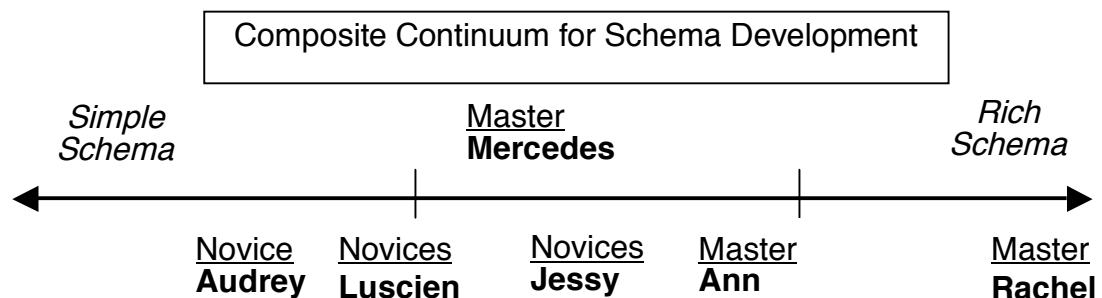


Figure 5.5 Composite Continuum for Schema Development

#### Summary

Novices Audrey and Jessy show little theorizing about learning, as was predicted. Their focus on survival concerns may block attention to thinking about learning. Consequently their personal theories of learning are simple, in contrast, Novice Luscién shows great depth in his personal theory of learning. His struggle with the role of the teacher is evidence of a transition from a more traditional to more a constructivist theory of learning. Luscién's focus on student learning is in contrast to a simple schema for teaching and learning. Luscién straddles between constructivist and traditional approaches to education. Perhaps this contributes to his simple schematization. By contrast Jessy stands out from the Novices as having rich schemas for learning and

teaching while at the same time being strongly concerned for survival. Perhaps her awareness that she draws from her own preferences and is focused on survival contribute to this rich schema. The schematization we see from her could be linked to being highly reflective.

Rachel is an excellent exemplar of what was expected from the Master teachers. She has a rich schema for interpreting classroom events. She is focused on student learning and she has a strongly constructivist personal theory of learning. Master teacher Ann lacks a strong focus on learning though she exhibits slightly constructivist leanings. She sits in the middle between two Master teachers who clearly describe how they think people learn. Mercedes occupies the seat opposite to Rachel in terms of having a more traditional theory of learning. However, her focus is clearly on student learning. Her schema development is certainly not simple, but sits more to the middle of the two participant groups. Mercedes represents, like Novice Jessy, an interesting conundrum, as compared to the expected results.

## CHAPTER 6

### CONCLUSIONS AND AREAS FOR FUTURE RESEARCH

#### Conclusions

From this research several conclusions can be drawn about understanding how Master and Novice teachers think about learning. First and foremost, the Master's in this study share qualities with experts in other domains. The Masters shared rich, interconnected stories relating to what they saw, often offering alternate explanations beyond their first interpretation. The Novices lacked both stories and alternate explanations. Nor did they story as a way of answering the interview questions. The Masters were anticipatory in how they answered the interview questions, often jumping ahead. The Novices did not show this quality. Each of these conclusions supports the claim, made here and in the literature across domains, that Masters have well-developed schemas whereas the Novices do not.

Secondly, Both the literature that frames this study and the data from the study itself suggest that how a teacher thinks about three facets of teaching and learning reveal a great deal about their personal theory of learning. Asking a teacher the role misconceptions play in their teaching and their students' learning reveals different ways to conceptualize a misconception. One perspective is to consider a misconception something to be replaced, like changing a light bulb. A second perspective is to consider a misconception as something that needs to be explored and challenged. Holding the first perspective would not be consistent with constructivist learning theory. Holding the second perspective would be consistent with constructivist learning theory. It is interesting to find a Master teacher like Mercedes who holds a light-bulb perspective on misconceptions. I would have

expected all of the Master teachers to be more like Ann and hopefully like Rachel. Likewise it was interesting to learn that Novice teachers like Luscién and Jessy appreciate misconceptions as notions students must confront themselves. As Luscién says,

*“For them – the best way is for them to make sense of it within themselves and then kind [of] take on a more – kind of work through their misconceptions and take on a more, a formal scientific understanding of things, not just learn someone else’s version of how the world works and transcribe that into their own brain – kind of make sense of it within themselves, I guess.” [Luscién Video-clip Interview]*

Master teachers Ann, Rachel and Mercedes each referenced their role as not leading students astray or down wrong paths. This teacher/guide is communicated with a sense of caution. Contrast this perspective with Jessy’s fear of misconceptions cropping up,

*“The thing I’m not comfortable with as sort of the novice, not even yet a novice teacher, is that there’s no way to control it and so it’s this wild thing, wild card out there that if you let it go, if you’re teaching in an experiential way it could balloon into something much bigger. An experienced teacher would know how to let it blossom for a while and then pop that balloon or clue them into something having taught the lesson before, and ask them just the right question that would send them down a path to address that misconception.” [Jessy Follow-up Interview]*

What they think the role of the science teacher is in the science classroom also adds to our understating of how they think about learning. If the teacher describes his or her role as clarifying or correcting student ideas their

perspective is less constructivist. If a teacher describes her role as facilitating student thinking, their perspective could be considered more constructivist. The locus for power is significant in understanding a teacher's personal theory of learning.

Where the onus for learning is placed, on the teacher or on the student, clarifies another aspect of the teacher's theory of learning. If emphasis is on student ideas as central, as well as student cognition as fueling the learning, the theory is more constructivist. If the teacher's ideas are central to the lesson and student understanding does not inform the teacher's progress, then the theory is more traditional.

The Novice exemplars tie their theory of learning to their own preferences. Some, like Jessy, acknowledge this, while others like Audrey do not. Regardless, they each emphasize how their past experiences of being a student are interfering with their teacher development. Their ability to develop understandings and habits that are akin to reform-minded principles of learning and teaching is complicated by years and years of being a student in a traditional classroom. The Master exemplars do not tie their teaching practice and theory of learning to their own preferences. Instead they each reflected on how they purposefully teach to address different students' needs.

Another interesting result is the connection the Novices tied to student engagement. Time after time they attributed success in teaching, during their interviews, to student attentiveness. By contrast the Master teachers tied success to student learning. While the Novices were preoccupied with issues of survival, the Master teachers conversed about survival issues but took the perspective of giving advice to the video-clip teacher Robert. The Master teachers, we could conclude, are not focused on survival for themselves but

can shift their critical lens to issues of survival to give advice to inexperienced teachers. Perhaps their ability to shift their critical eye from student learning to survival reveals the richness of their schema for teaching and learning.

It is interesting to see the diversity of response in this research made by the Novices. Luscien's struggle is a very sophisticated awareness that all constructivist teachers face: when to lead students and when to let them discover. Rachel also articulates this struggle, as do Ann and Mercedes. His awareness at such an early stage is encouraging. Audrey, however, having completed student teaching, represents a more typical novice teacher who may not have internalized such issues or may not clearly ascribe to a constructivist approach.

Each of the Master teacher exemplars are teachers with well-developed schemas and notions about learning, especially when compared to the Novice exemplars. Each of their perspectives is complex and supported by years of experiences. Interesting, their experiences have led them in slightly different directions. Ann and Rachel have similar approaches to student misconceptions while Mercedes stands a little apart having taken much more personal responsibility for students' cognition.

Driver and associates distinguish a core component of constructivist learning theory, "that knowledge is not transmitted directly from one knower to another, but is actively built by the learner" (Driver et al., 1994). Master Mercedes' theory of learning differs in several ways from Driver and associates' theory of learning. Because Mercedes believes strongly that the learner constructs understanding from experience, she does not want her students to have experiences that might reinforce wrong ideas. However, neither does Mercedes provide cognitive conflict to change students'

conceptions. In fact she does her best to eliminate all alternate interpretations in favor of highlighting the right answer. Changing students' ideas is achieved by telling them what to think and likewise, what not to think. Though she does provide reasons why they should change their ideas she does not encourage discussion or exploration of less accurate ideas. Novice Audrey, with her ideas about extracting information would also not align with Driver's perspectives on teaching and learning science. Audrey not only lacks an articulated perspective on how learning happens but also expects students to extract correct information. She has only a rough mechanism in place for being the cause of cognitive conflict for students' partially accurate science ideas.

Both Masters Rachel and Ann have ideas about learning and teaching that more closely resemble Driver's constructivist theory of learning because they value not only the necessity for cognitive conflict but also the role the teacher and student peers play in facilitating that discussion. Likewise Novices Luscien and Jessy recognize the teacher's role in bringing about cognitive conflict to facilitate change for students' conceptions. Luscien is struggling with when to step in and Jessy is struggling with how to step in, how to pop the balloon, as she put it.

Both Masters Rachel and Ann valued the role played by a student's peers as sources of alternate ideas but neither of the Novices Luscien, Jessy, nor Audrey emphasized that role. All six exemplars did emphasize the necessity to help students make sense of their world in terms of the science way of seeing. They fell into two groups when it came to how to achieve that goal. All six exemplars emphasized that students have prior conceptions of how their world works, gathered from past experiences that are often inaccurate when compared to science ideas.



## Areas for Future Research

However, the limitations of this study beg for further investigation. I have attempted to clarify the differences and similarities between Novice and Master teachers by looking at the relationship between their theory of learning, their focus and their schema development. How is a teacher's epistemology tied their schema development? How do schemas develop? We can imagine a teacher who's a traditional perspective on teaching and leaning is derived from her epistemology, still having well developed schemas for teaching and learning. What role does epistemology, especially about science knowledge, play in a teacher's theory of learning?

How do personal theories of learning, both traditional and constructivist, develop? The educational biography for each participant holds valuable data about their past experiences during teacher education but also of teachers from their childhood. This data has yet to be mined and analyzed in the context of this study's results.

Is a verbal explanation the best route to observe a participant's personal theory of learning? It is very likely based on the literature that Master teachers, like Mercedes, might have a rich theory of learning but not be able to articulate that theory. A rich theory of learning may be imbedded in practice, and as such may not be revealed through verbal description. What is the relationship between the principles of teaching and learning the participants describe and their actual teaching practice? To answer these questions longitudinal observations should be gathered of each participant. Such observations would allow the researcher to establish whether the theories of learning that are described in this study are not only evidenced in the actual

practice of the participants, but also to reconcile the participants articulated theory with their theory in practice.

Lastly, what kind of pre-service experiences foster reform-based perspectives on learning, schema development and a shift in focus from survival to student learning? As teacher educators we seek to facilitate the development of pre-service teachers. Early fieldwork experiences are an ideal opportunity to cultivate reform-based perspectives on learning. These opportunities could be designed in such a way to stimulate schema development, a shift from seeing oneself as the student to an image of self as the teacher, and a shift from focus on survival to student learning. Concurrent with this shift, we would hope, would be a shift towards reform-minded personal theories of learning.

## APPENDIX

Table A.1 Summary Table for Progression of Ideas

	Goals Q3		Success Q4	I would Q6	Reasoning Q10	I would Q13
1	M1	N4	N1			
2	M1	N5	M1			
3	M5	N7	M1			
4			M6 N6			
5				M3 N1		
6				M7 M7		
8					M2 N6	
9					M4 N4	
10					M7 N7	M2
11						M4
12						M3
13						M6 N7

Table A.2 Master Teacher Ann's Progression of Ideas

	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9	Q10	Q11	Q12	Q13
1	√											
2		√										
3			√									
4				√								
5					√							
6						√						
8							√					
9								√				
10									√			
11										√		
12											√	
13												No answer

Table A.3 Master Teacher Rachel's Progression of Ideas

	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9	Q10	Q11	Q12	Q13
1	√											
2		√										
3			√									
4				√								
5					√							
6						√						
8							√					
9								√	√			
10									√			√
11										√		√
12											√	√
13												√

Table A.4 Master Teacher Mercedes' Progression of Ideas

	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9	Q10	Q11	Q12	Q13
1	√											
2		√										
3			√									
4				√								
5					√	√						
6						√						
8							√					
9								√				
10									√			
11										√	√	√
12											√	
13												√

Table A.5 Novice Teacher Audrey's Progression of Ideas

	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9	Q10	Q11	Q12	Q13
1	√											
2		√										
3			√									
4				√								
5					√							
6						√						
8							√		√			
9								√	√			
10									√			
11										√		
12											√	
13												√

Table A.6 Novice Teacher Jessy's Progression of Ideas

	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9	Q10	Q11	Q12	Q13
1	√		√									
2		√	√									
3			√									
4				√								
5					√							
6						√						
8							√		√			
9								√	√			
10									√			
11										√		
12											√	
13												√

Table A.7 Novice Teacher Luscién's Progression of Ideas

	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9	Q10	Q11	Q12	Q13
1	√		√									
2		√	√									
3			√									
4	N/A											
5					√							
6						√						
8							√					
9								√				
10									√			
11	N/A											
12											√	
13												√

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